Vegetation period effect on winter bread wheat varieties productivity

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Abstract. Winter wheat breeding aimed at improving productivity is one of the most difficult tasks, which is associated with this trait unusual complexity. The length of a vegetation period is an important adaptive and economically valuable property, which is closely related to productivity, grain quality, drought resistance, and diseases. To a greater extent, the productivity potential is associated with the length of individual interphase periods, each of which plays a certain role in productivity formation. The length of individual interphase periods of plant development is affected by temperature conditions and water regime. The data obtained show that during the years of study a higher productivity was formed by the varieties with a longer period ‘beginning of a spring vegetation period – a heading phase’ and ‘a heading phase – complete ripeness’. The total vegetation period for these varieties and lines was also for two-three days longer. In our trials the variety ‘Univer’ was the most productive with 9.82 t/ha with 252 days of the vegetation period. The line 1005/14 was also productive with 9.81 t/ha and 251 days of a vegetation period as well as the variety ‘Donskaya Stepp’ with 9.61 t/ha and 251 days.

1. Introduction
The main criterion for any breeding program is productivity [1]. When developing new highly productive winter bread wheat varieties, it is of great importance to study the ontogeny of plants, in particular, the vegetation period. The length of the vegetation period is an indicator of cultivation suitability of varieties in a certain region [2]. For different regions, there is a need in the varieties with such a length of the vegetation period when the climatic conditions of this region ensure complete ripeness of the plants. The selection of such varieties which important stages of organogenesis take place under relatively favorable conditions, is a great reserve for productivity improvement of winter wheat [3].

The vegetation period is the variety’s passport, the sum of the time periods required for individual developmental stages, which is closely related to productivity, grain quality, drought resistance, and other traits and properties [4, 5, 6].

The length of the vegetation period is the most important biological property of plants, which consists of 12 stages of organogenesis. The most important of which are ‘sowing – sprouts’, ‘sprouts – a tillering phase’, ‘beginning of a spring vegetation period – a heading phase’, ‘a heading phase – complete ripeness’ [7].

The purpose of the current study was to research the vegetation period and its effect on winter
wheat productivity.

2. Materials and methods
The current study was carried out from 2013 to 2017 on the experimental plots of the Federal State Budgetary Scientific Institution “Agricultural Research Center “Donskoy”. Eleven samples of the Competitive Variety Testing were used as the material for study. The forecrop was green fallow. The variety ‘Ermak’ was used as a standard variety. The seeding rate was 4.5 million of germinating grain per 1m². The accounting area of the plot was 10m². The obtained data were processed according to B.A. Dospekhov’s method (2014) [8] by using computer programs.

During the study the phenological observations were conducted, the periods of winter wheat varieties and lines sprouts, tillering, heading and complete ripeness were accounted. The day when there were 10-15% of the plants was considered as the beginning of each period, and the period with 75% of the plants was considered as a complete period. Based on phenological observations for each variety and line, the length of the period from germination to complete ripeness was identified.

The weather conditions during the years of study were characterized by instability during the vegetation period, which made it possible to give an objective assessment of the studied samples, based on the weather conditions.

The years of 2013 and 2014 were arid, the amount of precipitation during the vegetation period was 191.5 and 190.0 mm, and the average daily air temperature was 20.9° and 20.3 °C, respectively. In 2015 there were 268.0 mm during the vegetation period with 19.3 °C of average daily air temperature. The years of 2016 and 2017 were characterized by the excessive moisture precipitation in the amount of 274.2 and 292.8 mm, the air temperature was 20.4 ° and 19.5 °C, respectively.

The objects of the study were the varieties ‘Tanais’, ‘Nakhodka’, ‘Aksiniya’, ‘Etyud’, ‘Shef’, ‘Donskaya Stepp’, ‘Yubiley Dona’, ‘Univer’ and the line 1005/14 developed by the Agricultural Research Center “Donskoy”.

