WHEAT YIELD IN MAGNETIC ANOMALIES AND BEYOND THEM

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Abstract

Ambiguous, sometimes contradictory conclusions follow from literary sources related to magnetic fields effects on wheat yield. There are statements on positive effect of short-term magnetic field increase on root system development, statements on close direct (sometimes reverse) yield dependence on natural changes in the magnetic field by hundredth-thousandths of per cents. Yield decline in areas of significant positive magnetic anomalies, for example, in Kursk magnetic anomaly (*KMA*), is explained by open ore mining which led to a drop in groundwater levels by tens to hundreds meters. To assess impact of significant anomalies on yield, we analyzed regions not so prone to anthropogenic declines in groundwater levels – Bryansk, Kaluga and Orel regions, north-east parts of Kharkiv and Odessa regions with the surrounding area. It was found out that complex effect of magnetic fields (on ionization, crystallization processes, loss of ferrous compounds from solutions) causes everywhere yield declines by several times compared to neighboring areas outside of magnetic anomalies. And this is despite similarity of soil condition, orography, precipitation and agricultural efforts. Available materials on soil moisture and Normalised Difference Vegetation Index (*NDVI*) were analyzed to define the effect causes and genesis. It was found out that, in spring, soil in areas with anomaly is as moistened as in the neighboring areas, but *NDVI* pictures for anomalies are "more green" (positive effect of the magnetic field on root system development). On the contrary, by middle – end of summer, low soil moisture and gray *NDVI*, and also yield declines are observed. For irrigated fields, yields are much higher everywhere.

Keywords: natural magnetic anomalies, *KMA*, Ukraine, wheat yields, soil moisture *NDVI*.

Introduction, basic data

Ambiguous, sometimes contradictory conclusions follow from literary sources related to magnetic fields effects on wheat yield. There are statements on positive effect of short-term magnetic field increase on root system development [1], statements on close direct (sometimes reverse) yield dependence on natural changes in the magnetic field by hundredth-thousandths of per cents [2]. Yield decline in areas of significant positive magnetic anomalies, for example, in Kursk magnetic anomaly (*KMA*), are explained by open ore mining which led to a drop in groundwater levels by tens to hundreds meters [3].

To assess impact of significant anomalies on yield, we analyzed regions not so prone to anthropogenic declines in groundwater levels – Bryansk, Kaluga and Orel regions, north-east parts of Kharkiv (Fig.1) and Odessa regions with adjacent not abnormally highly magnetized areas of Nikolaev area and South of Moldova (Fig.2).

We used fragmentary local materials on wheat yield from reference Internet publications, reports of governors and district leaders which were generalized for the period from 2000 to 2018, for example, [4].

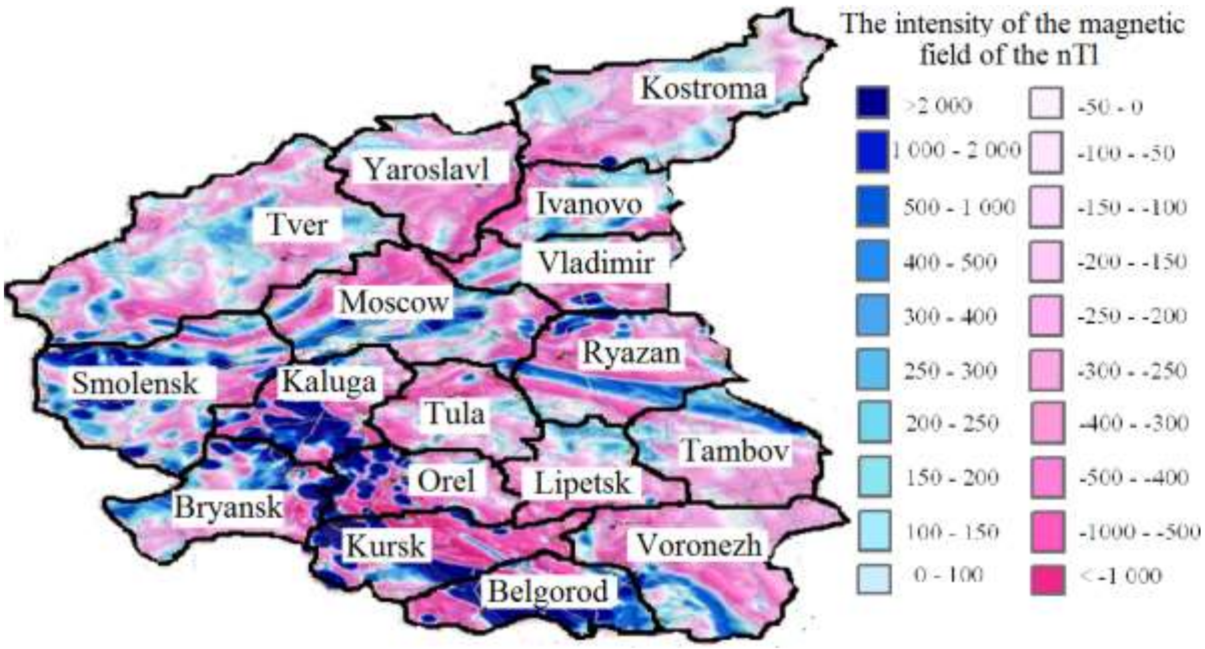

Fig. 1. Magnetic anomalies in the Central Federal district [5].

