

PCR analysis reveals low prevalence of the wheat-rye translocation 1RS.1BL among the most competitive spring bread wheat varieties cultivated in the Russian Federation in 2012-2025

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Abstract

This study investigated the prevalence of the wheat-rye translocation 1RS.1BL among the most competitive varieties of spring bread wheat cultivated in the Russian Federation from 2012 to 2025 using PCR with the SCM9 marker. The selection of the studied varieties was based on the annual rankings of the top 10 crop varieties (hybrids) by seeding volumes in the Russian Federation, published by the Federal State Budgetary Institution "Russian agricultural center" ("Rosselkhozsentr"). From 2012 to 2025, these rankings included a total of 25 spring bread wheat varieties, as well as two varieties of facultative growth type, cultivated in Russia as a spring crop. The 1RS.1BL translocation was detected in only 3 out of the 27 studied varieties: Omskaya 38, Uralosibirskaya, and Arkhat. At the same time, none of the 12 top cultivars, stably and widely cultivated for five or more years in 2012-2025 carried this translocation. The obtained results indicate a limited role of the 1RS.1BL translocation in the breeding of the most competitive spring bread wheat cultivars in Russia during the study period. As a hypothesis explaining the low prevalence of 1RS.1BL among the most competitive spring bread wheat varieties, we propose its possible negative impact on resistance to pre-harvest sprouting. In Russia, the main cultivation regions for spring bread wheat frequently experience unfavorable weather during harvest. Therefore, resistance to pre-harvest sprouting is of critical agricultural and economic value, as it determines the competitiveness of spring bread wheat varieties.

Introduction

Genetic studies of the best cultivars of crop plants represent a key area of breeding genetics. Given the ongoing changes in climatic conditions and phytosanitary situations, such research must be conducted continuously. This is certainly true for bread wheat (*Triticum aestivum* L.), the leading agricultural crop in the Russian Federation. Due to the specific agroclimatic conditions prevalent in a significant portion of the country's agricultural zones, the proportion of spring-type varieties relative to the total wheat acreage in Russia is extremely high. This underscores the critical importance of spring bread wheat for the Russian Federation. Consequently, identifying the genetic factors that determine the competitiveness of the most successful spring-type breeding lines is of particular significance.

Data on the actual production use of varieties can serve as a valuable indicator of their competitiveness. In this regard, the annual rankings of the top 10 crop varieties (hybrids) by seeding volume in the Russian Federation, published by the Federal State Budgetary Institution "Russian agricultural center" ("Rosselkhozsentr"), represent a valuable open-access information source. A retrospective analysis of these data allows for the identification of the most popular and time-tested spring bread wheat varieties for subsequent investigation of the genetic determinants underlying their competitiveness. Of particular importance is determining the breeding value of large clusters of linked genes, the transfer of which into the bread wheat genome is often associated with introgressions of alien genetic material (Leonova 2018).

A classic example of such a chromosomal rearrangement is the wheat-rye translocation 1RS.1BL, which involves the transfer of the short arm of rye chromosome 1RS into the bread wheat genome, accompanied by the introduction of a pool of disease resistance genes. Specifically, the 1RS arm carries the genes *Lr26*, *Sr31*, *Yr9*, and *Pm8*, conferring resistance to leaf rust, stem rust, yellow rust, and powdery mildew, respectively (Trubacheeva et al. 2011; Leonova 2018; Moskal et al. 2021; Korobkova et al. 2023). As a result, wheat lines carrying the 1RS.1BL translocation exhibit complex resistance to phytopathogens, which has contributed to the widespread use of this introgression in global bread wheat breeding.

The 1RS.1BL translocation has also been identified in a large number of Russian bread wheat varieties, and its frequency of occurrence continues to increase (Trubacheeva et al. 2011; Adonina et al. 2017; Fisenko et al. 2023; Korobkova et al. 2023). In this context, analyzing the presence of this introgression among spring bread wheat varieties most in demand by agricultural producers is of practical interest. The results of such a study would allow this genetic resource to be examined from a new perspective and would enable an assessment of its contribution to the development of modern competitive spring bread wheat cultivars for Russian conditions.

Therefore, the aim of this work was to assess the prevalence of the wheat-rye translocation 1RS.1BL among the most competitive spring bread wheat cultivars cultivated in the Russian Federation during the period 2012–2025.