3. Results and discussion
The length of the vegetation period depended on temperature and moisture during winter wheat sowing and vegetation. This period changed in dependence of the variety and conditions of the year (Table 1).

| Samples                             | 2013 | 2014 | 2015 | 2016 | 2017 | Average |
|-------------------------------------|------|------|------|------|------|---------|
| Ermak, a standard variety           | 258  | 242  | 249  | 249  | 251  | 250     |
| Tanais                              | 258  | 241  | 249  | 248  | 250  | 249     |
| Aksiniya                            | 256  | 240  | 247  | 247  | 248  | 248     |
| Nakhodka                            | 257  | 241  | 249  | 249  | 250  | 249     |
| Etyud                               | 254  | 238  | 245  | 246  | 248  | 246     |
| Shef                                | 259  | 242  | 249  | 250  | 256  | 251     |
| Donskaya Stepp                      | 259  | 244  | 250  | 251  | 253  | 251     |
| Yubiley Dona                        | 258  | 242  | 250  | 249  | 252  | 250     |
| Rostovchanka 5                      | 259  | 243  | 250  | 250  | 253  | 251     |
| Rostovchanka 7                      | 259  | 243  | 249  | 250  | 250  | 250     |
| 1005/14 (Donskaya yubileynaya × Tanya) | -    | 246  | 252  | 253  | 255  | 252     |
| Univer                              | -    | 245  | 252  | 252  | 253  | 251     |
| x                                   | 258  | 242  | 249  | 250  | 251  | -       |

The shortest period ‘sprouts – complete ripeness’ was in 2014. In dependence of the variety it ranged from 238 to 246 days.
The short vegetation period of 2014 is explained by the strongly arid conditions in the autumn of 2013. Due to the strong aridity of the topsoil in September, the sowing was done in dry soil only from 18 to 20 October, i.e. a month later than the optimal sowing time. The sprouts appeared in the first ten days of November (from 5 to 10 November).

The longest vegetation period was in 2013. In dependence of the variety, it ranged from 254 to 259 days. In 2012-2013 the sowing was carried out from 1 to 10 October, the sprouts appeared from 20 to 24 October. In 2014-2015 the length of the vegetation period varied from 245 to 252 days according to the varieties. In 2015-2016 the length varied from 245 to 253 days and in 2016-2017 it ranged from 248 to 255 days.

The positive correlation with the period ‘sowing – ripeness’ (r = 0.539) was identified.

According to our data, the length of the complete vegetation period does not always affect on the winter wheat varieties productivity level. To a greater extent, the productivity potential is associated with the length of individual interphase periods, each of which plays a certain role in productivity formation. The length of individual interphase periods of plant development is affected by temperature conditions and water regime. The length of the period ‘beginning of a spring vegetation period – a heading phase’ is in Table 2.

### Table 2. The length of the winter bread wheat varieties period ‘beginning of a spring vegetation period – a heading phase’.

| Samples                        | The years of study | Average |
|--------------------------------|--------------------|---------|
|                                | 2013   | 2014   | 2015   | 2016   | 2017   |
| Ermak, a standard variety      | 44     | 78     | 90     | 77     | 86     | 75     |
| Tanais                         | 44     | 77     | 89     | 77     | 86     | 75     |
| Aksiniya                       | 42     | 75     | 88     | 76     | 83     | 73     |
| Nakhodka                       | 44     | 77     | 89     | 77     | 85     | 74     |
| Etyud                          | 42     | 74     | 86     | 75     | 82     | 72     |
| Shuf                           | 46     | 79     | 91     | 79     | 89     | 77     |
| Donskaya Stepp                 | 49     | 79     | 90     | 79     | 89     | 77     |
| Yubiley Dona                   | 49     | 78     | 90     | 77     | 86     | 76     |
| Rostovchanka 5                 | 45     | 79     | 90     | 78     | 87     | 76     |
| Rostovchanka 7                 | 45     | 79     | 90     | 77     | 88     | 76     |
| 1005/14 (Donskaya yubileynaya × | -      | 82     | 94     | 86     | 94     | 89     |
| Tanya)                         |        |        |        |        |        |        |
| Univer                         |        | 82     | 95     | 83     | 93     | 88     |
| $\bar{x}$                      | 45.0   | 78.0   | 90.0   | 78.0   | 87.0   | -      |

The analysis of the obtained results showed that the beginning of spring vegetation period in the south of the Rostov region starts mainly in the second decade of March and depends on the presence of positive temperatures of this month, and ends on May, 15-27. This period varied according to the varieties from 45 days in 2013 to 90 days in 2015. The longest period of 88 days was shown by the variety ‘Univer’ and the line 1005/14, and the shortest period of 72 days was shown by the variety ‘Etyud’.

