The role of precipitation in the formation of winter wheat productivity under the influence of the forest belt

Olga Ruleva[1], Elena Seminchenko[2]
[1]Federal State Budget Scientific Institution "Federal Scientific Center for Agroecology, Complex Reclamation and Protective Forestation of the Russian Academy of Sciences" (Federal Scientific Center for Agroecology RAS), University Avenue 97, 400062, Volgograd, Russia
[2]Nizhne-Volzhsky Research Institute of Agriculture - Branch of the Federal Research Center for Agroecology of the Russian Academy of Sciences, Russian Federation, 403013, Volgograd Region, Gorodishchensky District, pos. Regional Agricultural Experimental Station
E-mail: *bifu@mail.ru, eseminchenko@mail.ru*

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Abstract
The aim of the study was to analyze the state and productivity of winter wheat variety Kamyshanka 6 in the system of forest belts in the conditions of the Lower Volga region by the phases of development. The characteristics of its growth functions depend on the conditions of moisture (in the form of precipitation) over a four-year period.

The research was carried out in the land use "Gorodishchenskoye" cadastral number 34:03:000000:6. The experiment and related observations were carried out according to the method generally accepted in agroforestry. Studies have shown that under the protection of forest belts by the time of sowing spring barley, the accumulation of productive moisture reserves in the 0-100 m soil layer is greater than in open space, and vice versa, at the time of sowing winter wheat, the supply of productive moisture in the open space is greater than in the forest belt. Analysis of the data shows that the lowest hydraulic technical coefficient occurs in the summer period (July-August) in almost all years of research. The most productive accumulation of precipitation was in 2016, where the HTC was 0.7, and in the other years, the HTC is varying from 0.3 to 0.5 characterizing them as dry. Structural (biometric) analysis of winter wheat showed that the highest yield was at a distance of 10H (H - height of the forest strip) and was 3.0 t/ha for winter wheat. The coefficient of correlation of winter wheat by factors X (the reserve of soil moisture in the soil layer 0-30 cm, the reserve of soil moisture in the soil layer 0-100 cm, the hydrothermal coefficient, precipitation, average daily temperature, average daily humidity, water consumption) showed that the high dependence of winter wheat yield from reserves of productive moisture R2– 0,7***0,9.

Keywords: forest belts; winter wheat; productivity; moisture; correlation coefficient

INTRODUCTION

Deficiency of available moisture is a limiting factor affecting obtaining a high yield in the arid conditions in region of Lower Volga (Balashov & Agafonov, 2011; Alimova, 2009). It can be reduced in the system of forest belts, with adaptive landscape farming. Currently, farmers are reluctant to take on the balance sheet and take into account the impact of forest belts when harvesting. But this problem is already being solved in the neighboring regions of the Krasnodar Territory and the Rostov Region. Earlier, in the works of domestic and foreign researchers (Adamen et al., 2012; Verin et al., 2018; Balakay, 2013; Poluektov & Balakay, 2018; Rozanov et al., 2013), a positive effect of forest belts on the increase in relative humidity in the system of strips, and consequently, the yield of agricultural crops, was proved (Proezdov, 2016; Tanyukevich, 2013; Zelenev et al., 2016).

As a rule, most of the research on experimental plots is carried out in the forest belt system or without them. The difference between our work is that we attach great importance to the role of even a single forest belt in dry years.

Work purpose – of the work is to substantiate the role of precipitation and other factors in the formation of the winter wheat yield under the influence of the forest belt.