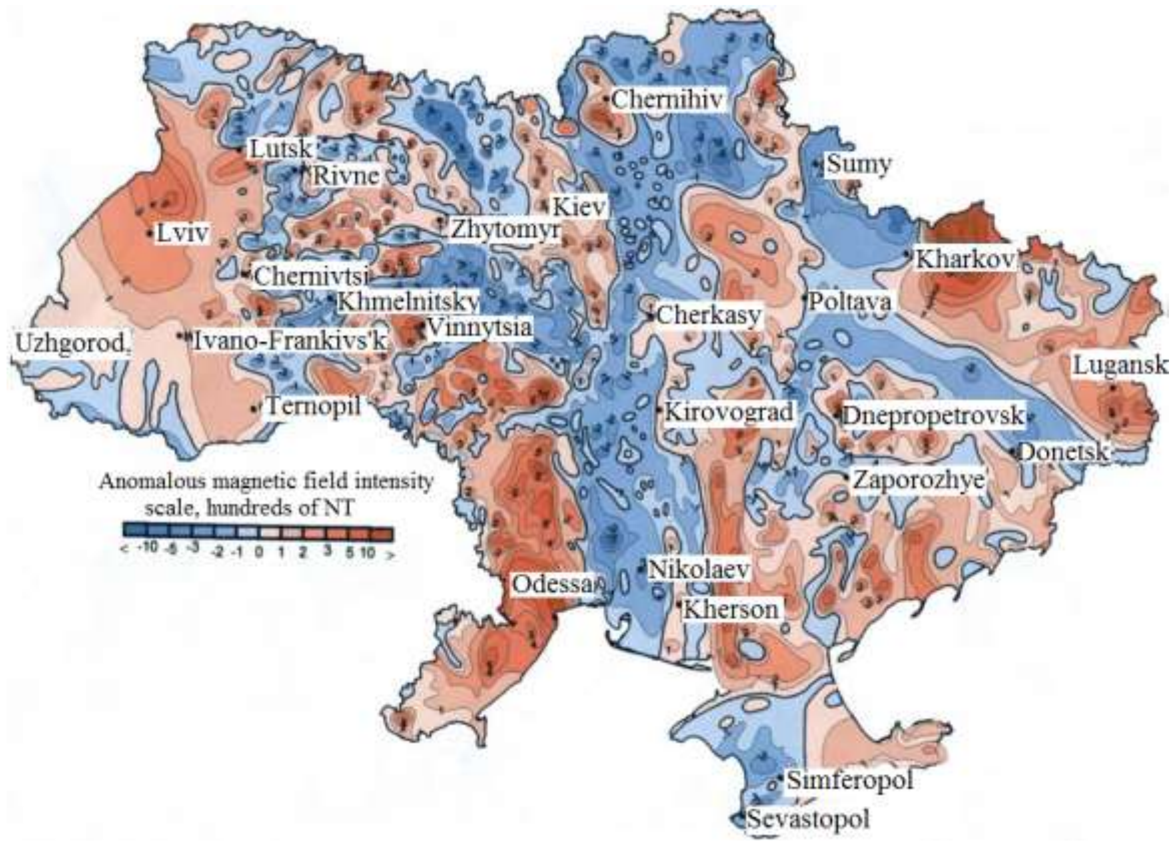

Fig. 2. Map of magnetic field anomalies in Ukraine [6].

To assess impact of natural magnetic anomalies on wheat yield, fragmental time and area data on autumn and spring wheat, maize and sunflower yields were analyzed. This was performed due to the fact that statistical collections and newspaper notes often contain only summarized data on yield of autumn and spring wheat, wheat and maize, etc. In general, it can be concluded from the analysis of the yield in the south area of Odessa region (Fig.3.4) and in the south area of Moldova (Fig.5) that grain yield is correlated with sunflower and maize yield both in time and in space [7].

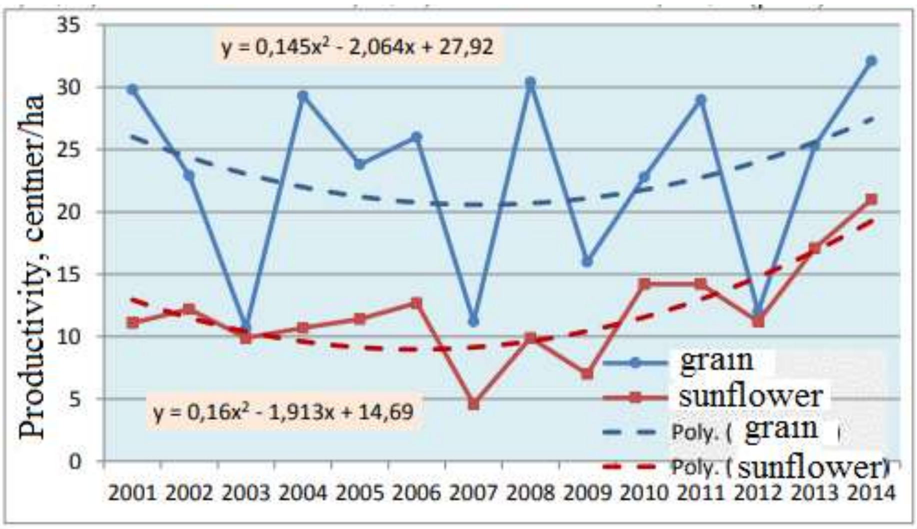

Fig. 3. Dynamics of grain crops and sunflower yield in Izmail district in 2001-2014 [8].