The positive correlation between the length of the period ‘beginning of a spring vegetation period – a heading phase’ and productivity (r = 0.54 ± 0.21) was identified. The longer this period was for the winter wheat varieties, the higher their productivity was.

On average, throughout the years of study, the average productivity varied from 8.08 t/ha (the variety ‘Ermak’) to 9.91 t/ha (the line 1005/14). The largest productivity of the winter bread wheat varieties was obtained in 2017, Table 3.
Table 3. The winter wheat varieties productivity in 2013-2017.

| Samples                  | The years of study | Average |
|--------------------------|--------------------|---------|
|                          | 2013   | 2014   | 2015   | 2016   | 2017   |
| Ermak, a standard variety| 6.68   | 6.43   | 8.78   | 7.94   | 10.57  | 8.08   |
| Tanais                   | 7.13   | 7.23   | 10.10  | 7.82   | 10.24  | 8.50   |
| Aksiniya                 | 6.80   | 6.61   | 9.97   | 7.91   | 10.38  | 8.33   |
| Nakhodka                 | 7.05   | 7.36   | 10.08  | 7.20   | 10.63  | 8.46   |
| Etyud                    | 7.63   | 7.40   | 9.72   | 6.63   | 10.70  | 8.42   |
| Shef                     | 7.34   | 8.04   | 9.81   | 7.20   | 10.70  | 8.62   |
| Donskaya Stepp           | 7.90   | 7.70   | 10.20  | 8.11   | 11.83  | 9.15   |
| Yubiley Dona             | 7.33   | 7.98   | 9.22   | 7.90   | 11.50  | 8.80   |
| Rostovchanka 5           | 7.09   | 7.26   | 10.00  | 7.78   | 9.38   | 8.30   |
| Rostovchanka 7           | 6.80   | 7.12   | 9.37   | 7.54   | 9.89   | 8.14   |
| 1005/14 (Donskaya yubileynaya × Tanya) | -     | 8.20   | 9.34   | 9.33   | 12.40  | 9.82   |
| Univer                   | -      | 9.30   | 9.13   | 8.70   | 12.50  | 9.91   |
| x                        | 7.18   | 7.55   | 9.64   | 7.83   | 10.89  | -      |

The weather conditions of the year significantly affect the length of the period ‘a heading phase – complete ripeness’. The information on the length of this period is presented in the Table 4. This phase of ontogenesis occurs on the second decade of May, as well as on the first and second decade of June.

Table 4. The length of the winter bread wheat varieties period ‘a heading phase – complete ripeness’ in 2013-2017, days.

| Samples                      | The years of study | Average |
|------------------------------|--------------------|---------|
|                              | 2013 | 2014 | 2015 | 2016 | 2017 |       |
| Ermak, a standard variety    | 41   | 42   | 43   | 48   | 53   | 45    |
| Tanais                       | 41   | 41   | 42   | 48   | 53   | 45    |
| Aksiniya                     | 39   | 40   | 40   | 47   | 52   | 44    |
| Nakhodka                     | 41   | 42   | 42   | 49   | 52   | 45    |
| Etyud                        | 38   | 40   | 39   | 47   | 50   | 43    |
| Shef                         | 41   | 44   | 42   | 49   | 55   | 46    |
| Donskaya Stepp               | 42   | 43   | 43   | 49   | 55   | 46    |
| Yubiley Dona                 | 41   | 42   | 43   | 47   | 52   | 45    |
| Rostovchanka 5               | 41   | 42   | 42   | 48   | 52   | 45    |
| Rostovchanka 7               | 40   | 42   | 42   | 48   | 51   | 45    |
| 1005/14 (Donskaya yubileynaya × Tanya) | 43   | 44   | 45   | 51   | 56   | 47    |
| Univer                       | 43   | 43   | 45   | 52   | 55   | 48    |
| x                            | 41   | 42   | 42   | 49   | 53   | -     |

