Method for Evaluation of Soil Conditions Suitable for Growing Emmer and Einkorn Wheat

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Abstract

Method is developed for the field rating of main soil characteristics that define the suitability for growing emmer and einkorn wheat. Soil texture of the fallow land, depth of the humus horizon, depth of the soil profile, texture differentiation of the soil profile, soil reaction, humus content and groundwater level have been evaluated. The method is harmonized with the officially accepted in Bulgaria parametric methods of the system of field ratings and the categorization of the agricultural lands. The end result is an evaluation of the soil conditions and a soil rating.

Key words: Field Ratings, Soil, Soil Characteristics, Emmer and Einkorn Wheat

Introduction

The emmer and einkorn are a type of wheat and some of the oldest food sources of humanity. Einkorn is thought to have originated in the upper area of the fertile crescent of the Near East (Tigris-Euphrates regions). Cultivated einkorn is Triticum monococcum (Stallknecht et al., 1996). Triticum dicoccum or emmer wheat rapidly spread to all farming areas in the Near East during the seventh millennium BC and became the most important cereal (Feldman, 1976). In Bulgaria they are grown on a quite limited area mostly on soils with low fertility not suitable for other types of wheat, in mountainous regions and near some river valleys. They have lower yield than bread wheat Triticum aestivum (Longin et al., 2016).

Nevertheless, during the last few years there is a growing interest towards the biological agriculture and healthy nutrition, these types of wheat are very beneficial. For example emmer wheat has high total antioxidant activity, total phenolics, ferulic acid and flavonoids whereas einkorn is rich in lutein (Serpen et al., 2008). Moreover, the emmer and einkorn wheat have fewer requirements in terms of soil and climatic conditions, rarely suffer from plant diseases, and overall fewer pesticides are needed (Koedzhikov et al, 1977). These qualities are a good ground for research in the field that will be useful and applicable in practice.

The aim of our research is the creation of scales for evaluation of the main soil characteristics in accordance with the environmental requirements of the einkorn and emmer wheat. Additional goal is to evaluate the soil conditions and create a soil rating using parametric methods.

Material and Methods

Biological requirements of the crops

These "ancient" wheat types i.e. emmer wheat and einkorn wheat are major products of organic agriculture owing to the increased interest in the search of unconventional food sources with low initial investments.

The characteristics of emmer wheat T. dicoccum Schranc are the following: Its ears are flattened with different thickness and in each of them there are two grains which give its name. The grains are small and flattened. Mainly spring types are known from this wheat type.

The einkorn wheat T. monococcum L has tender, small ears, compact and completely flattened. In every ear there is only one grain. The einkorn wheat is also represented by spring types. An interesting feature is that the grains are covered with color paleas which protect it from diseases and infestation from pests which is a property of its genome. Owing to the fact that they are exceptionally valuable crops, growing them can be environmentally friendly, as well (Koedzhikov et al., 1977). These wheat types are a suitable alternative to the farmers in Bulgaria because they can include one more crop in their crop rotation plan. This would guarantee them stable income in conditions of sudden climate change.

Soil conditions and the requirements of the crops

The crops are very unpretentious to the soil conditions. They can be grown on poor, impermeable, stony soils with low fertility. For optimal development and yield the most suitable soil has high clay content (content of physical clay 45-60%), with deep (over 40 cm) and rich in organic carbon content (over 2%) humus accumulative horizon, neutral to weakly basic soil reaction (pH in H2O 6,5 - 7,5), low level of the groundwater (100-200 cm under the soil surface), friable structure and good physical and aquatic characteristics. The soil has to provide high intensity root nutrition and water supply. For that reason the most suitable soils are the chernozems (leached, typical and calcareous), smolnitsas and leached cinnamonic forest soils.

Suitable predecessors are crops that leave the soil clean from weeds and in good structural conditions. Planting is not recommended following other cereals, i.e. wheat, barley, oats, triticale. The crops are unpretentious in their nutritional requirements and fertilization is not recommended (Koedzhikov et al., 1977)

Parametric method comparable to "Methods for work on the agricultural land cadaster in Bulgaria", 1988, (Petrov et al., 1988) is applied. The idea is to use new method for evaluation of additional crops that are missing at present.

Results and Discussion

The soil characteristics that are taken into account are the following:

1. Soil texture of the fallow land presented using the content of the physical clay, sum of particles < 0.01 mm (%); depth of the humus horizon (cm);
2. Depth of the soil profile (cm). The characteristic is evaluated only on shallow soils, developed on hard rock with the depth of the hard rock till 50 cm (root area).

3. Texture differentiation of the profile described using the texture coefficient. The ratio of the amount of the clay content (per cent amount of the sum of the particles with size <0.001 mm) in B horizon to the amount in A horizon.
4. Soil reaction (pH in H2O).
5. Organic content – humus (%).
6. Groundwater level (cm). The soil texture is also included in the evaluation of this characteristic (Georgiev, 2007; Krasteva, 2002; Mitreva, 2008). Using this characteristic the following characteristics are taken into account: the influence of the capillary rise of the groundwater, the conditions of marshiness, overmoisture or beneficial use of the groundwater.

Seven rating scales are developed, for individual rating of each one of the enumerated characteristics. (Rating scales with consecutive numbers 1 to 7) are presented below in Tables 1-7.

