The Impact of Landscape Conditions Upon the Grain Crops Productivity

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Abstract: This paper presents results of long-term monitoring over the yields of small grain crops in the agricultural landscape of terminal moraine hills. We highlight the correlation between the varied in scale structures within the landscape such as particular slopes, their morphological parts (elementary geochemical landscapes), soil phases and space fluctuations and productivity of winter rye and spring barley with grass underseeding. It is ascertained that barley has a significantly more pronounced reaction towards variations in landscape than that of the winter rye. Also there was identified a range of measures geared at optimizing the processes in growing those cultures in different landscapes.

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Introduction.

To efficiently grow agricultural crops it is imperative to understand the factors that determine their productivity formation in various landscapes. Productivity of the plants is the main manifestation of their adaptive reactions towards the landscape environment and various field and in-house methods are used [1-3] to study those. The data acquired allows to develop naturally adaptive technological systems of cultivating crops to assist with increasing their productivity and stability on the one hand and diminishing degradation in the agro-landscape itself on the other.

Spring barley is a major food, forage and technical crop. Its grains are used as a concentrated feed for cattle of all types. Barley hay surpasses that of rye and wheat in its nutritional values. Cattle feed on steamed barley very well. Winter rye is a traditional food crop of temperate zones and is characterized by a significant ecological resilience. Rye flour is used to make various types of breads, which are a stand-out in their energy content as well as great taste. Rye grains are also used for spirit and starch production. Quite a few research [4-7] were devoted to the development of methods of increasing grain crops productivity, however the correlation of uncontrolled landscape factors and the conditions of their growth are yet to be studied in further detail [8].

The conjoint research into the response of winter and spring cultures towards identical landscape conditions enables to better establish the principles of allotting crops within a farm.

Methods. Adaptive reactions of the winter rye cultivar “Dymka” and nurse barley of “Abava” cultivar to the landscape conditions of the terminal moraines ridge were researched at the agro-ecological station of the All-Russian Research Institute of the Reclaimed Lands, which were described in detail in the literature [1-3, 9]. It was established in 1996 4 kilometres east of Tver on the landmass of 52 ha. The station is situated within a hill with a relative height of 15 m, consisting of inter-hill depression (north and south), southern slope 3-5□ steep, flat top and northern slope 2-3□ steep. The topsoil is a variation mosaic of sod-podzol soils with degrees of moisture developing on binomial deposits of various degrees of thickness. The southern slope is characterized by predominance of sandy and sabulous soils, whereas the northern slope is dominated by their light-loamy phases.

The grain crops were studied at the agro-ecological transects – narrow fields 1300m long, which were divided into lengthwise parallel strips and each sown with a specific culture of the crop rotation. Up to 2001 the research was conducted on two transects and through to the present time just on one transect.

Transects cross all the main micro-landscape positions of the terminal moraine hill – transitional-accumulative elementary geo-chemical landscapes (EGL) of inter-hill depressions and of lower parts of slopes, where accumulation of moisture and nutritional substances prevail, transitory areas of central parts of slopes, characterized by the lateral flow of moisture, alluvial-transitory areas of the top parts of slopes where along with the lateral flow of moisture there can be seen some vertical leaching of the soil profile as well as alluvial-accumulative EGL at the flat top. Where along with the vertical (downward) flow of moisture there can be also seen its accumulation in the micro-depressions.

The soil-landscape conditions of transects vary – 52% of the first transect area, which crosses central highest parts of the agro-landscape, are situated at the hill top. Sloping micro-landscapes here take up 30% of the area, inter-hill depression 18%. The first transect is characterized by a relatively ill-expressed ruggedness of the terrain (V(%) = 22.5) and insignificant area of the gley (highly waterlogged) soils (15%), whereas weakly gleyed phases account for 28.5%. The second transect runs along the edges of the hill and is characterized by a more pronounced dissection of the land (V(%) + 41%). There is a prevalence of sloping (57%) and lower ground (24%) areas here. There is a larger proportion of gleyed soils (60%) and less weakly-gleyed soils (12%).

The monitoring of the yields was conducted over the period of 4 years in the testing spots 40m apart from each other and on the crops present in both transects at the same time. This research will present the results of the three-factor dispersion analysis calculated using the non-organized repetition method. It establishes the correlation of the varying calibre landscape structures such as slopes of different exposition (northern and south) (A), micro-landscape peculiarities of the terrain (of the EGL type) (B), the degree of soil moisture content (weakly gleyed, gleysolic and gley) (C) and their combinations over productivity of a specific culture within each transect. The degree of the impact of factors over the yields was determined according to N.A. Plokhinskiy method dividing a specific factorial sum of squares by the total [10].

