Seedbed quality preparation in Estonia

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Abstract. The field experiments for seedbed quality preparation were performed in five farms and experimenrtal areas. The laboratory tests were carried out with the use of the gutta-diagnostic indication method by E. Reppo, (1979). We have been using the Nordic Countries method for observation of seedbed quality preparation and have been improving this method through measurements of bulk densities and soil aggregate distributions within soil layers of the seed planting zone and immediately below the region of seed placement. We also used Litvinov cylinders (50 cm^3), standard compactor (Proctor apparatus – PST) and, for measuring the soil penetration resistance to depths up to 40 cm, the Alexeiev penetrometer. We have found that the optimum range of agronomically valuable aggregates (2-5 mm) at physical maturity of soil for the average soils in Estonia remains within the limits of 40–50%.

Key words: field experiments, seedbed quality preparation, soil structure, aggregates

INTRODUCTION

Seedbed preparation for spring-grown fields of wheat requires more investigation before sustainable production recommendations can be established for Estonia. Recent equipment developments of special seedbed equipment from the Swedish University of Agricultural Sciences (Uppsala) offer new possibilities for better seedbed preparation. Additional measurements of soil responses to this new equipment and follow-up production results are needed before complete adoption of this new equipment.

Measurements of soil aggregate modifications by this new Swedish equipment have been reported by Göran Kritz (Kritz, 1983). These methods sample surface layers of soil and determine the percentage of agronomically valuable aggregates 2–5 mm in diameter, before and following single and multiple passes by this new equipment.

Aggregates used in the Nordic countries' method were assessed directly in the field by means of screening moist soil, in contrast to the Kachinski method (Kachinski, 1960), in which whole soil volumes were transported to the laboratory, air dried, and dry sieved into diameters from 0.25 to 10 mm.

Our opinion is that the Nordic countries' method is more favourable for obtaining adequate results considering the soil physical properties in Estonian conditions. The supervisor introducing this method is Prof. Emer. I. Håkansson of the Swedish University of Agricultural Sciences (Håkansson, 1983).

MATERIALS AND METHODS

Field trial and experimental details

Specific listings of soil types by World Reference Base for Soil Resources (WRB) in our experiments were the following:

1)Väätsa (Järva County) – Endoeutri-Haplic Luvisol, location (58°56´N, 22°26´E), at field "Suiste" (65.6 ha), and experimental conditions (bulk density (0–10 cm) 0.94–1.50 Mg m^{-3} at seedbed depth, and volumetric moisture (per cent) 11.1–23.8, eg., previous cropping sequences (barley – spring wheat – oat – potato – winter rye – barley and pea – spring wheat, etc.);

2) Aaspere (Lääne-Viru County) – Endoeutri-Mollic Cambisol, location (59°27´N, 25°07´E) at field "Bärnbu" (33.7 ha), and experimental conditions (bulk density (0–10 cm) 1.03–1.31 Mg m^{-3} at seedbed depth, and volumetric mositure (per cent) 8.2–16.3, eg., previous cropping sequences (barley – spring wheat – oat – potato – winter rye – barley and pea – spring wheat, etc.);

3) Saida BTK (Harju County) – Endosceleti-Mollic Gleysol, location (59°04´N, 24°21´E) at field "Metsamaatalu" (28 ha),and experimental conditions (bulk density (0–10 cm) 0.95–1.09 Mg m^{-3} at seedbed depth, and volumetric moisture (per cent) 16.5–23.6, eg., previous cropping sequences (winter rye – barley and clover – clover – clover – winter rye – winter rye – spring wheat – barley and clover – clover, etc.);

4) "Tiigi" private farm (Ida-Viru County) – Endoeutri-Cutanic Luvisol, location (59°13´N, 27°20´E) at field No 1 (3 ha), and experimental conditions (bulk density (0-10 cm) 0.89–1.24 Mg m^{-3} at seedbed depth, and volumetric moisture (per cent) 11.9–24.7, eg., previous cropping sequences (potato – barley and pea – summer wheat – potato, etc.), co-author of field experiments Mr. Tiit Leppik;

5) Estonian University of Life Sciences (Tartu County) – Fragi-Stagnic Albeluvisol, location (58°23´N, 26°44´E) at field "Eerika", and experimental conditions (bulk density (0–10 cm) 1.03–1.33 Mg m^{-3} at seedbed depth, and volumetric moisture (per cent) 16.1–18.2, eg. previous cropping sequences (barley – potato – barley and clover – clover – spring wheat – spring barley, etc.). Experimental fields have used conventional tillage which is now typical for Estonian conditions (co-author of field experiments Assoc. Prof. Jaan Kuht).

Samples were collected during a three-year period from 1995-97 at the above sites of investigation in spring-sown fields in Estonia. These tests consisted of express diagnostic evaluations using the simplest and least expensive equipment, including those published by Reppo (1979). Specific measurements included gravimetric soil moisture evaluations and soil aggregation evaluations, with emphasis on aggregates ranging from 2–5 mm in diameter.

