Black Soils Agroecological Monitoring for Russia Export Potential Development in Durum Wheat
Агроэкологический мониторинг чернозёмов для развития экспортного потенциала России по твёрдой пшенице

Ivan I. Vasenev, Turmushbek M. Dzhanchorov, Mikhail Ju. Kurashov, Alexey M. Yaroslavtsev

Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, Moscow, Russia, vasenev@rgau-msha.ru

WSD, Sochi, 6 December 2019
Why we need to do this especially in the Black Soil regions of Russia?

- While globally projected climate changes will result in most crop yields general decline, Russia benefits from warming due to an increasing of growing season and generally more mild climate conditions.

- Growing RF agricultural potential will be strengthened due to durum wheat production increasing in the Middle Volga and Southern Ural Regions with mostly favorable agroecological conditions.

- High spatial variability of land quality, intra- and inter-seasonal dynamics of soil moisture often create the serious agroecological problems.

- Especial attention by successful agricultural business to the best available technologies and crop yield prediction

- Growing demand in land agroecological quality evaluation due to sharply increased input risks value in case of intensive farming

- Current high variability of durum productivity levels: from 35 to 7-5 dt/ha within one region

- High within-field crop yield variability (40-75%) due to complicated soil cover patterns in frame of 50-200-ha fields

- Consequences of the aggregated soil degradation in frame of the universal land-use systems dominated in XX century
The geography and volume of soft wheat world production is much wider than durum one.

- Soft wheat: ~95%
- Durum wheat: ~5%
Main countries of the durum wheat production: Italy, France, Canada, USA, Mexico, Turkey, Morocco and Algeria, mln t

In comparison with soft wheat, Russia is not the world leader in durum wheat production, Russia's share in global durum wheat production is less than 2%.

Source: IGC, Grain Union of Kazakhstan
Main countries-exporters and importers of durum wheat

1) North American countries are the main exporters of durum wheat.
2) The countries of the Mediterranean basin are key importers.
3) Russia is not a key player in the global durum wheat trading market, being the No. 1 country in the export of soft wheat.
4) Kazakhstan exports almost the entire volume of durum wheat and is becoming one of the key players in the region.

Source: IGC, Grain Union of Kazakhstan
GOST (R 52554-2006) and the main global requirements of pasta manufacturers

<table>
<thead>
<tr>
<th>Параметры</th>
<th>Классы зерна</th>
<th>Требования производителей пасты</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Количество сырой клейковины, %</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>Количество белка, % в с.в., не менее</td>
<td>13,5</td>
<td>12,5</td>
</tr>
<tr>
<td>Количество зерна других видов, %, не более</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Число падения, сек., не менее</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Натура, г/л, не менее</td>
<td>770</td>
<td>745</td>
</tr>
<tr>
<td>Стекловидность, %, не менее</td>
<td>75</td>
<td>70</td>
</tr>
<tr>
<td>Качество клейковины (индекс глютена)</td>
<td>Не регулируется Российским законодательством</td>
<td>Зависит от методики</td>
</tr>
<tr>
<td>Индекс цвета &quot;b&quot; Минольта</td>
<td>Не регулируется Российским законодательством</td>
<td>22</td>
</tr>
</tbody>
</table>

1) **According to most parameters, the grain should correspond to class 1 and 2, but there is very little such quality grain in Russia.**

2) **The two most important parameters for the production of pasta: gluten Quality and color Index "b" (Minolta) - are not regulated by Russian legislation.**

3) **Most durum wheat producers in Russia are not familiar with these parameters, which negatively affects the interest in Russian durum wheat on the world market.**
Russia has great potential to increase domestic production of durum wheat, as well as its exports

**What does exist for this**

- Favorable climatic and soil conditions in various black soil regions of Russia
- The use of "Glyphosate" before harvesting is not as common as in North America
- Fusarium head blight and as a result the mycotoxin DON are not so common for durum wheat
- Short distance to the world's main import zones – the Mediterranean countries, in comparison with the countries of North America

**What needs to change**

- Developing the official statistics on durum wheat production by the RF Ministry of agriculture and Rosstat
- Selection of durum wheat varieties, targeted at improving the gluten quality and color index, as well as selection of durum wheat low-stem varieties resistant to lodging
- Simplification of the procedure for registration of durum wheat new varieties
- When registering a new variety of the durum wheat, take into account also its qualitative characteristics (gluten quality and color index)
- The inclusion in the RF standard of the durum wheat it’s parameters measured in the countries importing the durum wheat
- [Agroecological DSS development for durum producers support](#)
Middle Volga and Southern Ural Regions of Russia

What actual agroecological problems we have in case of these Chernozems with rich SOC stocks?
Objects and methods. We study dominated in these regions of Russia Black Soils’ (Typical, Ordinary and Southern Chernozems) potential for durum wheat sustainable production in 2018 and 2019. GIS-based land quality analysis combining with agroecological monitoring in the representative plots with different combinations of durum varieties, bioclimatic regions and farming practices were used for cloud-based DSS development.
The observed and predicted (by DSAAT) winter wheat growth rate and yield values in at the RSAU Field Experimental Station in 2017 (Pivchenko, Meshalkina, Vasenev, 2018)

Model describing the growth of wheat plants from the beginning of intensive vegetation to flowering phase

\[ y = 1.4015x - 60071 \]
\[ R^2 = 0.95 \]

\[ y = 1.4263x - 61135 \]
\[ R^2 = 0.9789 \]

The observed and predicted yield values (t/ha)