MATERIALS AND METHODS

The research was carried out in the land use "Gorodishchenskoye" cadastral number 34:03:000000:6, in the zone of influence of forest belts on the experimental field of the Nizhne-Volzhsky Research Institute of Agriculture. The site is located in the light chestnut subzone of the dry-steppe zone of chestnut soils of the Lower Volga region. The territory of the landscape is a slightly undulating plain. The climate is sharply continental, HTC=0.5-0.6. The sum of the average daily positive air temperatures is 3400-3500 °C. The average annual precipitation is 300-350 mm. The amplitude of the minimum and maximum temperatures is 7.8 °C (from +43 °C to -35 °C). The main object is a forest strip with a height of 5 meters, 4-row. It contains Norway maple (Acer platanoides), common elm (Ulmus laevis) compacted with red currants (Ribes rubrum) and black currants (Ribes nigrum), and white acacia (Robinia pseudoacacia). The soils are low in nitrogen, medium in phosphorus, and high in potassium. The humus content is 1.2-2.0%, pH=7-8. The experience was laid according to the methods (Dospekhov, 1985; Kabanov et al., 1973; Stepanov, 2002). Yield accounting was determined at sites of 1 square meter at a distance of 5, 10 heights from the forest belts (H), respectively. The control was an open area without a forest belt. The sheaves were selected in three-fold repetition, then they were threshed. The resulting grain was weighed and the yield per 1 ha was recalculated. The grain yield obtained by weighing was reduced to 14% humidity and 100% frequency. Stalk length was determined using a ruler, the number of spikelets and grains in the ear was determined by direct counting. The

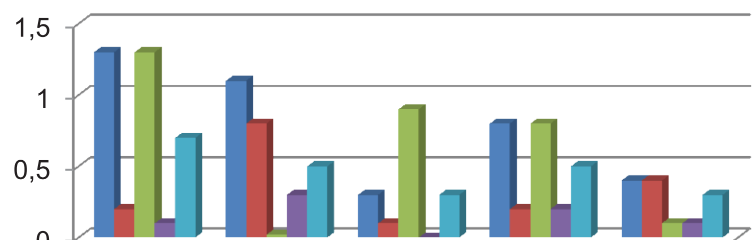
Figure 1. Layout of the experimental site

weight of 1000 grains was determined by the weight method.

The agrotechnical conditions for growing winter wheat in experimental fields include the classic processing of black fallow. Which includes peeling stubble with a disc harrow BDT-3 (disc harrow heavy-3) to a depth of 8-10 cm, after 10-15 days plowing with a non-shaft tool to a depth of 25-27 cm. In the spring, harrowing is carried out in 2 steps. Before sowing winter wheat, black fallow is processed with a KPS-4 cultivator to a depth of 6-8 cm. Winter wheat Kamyshanka 6 was sown for 4 years. The seeding rate is 3.8 million pieces/ha. The pilot site is shown in Figure 1.

RESULTS AND DISCUSSION

It is of great importance to take into account the assimilation and accumulation of atmospheric precipitation by plants in the root-inhabited layer in the dry-steppe zone of the Lower Volga region in the ecosystem space of the interstrip cell (Naboichenko et al., 2013; Azizov, 2019). Years with different precipitation intensity and temperature conditions are reflected in the HTC coefficients. The climate of the semi-desert zone of the Volgograd region is characterized by a lack of atmospheric precipitation in the spring-summer period, high temperatures in June-July and strong heating of the soil during this period, which provokes strong evaporation and low absorption of summer precipitation. The data in Figure 2 shows that the lowest HTC is in the summer period (July-August) in almost all the years of the research. This negatively affected the accumulation of moisture in the arable layer and, as a result, the low microbiological activity of the soil during this period. The most productive year for precipitation accumulation was 2016, where the HTC averaged the highest 0.7 for the period. The remaining



	2016	2017	2018	2019	2020
April - May	1,3	1,1	0,3	0,8	0,4
June	0,2	0,8	0,1	0,2	0,4
July	1,3	0,02	0,9	0,8	0,1
August -I decade of September	0,1	0,3	0	0,2	0,1
average for the period	0,7	0,5	0,3	0,5	0,3

April - May June July August -I decade of September average for the period

Figure 2. Distribution of HTC by month for the fallow period 2016-2020

Table 1 - Influence of meteorological conditions on winter wheat yield

Years of research	Precipitation, mm			Yield by year, t/ha
	Total for the growing season	Spring tillering phases-exit to the tube	Earing phases-full ripeness	
2015-2016	554,8	218,4	137,7	1,70
2016-2017	374,9	61,1	59,8	3,05
2017-2018	393	14,4	87,2	4,95
2018-2019	387,3	52,4	77,5	1,9
2019-2020	271,5	57,7	32,8	3,5

years can be considered dry with a HTC of 0.3-0.5. Observations of the dynamics of the movement of productive moisture in the soil showed that the accumulation of moisture near the forest belt was not inferior to the moisture reserves in classical vapors and, moreover, prevented freezing and the formation of an ice crust due to the ability to accumulate a high layer of snow. The height of the snow cover near the forest belt was 1.0 m, while in pairs it varied from 25 to 16 cm, respectively.