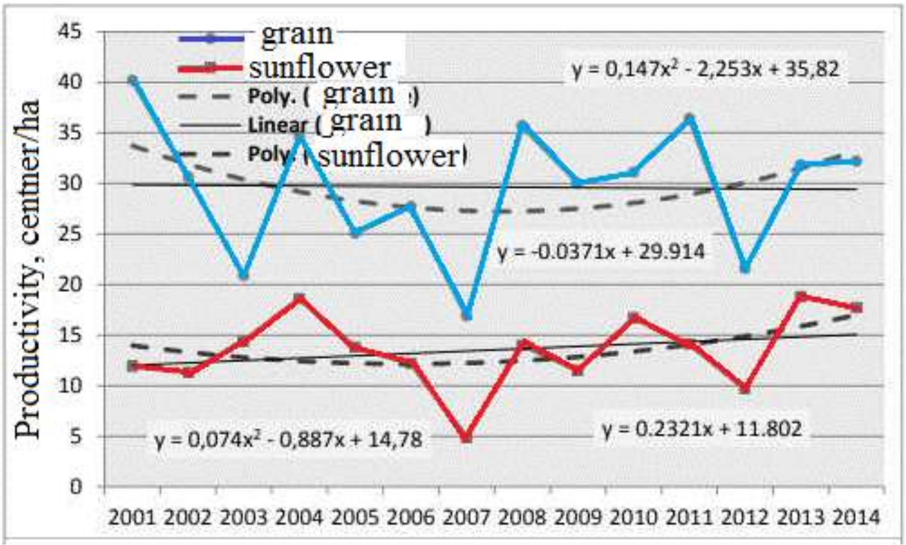

Fig. 4. Dynamics of grain crops and sunflower yield in Kilia district in 2001-2014 [8].

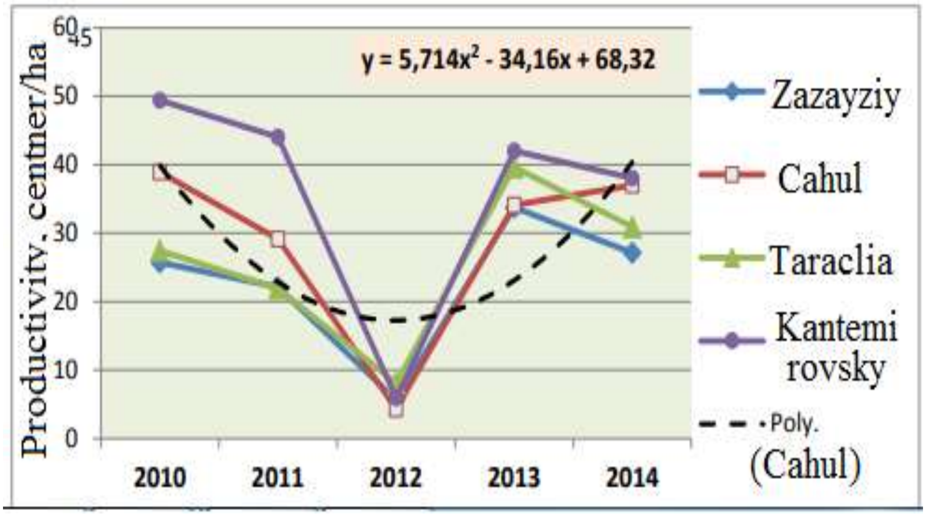

Fig. 5. Dynamics of maize yield in the southern regions of Moldova in 2010-2014 [8].

Local minima of wheat yield values in 2003, 2007 and 2009 were obtained due to dry years - local minimum of precipitation (Fig.6). Local yield minimum in 2012 was not associated with similar low precipitation level. But summer was extremely hot. After correction of the precipitation values by increased temperature evaporation, a local minimum was obtained here too.