Observed and predicted values of plant growth by DSSAT ($R^2=0.94$) for different development phases

[Graphs showing observed and predicted values for till and no-till conditions]
Agroecological modeling of wheat potential yield dynamics (Savin e.a., 2016)

**PAR and T limiting factors**

**Negative effect of soil available water limiting factor**

**PAR and T and soil available water limiting factors**

**Land agroecological evaluation for spring wheat**
% change of Annual Precipitation Amount in the medium term
2006-2050 vs. 1961-2005

RCP 4.5

RCP 8.5

(CMCC and RTSAU – R. Valentini, I. Vasenev, 2015)
Crop potential yield calculation with 2-nd limiting factor (water supply)

- \[ Y_{jw} = 10^5 \times W_j / (K_j \times L_j \times (100 - \varepsilon_j)) , \]
where \( K_j \) is the water consumption coefficient, \( mm \, dt^{-1} \, ha^{-1} \) (bio-production).

- The calculations use the adapted to the region conditions pedotransfer functions of productive moisture seasonal dynamics - depending on the seasonal distribution of precipitation, evaporation and traditional balance.

The average annual precipitation is 644.0 mm

![Precipitation Graph](image)
Mean seasonal cumulated precipitation: century → decade
Seasonal cumulated precipitation: mean for last decade and 2018
Seasonal cumulated precipitation 2018 vs decade average: Southern Ural and Volga regions

Red line – 2018, Blue line – decade average
Mean seasonal dynamics of air temperature: century → decade → 2018
Daily precipitation 2018 vs decade average: Southern Ural and Volga regions

Red line – 2018, Blue line – decade average
Daily precipitation 2018 vs decade average: 2 Volga regions

Red line – 2018, Blue line – decade average
Comparative analysis of the four investigated durum wheat varieties quantity and quality in Saratov, Samara and Orenburg regions shows principal regularities of their spatial distribution in conditions of very dry summer.

**Average yield per variety per plot**

![Graph showing average yield per variety per plot with whiskers indicating 95% confidence interval.](image)

*Whiskers show 95% confidence interval*
Maps of pH (H$_2$O) as limiting factors for 3 1-ha field plots in the representative sites with Haplic Chernozems in Saratov, Samara and Orenburg regions (April, 2018)
Average protein yield per variety per plot

**Diagram Description:**

- **Title:** Average protein yield per variety per plot
- **X-axis:** Variety (Annushka, Gordeya, Luch, Zolotaya)
- **Y-axis:** Protein, t/ha
- **Legend:**
  - Red: Orenburg
  - Green: Samara
  - Blue: Saratov
- **Graphs:**
  - Traditional
  - Intensive
- **Note:** Whiskers show 95% confidence interval.
Principal component analysis shows clear agroecological differentiation of 3 regional groups of samples with almost independent segmentation of durum yield and gluten quality factors (the most stable in Orenburg).

1 - Orenburg 2 - Samara 3 - Saratov (first number); 0 - Traditional technology, 1 - Intensive technology (second number)
Crop varieties and applied technology have been separated only at the subgroup level. More intensive technology allows decrease the level of regional and varietal differentiation.
Average raw gluten content per variety per plot

Whiskers show 95% confidence interval
Significance level correlogram shows the dominated role of precipitation for durum yield prediction that can be especially typical for extremely dry growing season. At the same time durum quality has additional set of predictors including soil limiting agroecological factors.
Clustering correlated variables

Red means negative correlation, blue - positive, white - no correlation. Lines show euclidean distance in cluster analysis.
In the interactive map you can choose the closest meteorological station to your fields, which represented by color dots.

Choose meteorological station closest to your field

<table>
<thead>
<tr>
<th>Climates condition</th>
<th>Field features</th>
<th>Resulting yield</th>
</tr>
</thead>
</table>

This is climatic conditions in your area according to closest weather station, if you are sure that you have more precise data, fill free to enter it.

<table>
<thead>
<tr>
<th>Precipitation sum per month, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
</tr>
<tr>
<td>16.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sum of active temperatures(above 5 C), C</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sum of active temperatures(above 10 C), C</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>
In the interactive map you can choose the closest meteorological station to your fields, which represented by color dots.

In the tab “Climatic condition”, after clicking on any meteorological station all fields will be updated according to data from this station (averaged for last decade).
In the interactive map you can choose the closest meteorological station to your fields, which represented by color dots.

In the tab “Climatic condition”, after clicking on any meteorological station all fields will be updating according to data from this station (averaged for last decade).

If you have more precise data for your site feel free to enter it in any field.
In the tab “Field features”, you should enter prevailing exposition, maximal slope and soil type specific for your field.
In the tab “Resulting yield”, you can different predicted yields:

**Yield according to obtained PAR** – yield prediction taking into account only PAR calculated from active temperatures, with assumption that precipitation and field features was ideal

**Yield according to precipitation limitations** – yield prediction taking into account PAR and precipitation, with assumption that field features was ideal

**Yield according to precipitation and soil limitations** – yield prediction taking into account PAR, precipitation and field features
Conclusions.

Developed basic element of the DSS for agro-ecologically based choice of best available land, durum wheat variety and agro-technology version, regional agro-climate GIS allows to calculate the durum wheat yield taking into account the principal land characteristics and one from three versions of the DSS algorithms: Yield according to local PAR, Yield according to precipitation limitations, Yield according to precipitation and soil type limitations, that becomes more and more interesting for innovative land-users in the steppe zone at the European territory of Russia.