Materials and methods

Wheat varieties. The most widely sown spring bread wheat varieties cultivated in the Russian Federation over the 14-year period from 2012 to 2025 were used as the object of study. These varieties were identified from the annual rankings of the top 10 crop varieties (hybrids) by seeding volume in the Russian Federation, published by the Federal State Budgetary Institution "Russian agricultural center" ("Rosselkhozsentr"). These data are publicly available for the period from 2012 to 2025, with the exception of 2018, for which leader rankings were apparently not published. It should be noted that in 2024, the Rosselkhozsentr ranking included 9 varieties of spring bread wheat and 1 variety of spring durum wheat; therefore, data for 2024 are presented for only 9 spring bread wheat varieties. For earlier years (before 2012), full rankings could not be located in open sources; therefore, the analysis was limited to the 2012–2025 period, which nevertheless spans 14 years and covers more than a decade of recent breeding history. In total, during this period, 25 spring bread wheat varieties appeared in these rankings, along with two varieties of facultative growth type (Triso and Cornetto), which are cultivated in Russia as spring crops (Table S1). Consequently, these varieties were also treated as spring types in the present study. Seeds of all investigated varieties were obtained from the collection of the N.I. Vavilov All-Russian Institute of Plant Genetic Resources (VIR). The main characteristics of the studied varieties are presented in Table S2. The English names of all cultivars mentioned in this study are given as they appear in the VIR catalogue (<http://91.151.189.38:8080/virdb/maindb>).

Study area. The territory of the Russian Federation is divided into 12 agro-climatic zones, characterized by relative similarity in soil and agro-climatic conditions (<https://gossortrf.ru/region/>). During variety trials, each crop variety or hybrid is tested in every recommended agro-climatic zone. Based on the results, the most suitable zones are specified in the official description of the variety. Our study focused on eleven of these agro-climatic zones: Northern (1), Northwestern (2), Central (3), Volga-Vyatka (4), Central Chernozem (5), Middle Volga (7), Lower Volga (8), Ural (9), West Siberian (10), East Siberian (11) and Far Eastern (12). Although the Far Eastern region is officially subdivided into Northern and Southern zones (12.1 and 12.2, respectively), the variety descriptions available to us still refer to it simply as "Far Eastern (12)." Therefore, we have followed this convention and treat the Far Eastern region as a single zone (12) in the present study.

Examination of the agro-climatic zones listed for each of the 27 studied varieties (Table S2) reveals that the North Caucasus region (6) is not represented among any of the cultivars. This finding is consistent with the biological and agronomic characteristics of the steppe part of the region, including Rostov Region, Krasnodar Territory and Stavropol Territory, where the bulk of bread wheat grain production is concentrated. Its mild winters and hot dry summers are more favorable for winter wheat cultivation, whereas spring-sown wheat is not competitive under these conditions. Consequently, none of the top spring bread wheat varieties in our dataset are registered or recommended for cultivation in zone 6.

DNA isolation and PCR. DNA was extracted from dried tissues of plants grown from seeds of the studied varieties using the CTAB method (Doyle and Doyle 1987). PCR detection of the wheat-rye translocation 1RS.1BL was performed using the SCM9 marker (Weng et al. 2007).

Results

Before proceeding to the genetic analysis of the selected spring bread wheat varieties, it was necessary to verify that they indeed represent the most competitive cultivars of this crop. Therefore, we first determined how many spring bread wheat varieties were approved for use in the Russian Federation during the studied period. Analysis of data from the Federal State Budgetary Institution "State Commission of the Russian Federation for Selection Achievements Test and Protection" ("Gossortkomissiya") showed that from 2012 to 2025, the number of spring bread wheat varieties approved for use in the Russian Federation grew steadily, increasing nearly twofold (Table 1).

Table 1. Number of spring bread wheat varieties approved for use in the Russian Federation in 2012-2025

Year	Number of varieties approved for use	Year	Number of varieties approved for use
2012	186	2019	242
2013	189	2020	261
2014	193	2021	274
2015	205	2022	296
2016	211	2023	320
2017	226	2024	336
2018	228	2025	362

Thus, the spring bread wheat varieties featured in the Rosselkhoztsentr rankings demonstrated their leading status under conditions of increasing competition from a constantly growing number of newly approved varieties.

However, being included in the top-10 by seeding volume, while an important indicator, does not reflect the quantitative contribution of these varieties to the total spring bread wheat production. To objectively assess their competitiveness and real significance for the country's agriculture, it was necessary to determine what proportion of the total spring bread wheat sown area in the Russian Federation they actually occupied during the studied period. Using data on the annual total seeding volume (Table S1) of the most widely sown spring bread wheat varieties, we could approximately calculate the sown area occupied by these varieties and compare it with the total crop acreage. According to official data from the Federal Service for State Statistics of the Russian Federation (Rosstat), the spring bread wheat seeding rate in the Russian Federation ranges from 160 to 270 kg/ha. Taking an average seeding rate of 215 kg/ha, we calculated the approximate areas annually occupied by the most widely sown varieties of this crop (Table 2).