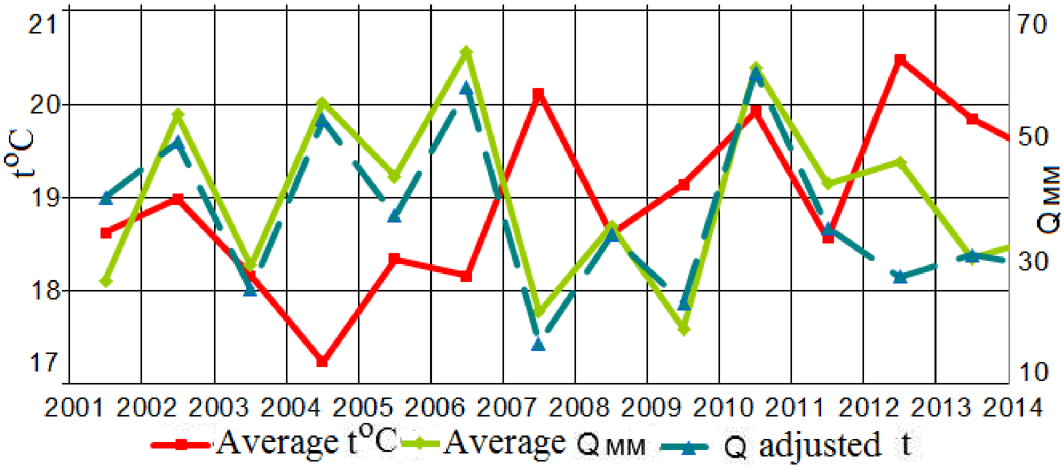

Fig. 6. Dynamics of average monthly air temperature (t) and precipitation (Q) from April to August in Odessa, and also corrected by t values (increased evaporation).

From the scope of remote sensing data, current and averaged maps of *NDVI* vegetation and soil moisture indices according to passive and active radiometry data were used.

Overlapping of grain yield maps on magnetic anomaly maps

Values of yield in south-west of the Central Federal district and in north of Kharkiv regions for 2001-2018 were divided into 5-7 levels-gradations for each regions (to take into account difference of soil properties, moisture, etc. for regions). We did not select specific values of the yield levels due to interannual and weather variations, difference of anthropogenic efforts (change of seed, fertilizer and pesticides application, machinery use, etc.). It was found out that there are areas in each region which are always foremost, and others are always lagging. Overlapping of magnetic anomaly maps to the scheme of grain yield gradation shows that low local yields are characteristic for the vast majority of places with abnormally high magnetic field (Fig.7). Some discrepancies may be due to the fact that the area of magnetic anomalies is less than 1/3-1/4 of the district areas and vanishes at averaging. Information is not provided in this form for regional administrators. As a result, for example, Belgorod governor does not understand a reason for 2.5 times difference in the yield values between the regions: "I suppose, there is something to think about for both lagging areas, their leaders and specialists who work in agriculture" [9].

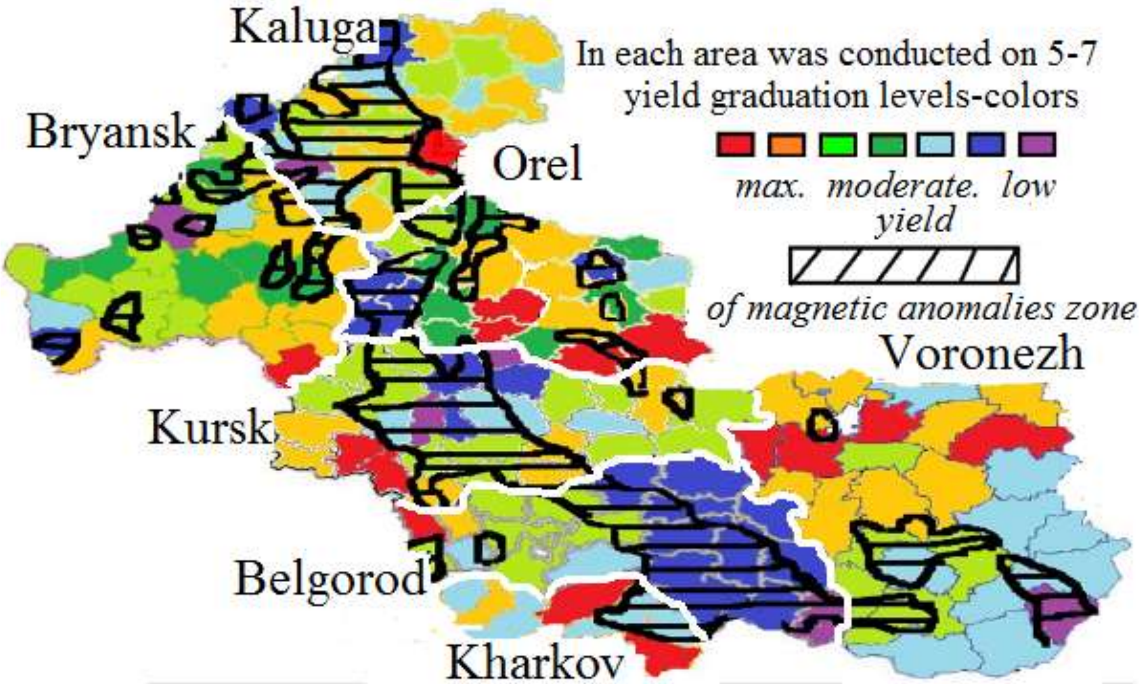

Fig. 7. Overlapping of magnetic anomalies and grain yield in south-west areas of Central Federal district and in north areas of Kharkiv region.

In general, a similar situation is observed in Odessa region. Minimum crops are produced in the central and northern areas of the region, over the magnetic field anomaly. High yield were reached in the neighboring non-anomalous north-west and south-west areas of the region, in the adjacent areas of Mykolaiv region and south of Moldova (Fig.8). Chairman of the regional administration believes that there is no reason for twice decline in grain yield in central and northern areas of the region in comparison with the neighboring ones and he says with indignation "I think something is wrong here!" [10].