For field experiments we have used (Fig. 1) the Penetrometer "Alex". Rummer thrusts were measured by means of standard compactor – Proctor apparatus (PST). The number of thrusts was specified and work (GJ ha^{-1}) calculated to make the plunger penetrate the reference depth of 10 cm in the soil layers situated below the seedbed.

For laboratory tests the optimal parameters of seedbed soil were determined. For this E. Reppo's gutation method was used (Reppo, 1979).

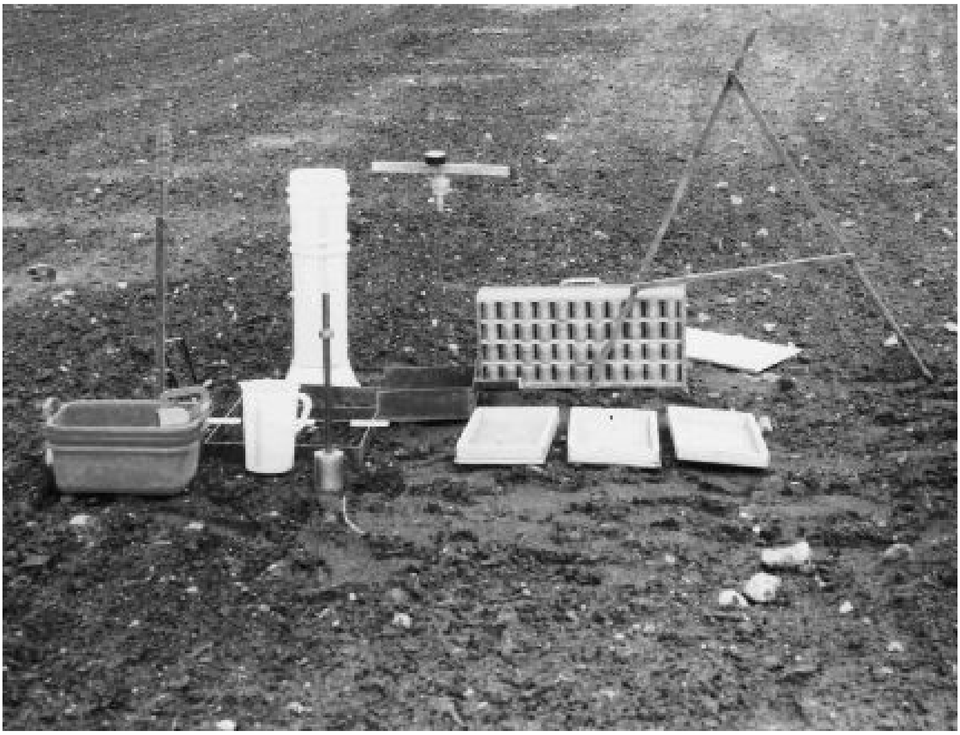

Figure 1. The general view of equipment for assessment of seedbed quality preparation.

The laboratory tests were performed in Saku, in the Estonian Research Institute of Agriculture on test culture's (barley Anni) reaction (gutation's relative intensity in % pro yield) and was evaluated. This method is protected by the appropriate patent.

RESULTS AND DISCUSSION

The results of research from the field tests.

Tables 1 and 2 illustrate the results for the abovementioned permanent observation points in 1995–97.

The analyses preceding 1997 are presented in Table 1. The final analysis (Table 2) will be carried out during the next trial period.

Comparison of different opportunities and ways of seedbed press in the tests of 1996 showed that the optimal conditions had been created in Väätsa PÜ Röa department Garaasi field where harrows with S-tines and caterpillar tractor DT-75M were used. The drilling was performed with the drill Juko-400. The Proctor measurement equipment fixed the work for deforming the soil as 13 MJ m^{-3}. If this result is taken as the basis for the norm then the standard energy consumed for deforming the soil with 0.8 FC moisture (FC is the soil's content of exterior water that varies from one soil association to another) in one hectare is 13 GJ ha^{-1}.

In order to achieve results of some of our field experiments, to find the extreme (best/worst) values for the abovementioned factor of structural composition of soil, it could be fixed that, logically, the best level K_{str} is equal to 1.0 and the worst level – 0.02. After that, according to the abovementioned (Table 1), we could calculate the final quantity of S_{str} (Nugis, 1997).