Table 1. *Evaluation (Btx) of the soil texture in fallow land (Tx)*

Tx (sum of particles < 0.01mm %)			Btx (ratings*)
	<=	5	0
5	÷	10	10
10	÷	20	30
20	÷	30	70
30	÷	45	90
45	÷	60	100
	>	60	70
* At the end the values are multiplied by 2			

Table 2. *Evaluation (Bthh) of the depth of the soil humus horizon (Thh)*

Thh (cm)	Bthh (ratings)
1 - 20	40
20 - 40	80
> 40	100

Table 3. Evaluation (Btsp) of the depth of the soil profile (Ttsp)

Tsp (cm)	Btsp (ratings*)
<= 30	10
30 ÷ 50	30
> 50	Not evaluated
* Only for soils developed on hard rock. At the end the values are multiplied by 3.	

Table 4. Evaluation (Btc) of the texture difference coefficient (Tc)

Tc (texture coefficient)	Btc (ratings)
<=1	80
1 – 1.3	100
1.3 - 2	90
>2	50

Table 5. Evaluation (Bph) of the soil reaction (pH in H_2O)

pH (in H_2O)			Bph (ratings)
	<=	5.0	60
5.0	÷	7.5	100
	>	7.5	80

Table 6. Evaluation (Bhc) of the humus content (Hc)

Hc (%)	Bhc (ratings)
< =1.0	50
1.0 – 2.0	80
>2.0	100

Table 7. Evaluation (Bgwt) of groundwater level (Gwt) relative to soil texture.

↓ Gwt (cm)	Range Tx (%)				
Bgwt (rating)↘	< =20	20 ÷ 45	45÷60	>60	
< = 50	50	30	10	0	
50 ÷ 100	90	70	40	20	
100 ÷ 200	100	100	100	80	

In the presented scales for individual rating of soil characteristics the principles of the officially accepted methods are applied (Petrov et al., 1988). Because of the similarities of the requirements of the crops the scales are created for both of them. When groundwater rating is not evaluated because it is below 200 cm and therefore is not a limiting factor it is calculated in the equations with a rating of 100. The ratings are in a range of 0 to 100 rating grades. The optimal values of the characteristics receive a maximum grade; the restrictive values receive a lower grade. When the conditions are extremely unsuitable the grade becomes zero. When one of the grades is zero the entire soil rating equals zero. In shallow soils developed on hard rock the rating task is solved using Equation (1). In deep soils the rating task is solved using Equation (2).

$$SR = \frac{2Btx + Bthh + 3Btsp + Btc + Bph + Bhc + Bgwt}{10} \quad (1)$$

$$SR = \frac{2Btx + Bthh + Btc + Bph + Bhc + Bgwt}{7} \quad (2)$$

Where

SR – soil rating

Btx – Rating for the soil texture.

Bthh – Rating for the depth of the humus horizon.

Btsp – Rating for the depth of the soil profile.

Btc – Rating for the texture differentiation of the soil.

Bph – Rating for soil reaction (pH in H_2O).

Bhc – Rating for organic content represented by humus content (%).

Bgwt – Rating for groundwater level.

The soil ratings alone cannot be used to measure the suitability of the land for growing emmer and einkorn wheat because other factors also influence the development and yield of the crop exemplified by erosion and accumulation, salinization, stoniness, climate, etc.. Taking into consideration the influence of these characteristics leads to field ratings of the whole land which can be performed by further research.

To demonstrate the methods in Table 8 are evaluated three soil examples.

Table 8. Examples of application of the methodology

Soil code	*Indexes and values of the characteristics and ratings*							
	Tx (%)	*Thh (cm)*	*Tsp (cm)*	*Tc*	*Ph*	*Hc (%)*	*Gwt (cm)*	
KCR	*34*	*50*	*90*	*0.9*	*6.8*	*2.1*	*Deep*	
	Btx	Bthh	Btsp	Btc	Bph	Bhc	Bgwt	SR
	90*2	100	Not evaluated	80	100	100	100	94
Soil code	*Indexes and values of the characteristics and ratings*							
	Tx (%)	*Thh (cm)*	*Tsp (cm)*	*Tc*	*Ph*	*Hc (%)*	*Gwt (cm)*	
ALM	*48*	*30*	*100*	*1.3*	*4.8*	*1.7*	*120*	
	Btx	Bthh	Btsp	Btc	Bph	Bhc	Bgwt	SR
	100*2	80	Not evaluated	100	60	80	100	89
	Indexes and values of the characteristics and ratings							
Soil code	*Tx (%)*	*Thh (cm)*	*Tsp (cm)*	*Tc*	*Ph*	*Hc (%)*	*Gwt (cm)*	
KI	*19*	*20*	*20*	*0,9*	*5,5*	*1,3*	*deep*	
	Btx	Bthh	Btsp	Btc	Bph	Bhc	Bgwt	SR
	30*2	40	10*3	80	100	80	100	49

Legeng:
KCR – Calcareous chernozems, average depth.
ALM – Alluvial meadow soils, deep.
KI – Cinnamonic forest soils, shallow, low and middle eroded.
SR – Soil rating.
All indexes are from tables with consecutive numbers from 1 to 7

The calcareous chernozems with average depth receive the highest rating.

Conclusion

A method for evaluation of the main soil characteristics in accordance with the emmer wheat and einkorn wheat requirements is suggested. The method is harmonized with the officially accepted in Bulgaria parametric methods that comprise the system of field ratings and categorization of the agricultural lands. The end result is a rating of the soil characteristics, i.e. soil rating. Further algorithms for erosion or accumulation of the soil, stoniness, salinity level and climate can be added in further research to reach a full field rating and then the method developed can be used for evaluating the land suitable for growing emmer and einkorn wheat.

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