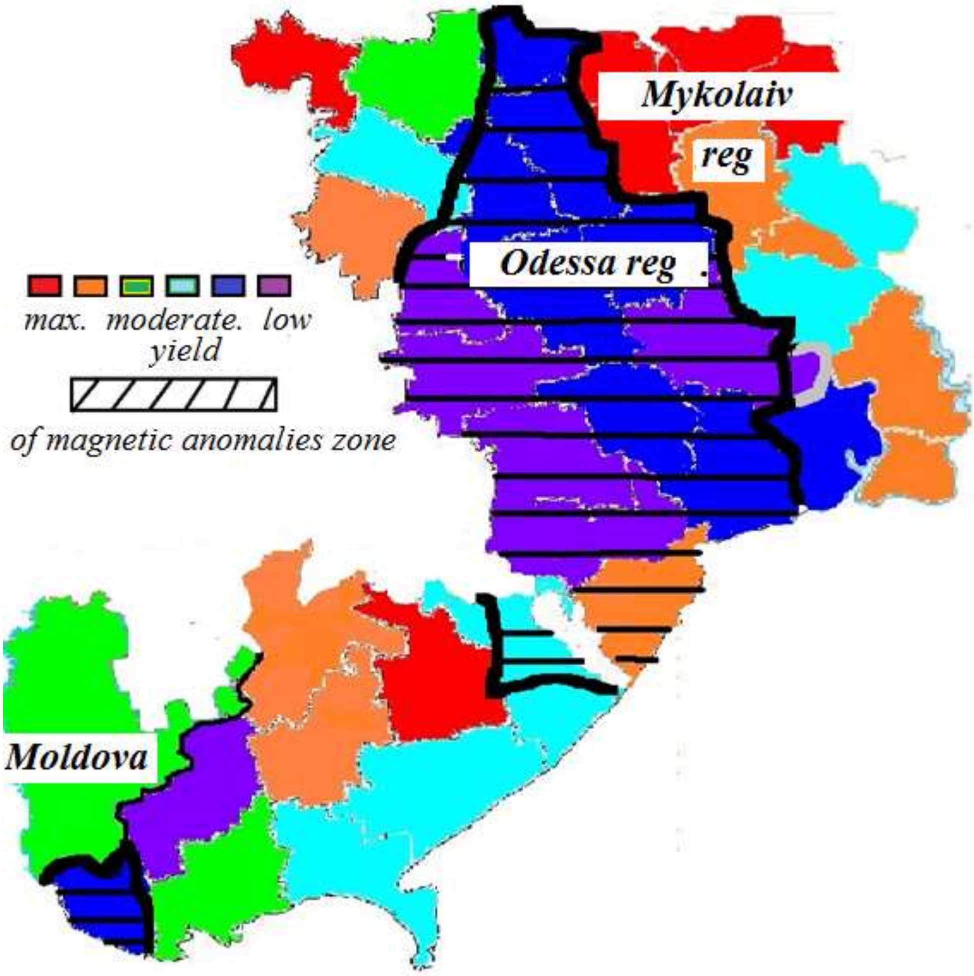

Fig. 8. Overlapping of magnetic anomalies and grain yield in the areas of Odessa region and in west of Mykolaiv region and south of Moldova.

In May, values of soil moisture at *KMA* and in the center of Odessa region are similar to the background (Fig.9.a.). In June 2007, *NDVI* vegetation index values in the territory of the anomalies under consideration are close to the background values (*NDVI* is not less "green"), and even higher by 0.1-0.3 ("more green") that background (Fig.10.a). Apparently, this is the effect of the magnetic field on root system development. In July, on the contrary, soil moisture values are lower by 0.05-0.1 in the anomalous zones if compared with areas beyond the anomalies, *NDVI* values are less than the background ones by 0.1-0.3 (*NDVI* values are more "gray") (Fig.9.b, 10.b) [11].

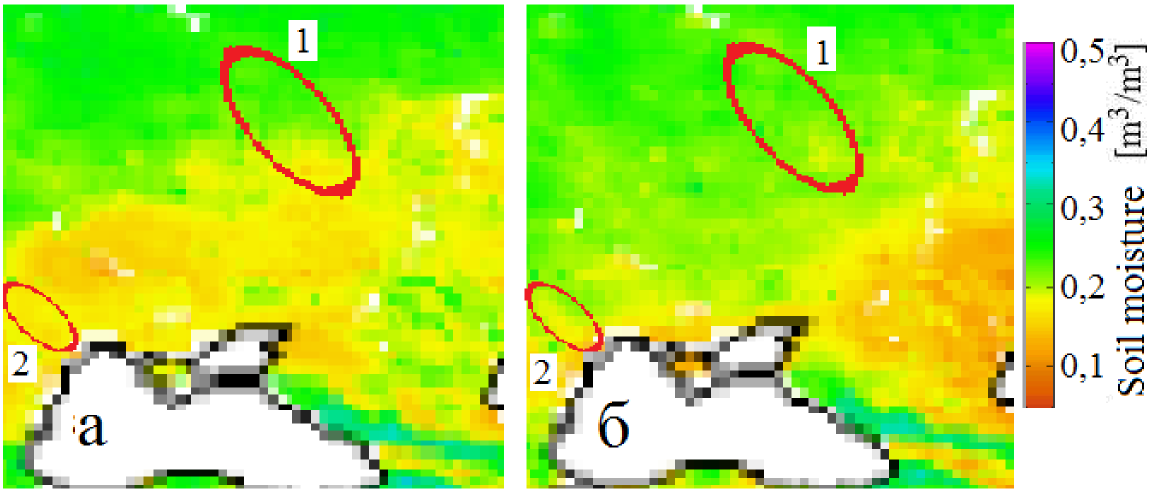

Fig. 9. Average soil moisture obtained from a combination of six active and passive sensors in the period 1979-2010, 1 - *KMA* region, 2 – magnetic anomaly in the center of Odessa region (a – May, b – July) [12].