Table 2. Annual sown areas of the top 10 spring bread wheat varieties by seeding volume in the Russian Federation in 2012-2025

Year	Total crop sown area, thsd ha	Total seeding volume of 10 leading varieties, thsd tons	Sown area of 10 leading varieties	
			thsd ha	% of total crop sown area
2012	12843	961.0	4469.9	34.8
2013	12715	876.9	4078.5	32.1
2014	13103	935.0	4348.8	33.2
2015	13463	949.8	4417.6	32.8
2016	13668	945.5	4397.7	32.2
2017	12969	869.1	4042.3	31.2
2019	12256	850.6	3956.3	32.3
2020	12530	858.3	3992.1	31.9
2021	13135	923.2	4294.0	32.7
2022	12790	810.3	3768.8	29.5
2023	13297	884.1	4112.1	30.9
2024	11231	716.8	3334.0	29.7
2025	10119	678.5	3155.8	31.2

It was found that the spring bread wheat varieties included in the Rosselkhoztsentr rankings during 2012–2025 annually occupied a significant portion – about one third – of the total Russian spring bread wheat acreage. Consequently, their combined contribution to grain production was substantial. This indicates the high demand for these varieties among agricultural producers and their sustained competitiveness against the background of increasing varietal diversity.

Next, using PCR analysis, we investigated the presence of the wheat-rye translocation 1RS.1BL in the selected spring bread wheat varieties. The analysis revealed that the 1RS.1BL translocation was detected in only 3 out of the 27 studied varieties, namely Omskaya 38, Uralosibirskaya, and Arkhat (Table 3).

Table 3. Presence of the 1RS.1BL translocation in the most widely sown spring bread wheat cultivars in the Russian Federation in 2012–2025

№	Cultivar	1RS.1BL presence
1	Saratovskaya 42	-
2	Ester	-
3	Novosibirskaya 15	-
4	Simbirtsit	-
5	Duet	-
6	Altaiskaya 530	-
7	Novosibirskaya 29	-
8	Omskaya 35	-
9	Dar'ya	-
10	Omskaya 36	-
11	Iren'	-
12	Ekada 70	-
13	Novosibirskaya 31	-
14	Altaiskaya 70	-
15	Triso	-
16	Ikar	-
17	Omskaya 38	+
18	Ekada 109	-
19	Uralosibirskaya	+
20	Granny	-
21	Arkhat	+
22	Licamero	-
23	KWS Buran	-
24	KWS Torridon	-
25	Cornetto	-
26	KWS Akvilon	-
27	KWS Sunset	-

Meanwhile, the duration that the selected varieties remained in the Rosselkhoztsentr rankings could range from one to thirteen years, given that no rankings were published in 2018 (Table S1). This means that some varieties may have appeared in the leader rankings only once, which could potentially bias the conclusions of the study. The average time that spring bread wheat varieties spent in the Rosselkhoztsentr rankings during 2012–2025 was approximately five years (rounded). Therefore, we subsequently selected varieties of this crop that appeared in the leader rankings for five years or more, as representing the most successful breeding lines that reflect key trends in the breeding process. This selection yielded 11 spring bread wheat varieties, along with one facultative variety (Triso), which, as already noted, is sown in Russia as a spring crop. None of these 12 top cultivars carried the 1RS.1BL translocation (Table 4).

Table 4. Presence of the 1RS.1BL translocation in spring bread wheat top cultivars in the Russian Federation in 2012-2025

Nº	Cultivar	Duration of inclusion in the leader rankings during 2012-2025, years	1RS.1BL presence
1	Altaiskaya 530	5	-
2	Novosibirskaya 29	6	-
3	Omskaya 35	6	-
4	Dar'ya	11	-
5	Omskaya 36	12	-
6	Iren'	13	-
7	Ekada 70	7	-
8	Novosibirskaya 31	11	-
9	Triso	7	-
10	Ikar	8	-
11	Granny	7	-
12	Licamero	5	-

Thus, the results of our study demonstrate the low prevalence of the 1RS.1BL translocation among the most competitive spring bread wheat cultivars in the Russian Federation during 2012–2025. Furthermore, our data regarding the varieties Saratovskaya 42, Ester, Novosibirskaya 15, Duet, Novosibirskaya 29, Omskaya 35, Omskaya 36, Novosibirskaya 31, Triso, Omskaya 38, Uralosibirskaya, Arkhat, Licamero, KWS Buran, KWS Torridon, Cornetto, KWS Akvilon and KWS Sunset are consistent with previously published reports (Trubacheeva et al. 2011; Adonina et al. 2017; Baranova 2020; Gulyaeva and Shaydayuk 2021; Meshkova et al. 2021; Fisenko et al. 2023; Sochalova et al. 2023; Baranova et al.