There is an opinion that the yield of agricultural crops in the dry steppe zone depends on the amount of precipitation during the spring-summer growing season. An average positive correlation was revealed in winter wheat between the level of yield and the amount of precipitation $R^2 = 0.6$. Approximately the same coefficients were found between the yield and the hydrothermal coefficient $R^2 = 0.6$. Consequently, 40% is accounted for by other factors, namely, the influence of forest belts, the sequence of crop rotations (Seminchenko, 2019) and timely fertilization (Ruleva & Seminchenko, 2020) during the spring regrowth of stems. The analysis of the experimental data also showed (Table 1) that not only the total amount of precipitation is important, but also its distribution throughout the growing season. Winter wheat in the driest years had a minimum grain yield of 1.7-1.9 t/ha. In years with an average amount of precipitation, with their uniform distribution during the spring-summer vegetation, the maximum yield of 3.5-4.95 t/ha was obtained, when the main amount fell in the tillering phase-exit into the tube, and during the formation and filling of grain crops of only 30-40 mm – the yield decreased by 35-40%.

The number of productive stems per unit area is determined by the number of preserved plants and their productive tillering, which in turn depend on the seeding rate, germination, preservation in the autumn-winter and spring-summer periods, the conditions of the growing season, as well as the mass of organic matter entering the soil (Saifulina et al., 2017). The denser stem of winter wheat was formed at a distance of 10H from the forest belt, where it was 176 pcs/m^2, slightly lower at a distance of 5H and low-160 pcs/m^2 at a distance of 30H from the forest belt. The same pattern can be traced throughout the structural (biometric) analysis of winter wheat. According to the results of the biological yield, the highest yield of winter wheat was at a distance of 10 and 30H and amounted to 3.0 t/ha, the lowest at a distance of 5H from the forest belt.

The results of the correlation analysis of the dependence of the yield and the number of grains per year on the most important criteria affecting crop productivity (soil moisture in the soil layer 0-30 cm (X1) and the meter layer (X2) of the soil, average daily temperatures (X6) and relative humidity (X7) for the growing season, precipitation (X4), soil density (X8), complex indicators - HTC (X3) and total water consumption (X5) conducted for 2016-2020, when weather conditions were different and varied