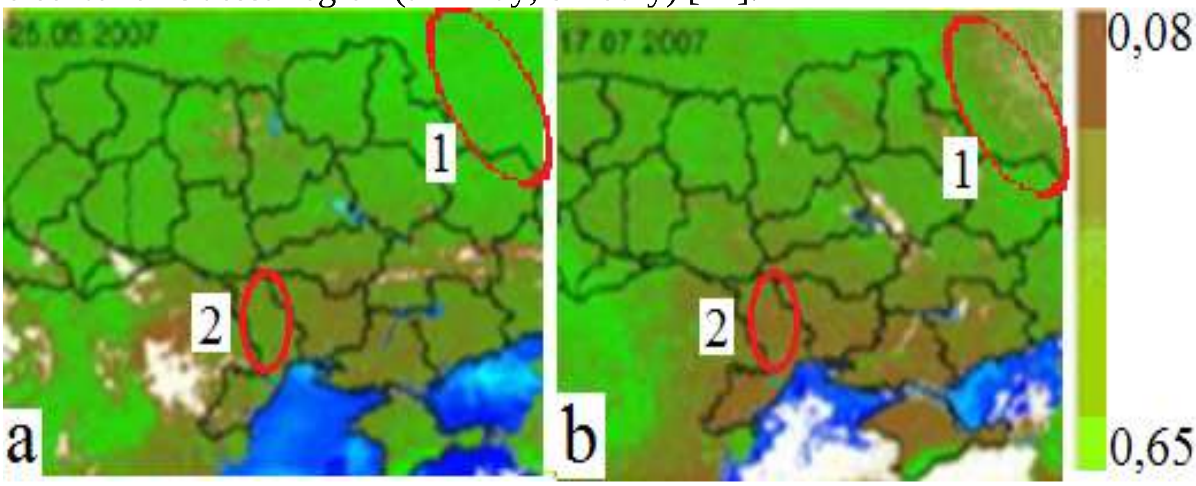

Fig. 10. Vegetation index in Ukraine in 2007, 1 - region near *KMA*, 2 – magnetic anomaly in the center of Odessa region (a – June, b – July) [13].

Analysis of regional maps of soils and agro-climatic resources does not show similar local areal anomalies (Fig.11). In the center of Odessa region, considered environment parameters are identical to those in west of Nikolaev region. In the area of Odessa, they are identical to parameters of south-west part of Odessa region and south-west part of Mykolaiv region.