2025). For the remaining 9 varieties, we did not encounter any studies in which they were examined with direct indication of the method used to detect the 1RS.1BL translocation.

Discussion

The low prevalence of the 1RS.1BL translocation among the most in-demand spring bread wheat varieties in the Russian Federation during 2012–2025, and its complete absence among the top cultivars, indicates a limited role of this introgression in developing competitive varieties of this crop. A first possible explanation is a decline in the breeding value of this genetic resource due to the documented loss of effectiveness of key resistance genes associated with this introgression, particularly *Lr26* and *Yr9* (Plotnikova et al. 2022; Gulyaeva et al. 2024). At the same time, the 1RS.1BL translocation is widely represented among Russian top winter bread wheat cultivars such as Tanya, Skipetr, Yuka, Alekseich, and Besostaya 100, which were widely cultivated during the studied period (Gulyaeva et al. 2021; Fisenko et al. 2023). This indicates that this introgression has not lost its breeding significance for developing highly competitive winter bread wheat varieties. Furthermore, the negative effect of the 1RS.1BL translocation on bread wheat baking quality is well known (Leonova 2018; Moskal et al. 2021). However, given that the winter cultivars Skipetr and Yuka are classified as valuable wheats, while Alekseich and Besostaya 100 are classified as strong wheats, it can be concluded that this introgression does not necessarily preclude the development of high grain quality cultivars. This is further supported by the fact that the spring varieties carrying the 1RS.1BL translocation analyzed in our study — Uralosibirskaya and Omskaya 38 — are classified as strong wheats, while Arkhat is classified as a valuable wheat. Therefore, the reasons for the low prevalence of this introgression among the most widely sown spring bread wheat varieties and its complete absence among the top cultivars should be sought among factors that determine the competitiveness specifically of spring varieties of this crop.

One of the key requirements for bread wheat varieties, especially spring forms, is resistance to pre-harvest sprouting (PHS). PHS is a global phenomenon in which mature grains germinate on the mother plant under cool, rainy conditions before harvest, leading to severe losses in grain yield, end-use quality, and market value, with estimated annual economic losses exceeding one billion USD worldwide (Matilla 2024; Yang et al. 2025). In this context, PHS resistance of spring bread wheat varieties is of critical agricultural and economic value for the Russian Federation. Unlike winter wheat, which is harvested from late June to mid-July, spring cereals in Russia are harvested from August to September, making them especially vulnerable to the unfavorable weather conditions of late summer in the main cultivation regions — the Urals, Siberia, and the Non-Chernozem zone.

The primary cause of PHS is insufficient seed dormancy, a complex quantitative trait that prevents germination under otherwise favorable conditions (Fedyaeva et al. 2023; Matilla 2024). The biochemical hallmark of PHS is the elevated activity of alpha-amylase, which degrades starch, drastically reducing the Hagberg falling number and compromising bread-making quality (Fedyaeva et al. 2023; Hull et al. 2024; Yang et al. 2025). The balance between abscisic acid (ABA, promoting dormancy) and gibberellins (GA, promoting germination) is the central hormonal switch controlling the onset of PHS (Fedyaeva et al.

2023; Matilla 2024). Modern research on PHS resistance has focused primarily on identifying quantitative trait loci (QTLs) and causal genes governing seed dormancy, alpha-amylase activity and grain color (Fedyaeva et al. 2023; Hull et al. 2024; Matilla 2024).

Notably, the 1RS.1BL translocation is not mentioned in the context of PHS resistance genetics. Nevertheless, some evidence suggests that the 1RS.1BL translocation may indeed compromise PHS resistance. At first, there are some field investigations reports revealing that varieties carrying the 1RS.1BL translocation – Omskaya 38 and, in particular, the medium-late variety Uralosibirskaya – indeed demonstrated an increased susceptibility to pre-harvest sprouting (Filippova et al. 2024a, b; Tobolova and Loginov 2024). At the same time, highly competitive varieties without this introgression, such as Ikar, Iren', Novosibirskaya 31, and Omskaya 36, were characterized by low levels of pre-harvest sprouting (Filippova et al. 2024b; Tobolova and Loginov 2024). It is worth emphasizing that all new varieties without the 1RS.1BL translocation that have become widely distributed in Russia in recent years – Licamero, KWS Buran, KWS Torridon, Cornetto, KWS Akvilon and KWS Sunset – demonstrated high resistance to pre-harvest sprouting (Filippova et al. 2024b). These findings confirm the key role of breeding for pre-harvest sprouting resistance in the development of commercially successful spring bread wheat varieties in Russia and suggest that the presence of the 1RS.1BL translocation may limit the competitiveness of spring wheat cultivars, particularly medium-late ones, through its potential negative effect on this critically important agronomic trait.