A large amount of precipitation in late May and early June favorably affects grain formation and filling. Therefore, the winter wheat varieties with a longer period ‘a heading phase – complete ripeness’ fully using the precipitation of this period form large yields. The shortest period in dry 2013 varied from 38 to 43 days, according to the varieties the difference was 2-5 days.

The longest period ‘a heading phase – complete ripeness’ in 2017 varied from 50 to 55 days. On average, throughout the years of study, the longest period ‘a heading phase – complete ripeness’ was shown by the variety ‘Univer’ (48 days) and by the line 1005/14 (47 days). The period ‘a heading phase – complete ripeness’ of the varieties ‘Shef’ and ‘Donskaya Stepp’ lasted 46 days, the period
length of other varieties ranged from 43 to 45 days. The positive correlation between the period ‘a heading phase – complete ripeness’ and productivity in 2016 ($r = + 0.50 \pm 0.20$) and in 2017 ($r = + 0.56 \pm 0.18$) was identified.

4. Conclusions
Thus, the data obtained showed that the largest grain productivity was formed by the varieties with a longer period ‘beginning of a spring vegetation period – a heading phase’ and a long vegetation period ‘a heading phase – complete ripeness’. The total vegetation period for these varieties and lines was also for two-three days longer in comparison with less productive varieties. The productivity decrease of the varieties with a shorter vegetation period is associated with high air temperatures and dry winds during grain ripening (late June - early July). As the result of these phenomena, the early ripening varieties grow in arid conditions, and so form shrivelled grain. On the contrary the late ripening varieties ripen later and, as a rule, during this period (end of June - beginning of July) it rains; and this has a positive effect on grain ripening. The varieties form large, high-quality grain.

The most productive variety was the variety ‘Univer’ with 9.82 t/ha and 252 days of the vegetation period. The line 1005/14 was also productive with 9.81 t/ha and 251 days of a vegetation period as well as the variety ‘Donskaya Stepp’ with 9.61 t/ha and 251 days.

References
[1] Ashiev A R, Khabibullin, K N and Skulova M V Agroecological estimation of the new soybean lines developed in the Agricultural Research Center “Donskoy” Grain Economy of Russia 6(66) 7-11
[2] Goldvarg B A, Boktaev M V, Filippov E G and Dontsova A A The effect of precipitations in a vegetation period on productivity of the zoned spring barley varieties in the arid central zone of the Republic of Kalmykia Grain Economy of Russia 5(65) 14-17
[3] Ivanisov M M, Marchenko D M, Nekrasov E I, Rybas I A, Grichanikova T A, Romanyukina I V and Kravchenko N S The study results of the winter soft wheat varieties of various ecological and geographical origin in the south of the Rostov region Grain Economy of Russia 6(66) 12-17
[4] Zhuchenko A A 2004 Resource Potential of Grain Production in Russia (Theory and Practice) (Moscow: LLC «Publishing House Agrorus») p 1109
[5] Vlasova O I, Perederieva V M and Volters I A 2018 Previous crop – as an element of organic farming in the cultivation of winter wheat in the Central pre Caucasus Research J. of Pharmaceutical, and Chemical Sciences 6 1272–1276
[6] Borisenko I B, Ovchinnikov A S, Meznikova M V, Fomin S D, Bocharnikov V S, Rogachev A F and Ulybina E I 2019 Resource-saving method of chemical treatment of tilled crops Conference on Innovations in Agricultural and Rural development IOP Conf. Series: Earth and Environmental Science 341
[7] Ivanova I and Ilina S 2018 Variability of morphological features of spring soft wheat Moskovskaya 35 IOP Conf. Series: Earth and Environmental Science 433 012016
[8] Dospekhov B A 2014 Methodology of a Field Trial (Moscow: Alliance) p 351