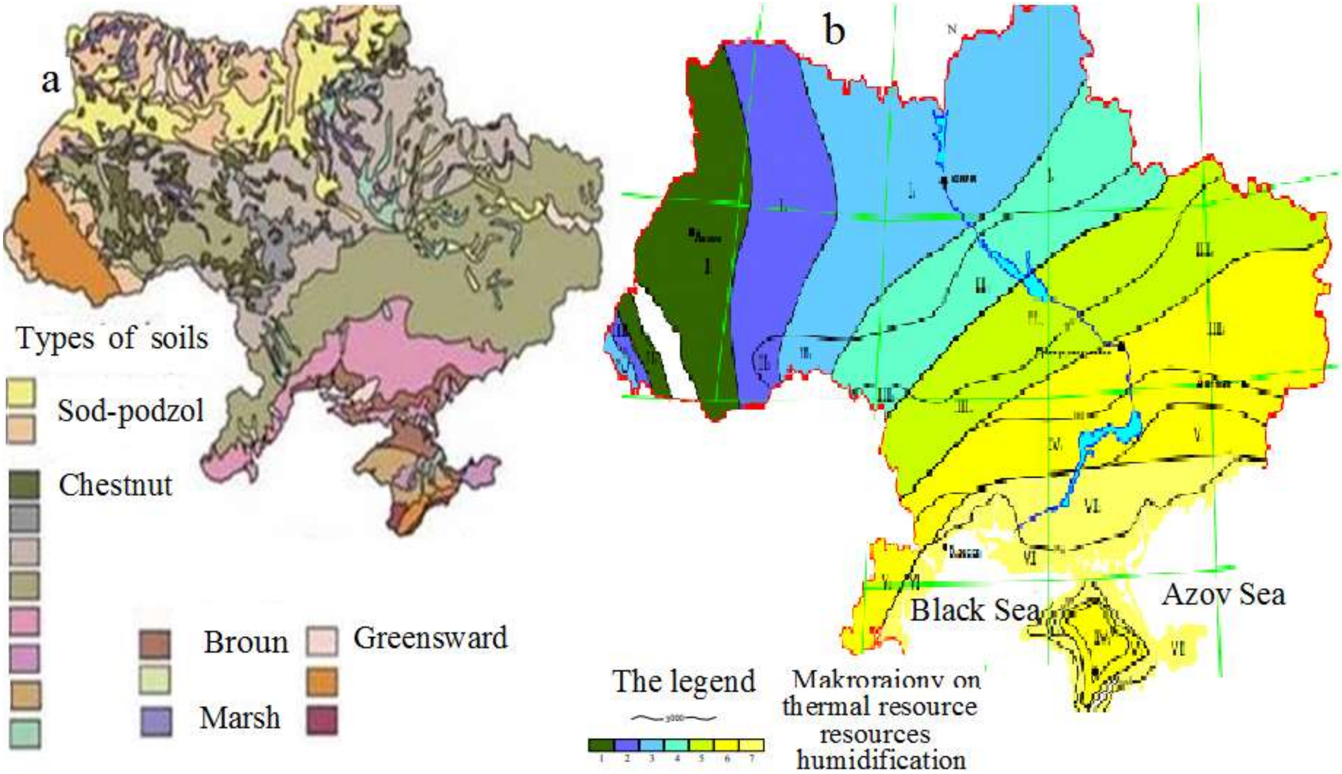

Fig. 11. Soil map of Ukraine (a) [14]. Complex map of agricultural and climatic resources of Ukraine. Isolines show zoning by thermal resources, color – moisture resources [15] (b).

Similar results were obtained in the analysis of operational data. At the end of April, soils of Kursk, Belgorod, Tambov and Tula regions are not sufficiently moistened (Fig.12.a) [16]. In September, local soil moisture minima are observed in north part of Kursk and south part of Belgorod regions, as well as in north areas of Bryansk and Kaluga regions – in the areas of magnetic anomalies (Fig.12.b).

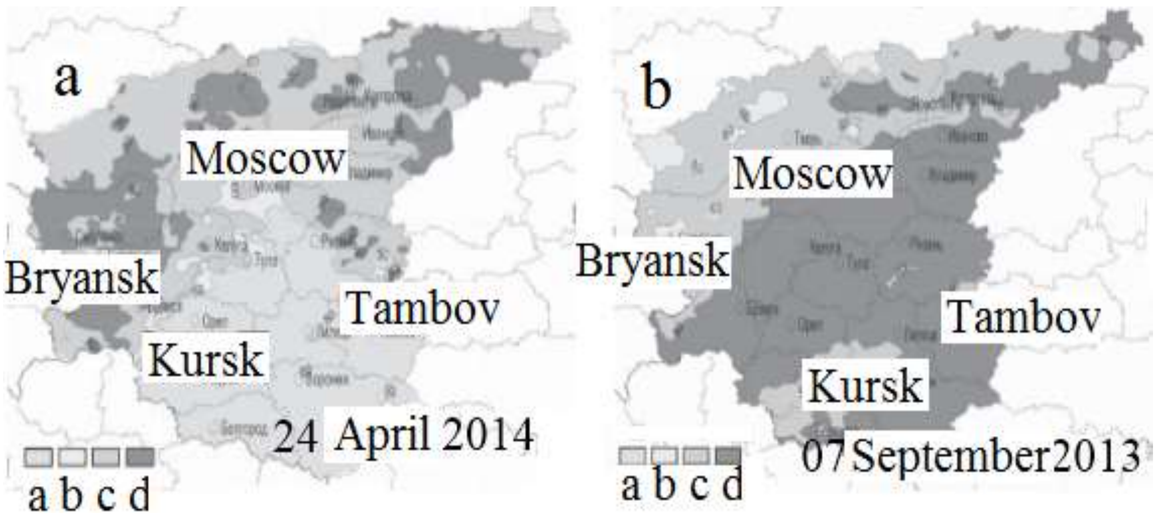

Fig. 12. a - relative humidity of the topsoil according to ASCAT (*MetOr-A* and *MetOr-B ESVs*) for 24/04/2014. *a* - <50% *soil moisture*; b – 51-60% *soil moisture*

(insufficient moisture); b – 51-81% *soil moisture* (optimal moisture); g - ≥80% *soil moisture* (overwatering). b - data for 7/09/2013.

Finally, soil moisture and magnetic fields in Europe (Fig.13) were mapped. In the spring, near the border of Germany and Denmark and in north-east area of Poland (similarly to Odessa and *KMA* anomalies), soil over the magnetic anomalies is as moistened as in the surrounding area. In the Czech Republic and in the center of Poland moisture falls over anomalies by ≈20-40 mm (Fig.13.a,c). By middle – end of summer, soil moisture is 40-80 mm less that background values everywhere in magnetized areas (Fig.13.b,c).