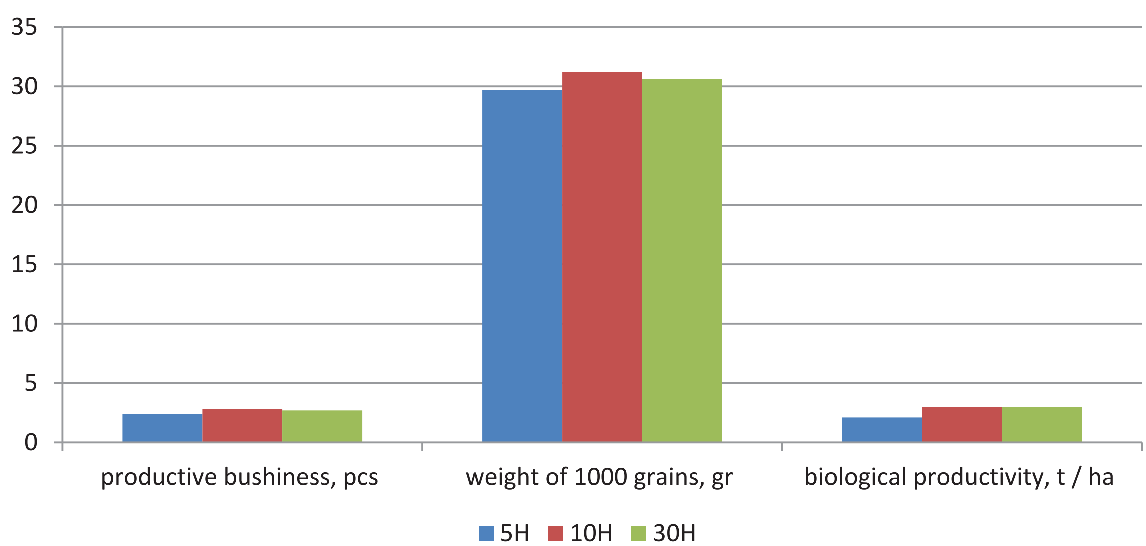


Figure 3. Structural (biometric) analysis and winter wheat yield on average for 2016-2020

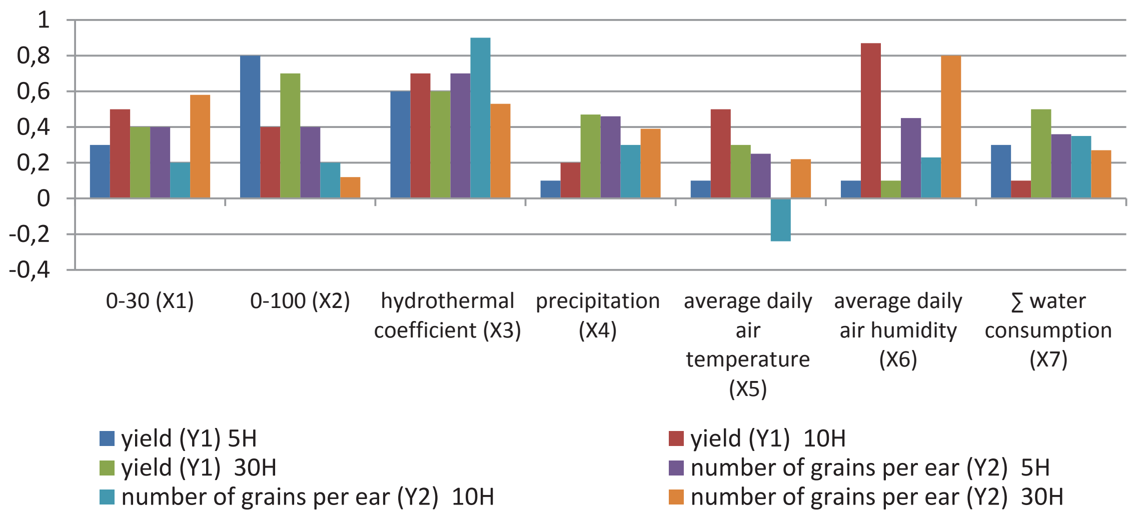


Figure 4. Dependence of the correlation coefficient of yield (Y1) and the number of grains per ear (Y2) on various factors during the spring regrowth to the full maturity of winter wheat, 2016-2020

they affected the yield, and are represented by Pearson correlation coefficients.

The correlation analysis of winter wheat was calculated for the period from spring growth to full ripeness. This period is chosen as the most important for the formation of the future crop. The correlation activity on the chart is consistently positive. The influence of the HTC with the highest indicators of R2-0.7*...0.9*is highlighted. The yield of winter wheat at a distance of 5H-10H depends very much on the reserves of productive moisture in the soil, which allows us to conclude that grain crops grown near the forest belt in our zone are able to produce higher yields. Formation of winter wheat grain begins somewhat earlier than that of early spring crops, and this period is basically a turning point in terms of lack of precipitation combined with high temperature (X5) and relative humidity (X6) of the air, which almost always leads to soil and air droughts. It is during this period that winter wheat plants are so affected by factors X5 and X6.

CONCLUSION

Thus, long-term studies conducted in the zone of insufficient and unstable moisture have established that the yield of agricultural crops in the conditions of the dry-steppe zone depends not only on the amount of precipitation during the spring-summer vegetation period, but also on other factors, namely, the influence of forest strips, the sequence of crop rotations and timely fertilization during the spring growth of stems. To the greatest extent, the mitigation of stress manifestations of environmental factors is manifested in the zone of distance from the forest strip at a distance of 5-25H and fades after 25H.

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