Factor A determines the nature of the space related distribution of heat and light in the agro-landscape. Factor B reflects the main features of the soil-water regime and factor C – peculiarities of soil moisture content at a given area. The correlation of factors A and B determines the nature of the micro-landscape arrangement of particular slopes (re-distribution of heat and moisture there), A and C – of the peculiarities of the topsoil in particular slopes (soil rotation of different degrees of moisture content in different conditions of heat and light), B and C – peculiarities of topsoil of specific EGLs (the nature of soil rotation in the condition of various water regime). The correlation of ABC qualify the nature of topsoil of a particular EGL within various slopes (soil rotation in the conditions of different moisture content, light and heat exposure).

Main Part. The values of the long-term averages in the yields of the studied cultures are verifiably different. The productivity of the winter rye on the first transect came up to 2.33, and on the second transect 2.71 t/ha, barley respectively 1.07 and 1.18 t/ha. The variations in yields of a specific culture between transects are not reliable.

On the whole the productivity of the grain cultures under research depend to a great degree upon the nature of EGL alternation within the agro-landscape. And to a less degree does it react to peculiarities of the micro-landscape organization of specific slopes. Exposure factor, which underpins the distribution of heat, light and snow on the terrain, is responsible for 7% in variation of grain yields. And 3% in the yield fluctuations are accounted for by the peculiarities of alternation in space of the soil moisture zones as well as of particular soil bodies.

It was established that the structural peculiarities of the terrain on the average are responsible for over 30% of yield variations in winter rye and around 48% in yield variations of nurse barley. In the winter rye the composite impact of the exposure factor and micro-landscape organization have the most pronounced impact in the overall agro-landscape (13% of variability), in barley with the grass underseeding it is only true of the nature of the micro-landscape organization of the terrain (22%). The peculiarities of the micro-landscape organization are in general responsible for around 12% in winter rye yield variations. The exposure of the slopes as such has a much less significance upon the grain crops. And the diversity of the topsoil has the least impact upon the cultures' productivity (Table 1.).

The data in Table 1 shows that in relatively dry and less transect locations (of transect 1) the variability in the winter rye productivity depends mostly upon the nature of the moisture exchange within particular slopes. The increase in soil moisture as well as in terrain ruggedness (of transect 2) result in weakening of the exposure factor over the yield of this crop while the composite effect of the structural parts of the landscape over it significantly decrease.

Table 1. The correlation of landscape features and fluctuation of grain crops productivity (%).

Fac-tors	Barley			Winter Rye			Average for grain crops
	1 Transect	2 Transect	Average	1 Transect	2 Transect	Average	
A	4.4	12.0	8.2	6.8	3.8	5.3	6.75
B	23.8	19.0	22.0	11.9	11.4	11.7	16.85
C	1.6	6.5	4.0	1.8	3.0	2.4	3.20
AB	5.0	4.9	4.5	16.8	9.2	13.0	8.75
BC	1.4	2.2	1.8	-	-	-	0.90
AC	-	1.7	0.9	-	-	-	0.45
ABC	8.3	4.6	6.5	-	-	-	3.25
Сумма	44.5	50.9	47.9	37.3	27.4	32.4	

(-) – Absence of reliable values

Barley yields, notwithstanding the degree of terrain ruggedness and moisture content, change significantly in space alternation of EGL, which regulate the nature of the moisture redistribution on the terrain. In humid locations there was observed a sizable increase in impact over its productivity in varied thermal and photo-synthetic conditions, which are regulated by the exposure factor as well as by the hydro-morphism of the soils. Furthermore the impact of the finest structural elements of the landscape, which are determined by the combination of factors ABC, over the yields of this culture dwindles.

We also observed synchronicity in the space winter rye productivity fluctuations in both transects. The relatively high productivity in alluvial-accumulative EGL at the top, while gradually reduces down the slopes, reaches local minimal values in the transit area of the southern slope and at the bottom area of the northern. The drop in the productivity in the southern slope is accounted for by the presence of excess amount of sun radiation and insufficient moisture. On the northern slope the productivity peters out due to unfavourable winter conditions (asphyxiation).