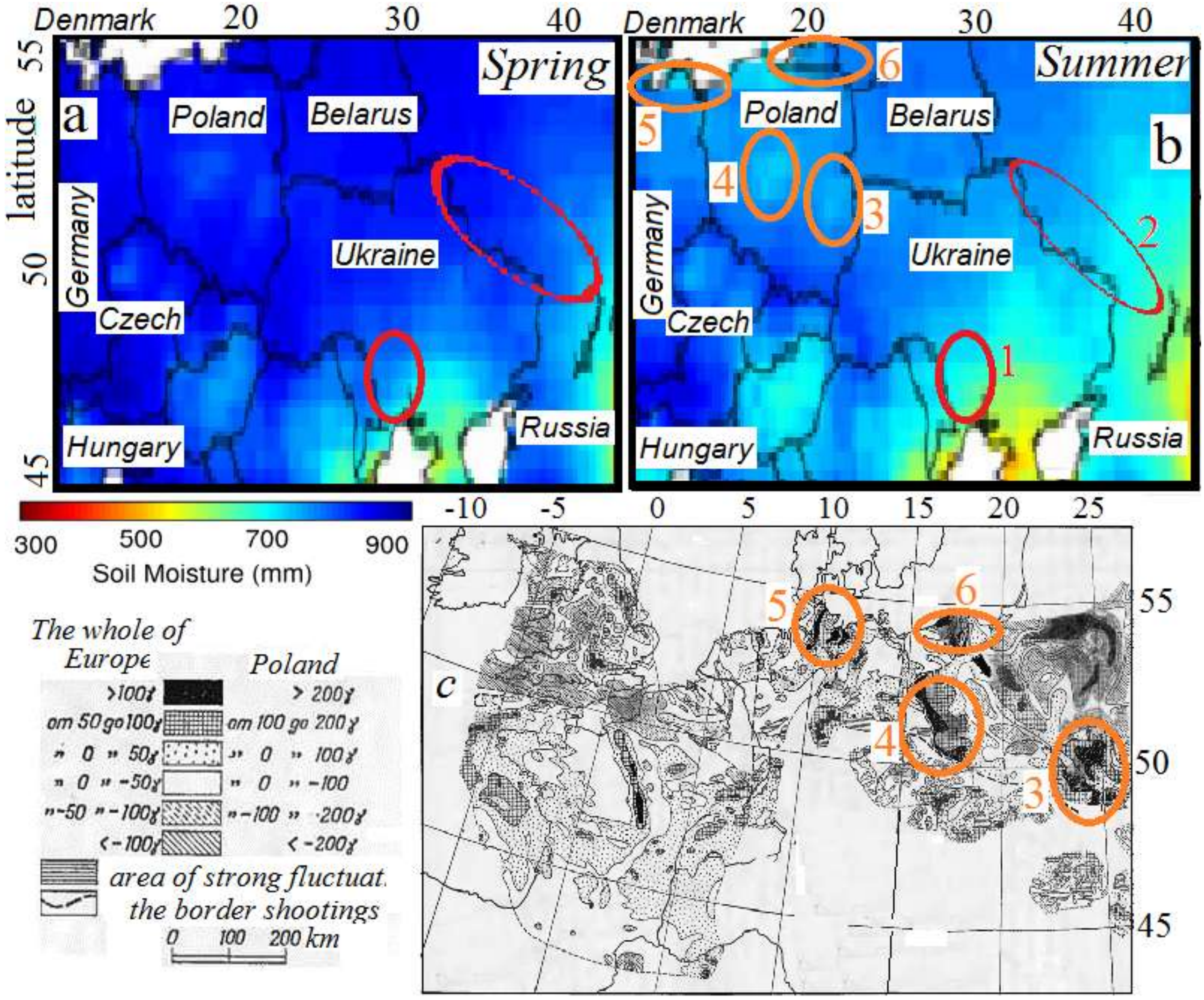

Fig. 13. Assessed values of soil moisture in spring (a) and summer (b) for 1984-2013. [17] ellipses designate areas of increased magnetic field anomaly. 1 – in the center of Odessa region; 2 – *KMA*; 3,4 – in Poland, 6 – at north-east border of Poland; 5 – at the border of Denmark and Germany. Magnetic anomalies in Europe (50γ isolines (for Poland - 100γ) (c) [18].

Insufficient amount of moisture in the soil significantly reduces grain yield. In dry years, the yield in irrigated areas exceeds the yield in non-irrigated areas by 3 or more times [19-21]. Values of grain yield in Russia and Ukraine are traditionally compared with the yield in Germany. As a rule, the yield in the latter is several times higher. One of the reasons for this is continental climate; in Germany, amount of precipitation is 1.5-2 times more.

Conclusions

Anomalous magnetic fields lead everywhere to yield decline by several times compared to neighboring areas where there is no significant magnetic anomalies. And this is despite the similarity of soil condition, orography, amount of precipitation and anthropogenic efforts.

After snow melting and spring rains, the soil over the magnetic anomalies is as moistened as in the surrounding area, but *NDVI* anomaly pictures are "more green" (effect of the magnetic field on root system development). On the contrary, by middle – end of summer, low soil moisture and gray *NDVI* are observed, and yield declines. Magnetic ionization causes formation of local humidity minima not only in the atmosphere, but also in the soil – drying by evaporation of more rapidly growing vegetation.

To partially minimize losses in grain yield in areas with abnormally high magnetic field, it is expedient to provide for irrigation or to change agricultural culture, including arrangement of the coniferous plots, or airfields, wind turbines, solar power plants, transmission lines, various training ranges, etc. The above listed has been repeatedly fragmentary studied and described but it is not properly brought to the administrative staff, including governors

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