Table 1. Soil's structure incl. K_{str}, bulk density and moisture content at the permanent observation points in the 1995/1996/1997 years

Call of permanent observation point	The soil´s				
	Diameter of soil structural element, mm		Bulk density, Mg m^{-3}	Moisture content, per cent	Degree of structural composition, K_{str}
	>5	2 - 5			
Väätsa PÜ	43.6/ - / - **	34.0/ - / - **	1.16/ - / **	30.2/ - / - **	
Röa	- /44.3/ - *	- /46.8/ - *	- / - / -	- /20.9/22.3*	0.34*
Röa 2	- /38.9/45.1	- /48.1/44.9	- /1.09/1.61	- /15.6/ -	0.14
Lõõla	- /35.0/42.6	- /44.8/45.4	- /1.35/1.56	- /16.8/21.2	0.18
Aaspere PÜ	28.6/33.0/37.9	36.6/41.6/48.8	1.04/1.06/1.52	14.6/11.2/25.6	0.21
EMÜ	40.0/33.9/44.6	38.6/42.9/36.6	1.16/1.21/1.56	17.1/12.5/13.8	0.35
Saida BTK	25.3/26.3/22.1	36.0/46.3/50.6	1.02/0.95/1.57	18.8/20.5/22.9	0.21
Farm "Tiigi"	- /42.3/33.4	- /34.6/50.3	- /0.96/1.45	- /14.8/22.9	0.31

Note: * - tests were carried out on May 6-8, 1996; others on May 9-18;
** - tests in 1995.
Maximum LSD of K_{str}, i.e. LSD_{05} = 0.07

Comparing the calculation results obtained (Table 1), it is obvious that the result at Röa 2 of Väätsa PÜ (Väätsa Agricultural Co-operative) is more favourable for soil structure conditions, in comparison with conditions at field Eerika (Estonian University of Life Sciences); this level is the most unfavourable because it represents results of inveatigations with overcompaction of soil carried out by Jaan Kuht in his experiments.

The results of laboratory tests

We have explained the possibilities of forming different seedbed conditions and its influence on the relative yield in Väätsa permanent observation points with the use of E. Reppo's method (Table 2). The most effective test version was the one where the soil aggregates of diameter > 5 ... < 10 mm form a 0.9 cm (in 1996 tests) and 1.3 cm (in 1997 tests) layer upon the seedbed. This means that the relative gutation or yield is 100 per cent in the case where the density below the seedbed layer does not exceed 1,18 ± 0,04 Mg m^{-3}. This layer of 7.3 cm depth in the given circumstances (in field conditions up to 12 cm) should consist of agronomically valuable soil aggregates with a diameter between 2–5 mm. Table 2 allows us to draw wide conclusions for further research.

The data base obtained in three years (in 1995–97) from permanent observation of six different soil associations and cultivating intensity that could be used for further monitoring was rather excessive. Therefore, the current paper will present only the most general results.

Concerning lab tests, the layer of ca 1.5 cm upon the seedbed that is loose and covers the seeds uniformly should also consist of structure aggregates with a diameter within the previously mentioned range.. The soil layer covering the seedbed that consists of aggregates with a 5–10 mm diameter is a defensive layer which forms the necessary aeration for soil – a factor for which parameters have not been previously determined.

Table 2. Influence of thick soil layer over the seedbed bottom on the relative gutation.

The soil bulk density of layer located above the seedbed bottom, filled with soil aggregates fractions >5 mm	Relative gutation (yield) of the test-plant, %	
	1996	1997
1.9	61	95
1.3	50	100
0.9	100	92
0.4	95	79
0.0**	47	95
1,9*/0.0**	26	94

Notes: * the layer over seedbed; the whole cylinder is filled with soil of aggregate diameter < 2 mm (agronomically not valuable); gutation path on filter paper;
** soil's structure aggregates of diameter > 5mm are missing in the cylinder - this means that the density of layer covering seedbed was zero;
LSD_{05} = 84 mm², that corresponds to relative gutation (84 mm x 6 times guttate collected on a filter paper = 504 mm² (where 504 mm²/1653 mm² = 0.304 ~ 0,30 or 30%).

CONCLUSIONS

A new approach to economic land use on soil tillage preceding the drilling of grain has been offered, based on optimising the seedbed soil's physical characteristics. To achieve that, field-laboratory and laboratory tests were carried out and the cultivating technologies of standard and complex cultivation were evaluated from biotechnological and energetical standpoints. The result was that even the most unfavourable agronomic conditions of soil emerging after autumn ploughing and after winter (in Väätsa PÜ in 1996 tests) were removed by complex soil tillage machinery. With standard technology the required seedbed conditions could be achieved by 9 cultivations and fertilisations, however, the field is too much compacted: the soil structure would be ruined and the energy consumption is 30% larger. Thus complex technology can be called economic technology. The protector measuring equipment used for evaluating bioenergetic effectiveness indicates the energy required for standard soil deformation; this is compared to total energy consumed for seedbed preparation. The relative figure for using standard equipment is 0.12 (transfer factor) which could be used for prognosticating energy consumption. With the use of complex technology this figure is 20–30% smaller.

A novel theory for assessment of structural composition of the effect of seedbed quality preparation has been offered. These conclusions are valid in average Estonian soil conditions. We recommend introducing the above-mentioned method for other Baltic countries, as well. However, for different soils research should be continued.

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