Southern slope showed signs of simultaneous space change in productivity and nurse barley. In both transects the relatively high productivity in transitory –accumulative EGL is replaced by the minimal one in the transit in the southern slope due to the lack of moisture in this location. The maximum productivity in the first transect is observed within the alluvial-transit EGL on the southern slope, and in the second – in the alluvial-accumulative EGL of the summit. In the northern part of the station the synchronicity of space fluctuations in barley productivity is disrupted due to the significant ecological diversity between transects. The low level of underground water (UWL) in alluvial-accumulative EGL (lower than 2 m) in the first transect is a determining factor in lower productivity in this micro-landscape. And as we move north the productivity of the culture increases due to the increased soil moisture because of the elevated levels of the underground water to 1.5 m. In the northern part of the first transect the barley productivity reaches high values in the transitory-accumulative EGL (inter-hill depression), where there exists an optimal moisture content of the soil. In the second transect and in this area minimal productivity was recorded due to the excess content of the soil moisture by the underground water (UWL 0.5-0.7 m).

Results.

We can deduce that the productivity of the grains within the terminal moraine hill on the Russian plain is mostly dependent upon the factors, which underlie the water exchange in the soil and subsoil. An important role in productivity of these cultures also play redistribution of heat as well as factors of light and snow in particular slopes. The factors of redistribution of heat and exposure to light within the agro-landscape as a whole have a palpable impact upon the process of yield formation. The finest structural parts of the agro-landscape play a subordinate role in the grain yield formation.

The grain cultures cultivated in the same landscapes differ in their average productivity as well as in peculiarities of its space variability due to disparities in their adaptive reactions towards external factors. The productivity of winter rye is more than double than that of barley. It reacts to a less extent to the peculiarities of the structural elements of the agro-landscape, because most of its vegetation period falls on autumn and spring in sufficient and uniform soil moistening.

The transformation in the adaptive reactions of winter and spring crops in similar landscapes changes dissimilarly. Winter rye crop allotments in areas with pronounced terrain ruggedness and soil moisture result in decreased impact of landscape structural features upon the fluctuations in its productivity, because the slope exposure factor becomes less of a factor. Barley crop in similar conditions will yield more to the effects of the exposure factors over productivity.

To achieve maximum winter rye crop productivity in sufficiently flat and relatively dry fields it is imperative to conduct snow management on a regular basis in order to improve overwintering of the crop. In agro-landscape inundations the ground will require also tile drainage.

Barley crops need to be tended to with double management of the water-air regime of the soil (through drainage-irrigation systems). Whereby the rate of water application should match the evaporation to obtain high yields in rugged terrain with sufficiently moist soils, and in flat and relatively dry fields the level of irrigation must be even higher.

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References

1. Ivanov, D.A., 2001. Landscape-Adaptive Arable Systems (Agro-Ecological Aspects). Tver: Chudo, pp: 304.
2. Ivanov, D.A., 2012. Agro-Geography (Theoretical and Applied Aspecs). LAP

Lambert Academic Publishing, Gmbh & Co.KG, Heinish-BocKing Str. Saarbrucken, Deutschland, pp: 311.
3. Kovalev, N.G., D.A. Ivanov and V.A. Tyulin. Introduction into Agro-Landscape Science. Moscow-Tver, pp: 212.
4. Stark, J.L., 1986. T. Changes in Spring Wheat Tillering Patterns in response to Delayed Irrigation. Argon J., 5(78): 892-896.
5. Wade, L. and J. Tonks, 1986. Nitrogen and Phosphorus Pertlisen Requirements of Irrigated Wheat at Emarald, Queensland. Queensl. J. Agr. And Anim. Sie., 1(43): 1-8.
6. Zenfner, R., E. Spratt and H. Reisdorf, 1987. Effect of Crop Rotation N and P Fertilixen on Yields of Spring Wheat Grown on a B lach Chernozemic clay. Can. J. Plant Sie, 4(67): 965-982.
7. Hart, P.H. and G.W. Burton, 1966. Effect of Weather on Forage Yields of Winter Oats, Rye and Wheat. Agronomy J., 5(58): 58-59.
8. Ivanov, D.A., N.G. Kovalev, O.N. Antsiferova, O.V. Karaseva, M.V. Rublyuk, 2013. Influence of Landscape Conditions on Efficiency of Winter Rye. Russian Agricultural Sciences, Allerton press, Ink., 4(39): 294-297.
9. Ivanov, D.A., E.M. Korneeva, R.A. Salikov, L.I. Petrova, L.V. Pugacheva and M.V. Rublyuk, 1999. Creation of Landscape Testing Ground of a New Generation. Farming, 6: 15-16.
10. Plokhinskiy, N.A., 1970. Biometrics. M., pp: 268.

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