Secondly, as mentioned above, pre-harvest sprouting resistance in bread wheat is closely associated with the falling number. Evidence of the negative effect of the 1RS.1BL translocation on falling number is reported in several sources (Krupnov and Krupnova 2015; Tang et al. 2017; Begum et al. 2025). The mechanisms underlying the negative impact of this introgression on falling number may include, among other factors, increased late alpha-amylase activity in bread wheat grain (Farrell et al. 2013). Furthermore, a proteomic study by Gobaa et al. (2007) revealed that a dimeric alpha-amylase inhibitor protein is absent in lines carrying the 1BL.1RS translocation, suggesting that the introgression may also compromise the grain's natural capacity to regulate alpha-amylase activity.

Furthermore, pre-harvest sprouting resistance is known to be closely associated with red grain color (Khlestkina 2012; Krupnov and Krupnova 2015; Fedyaeva et al. 2023; Chen et al. 2025). Red spike color is not typically mentioned in the context of PHS resistance in bread wheat varieties. However, it can be assumed that this association exists, since red-spiked wheat varieties, such as *millitum* and *ferrugineum*, are considered better adapted to cultivation under low temperatures and high moisture availability – conditions that strongly promote pre-harvest sprouting (Lentochkin and Kuklina 2022; Stepanova 2024). One of the genes responsible for red spike color is *Rg-B1*, located on the short arm of bread wheat chromosome 1B (Khlestkina 2012). It can be hypothesized that the loss of the *Rg-B1* gene in bread wheat due to the replacement of the wheat 1BS chromosome arm with the rye 1RS arm also contributes to reduced PHS resistance under high moisture conditions. It is also possible that other, as yet unknown, genes associated with pre-harvest sprouting are localized on wheat chromosome 1BS. Thus, the 1RS.1BL translocation may negatively affect pre-harvest sprouting both by introducing

rye-derived genetic factors and by displacing wheat genes that are positively associated with this important agronomic trait.

Regarding the variety Arkhat, we did not find any published data on its susceptibility to pre-harvest sprouting. However, it is known that this variety also carries the wheat–ryegrass translocation 7DS-7DL-7Ae#1L, which introduces the resistance genes *Lr19/Sr25* into the bread wheat genome (Lebedeva et al. 2023). In this context, data analyzing the effect of the combination 1RS.1BL + 7DS-7DL-7Ae#1L on the yield and grain quality of spring bread wheat under different moisture conditions are of interest. This combination has been shown to have directionally variable effects, with a positive influence on the studied traits in dry years and a negative or neutral effect in years with favorable moisture availability (Sibikeev et al. 2018). Thus, the negative effect of the 1RS.1BL translocation on the PHS resistance of Arkhat may potentially be compensated by the presence of the wheat–ryegrass translocation 7DS-7DL-7Ae#1L. However, under high moisture conditions, the compensatory potential of this translocation may be insufficient to completely offset the proposed negative effect of 1RS.1BL, which manifests as reduced grain quality.

Concerning the compensatory effect of other introgressions on the negative manifestation of the 1RS.1BL translocation, it should be noted that Omskaya 38 also possesses a wheat–ryegrass translocation, but not 7DS-7DL-7Ae#1L like Arkhat; instead, it carries 7DL-7Ai (Fisenko et al. 2023). Nevertheless, this variety, as already noted, was susceptible to pre-harvest sprouting, albeit to a lesser extent than Uralosibirskaya. Overall, based on published data, the discussed varieties can be ranked by their susceptibility to PHS as follows: Uralosibirskaya (1RS.1BL) > Omskaya 38 (1RS.1BL + 7DL-7Ai) > Arkhat (1RS.1BL + 7DS-7DL-7Ae#1L). This suggests that the 7DS-7DL-7Ae#1L translocation has a greater compensatory effect on the presumed negative effect of 1RS.1BL than does 7DL-7Ai. This may be due to the fact that the ryegrass segment 7Ai can be introgressed either onto the long arm of wheat chromosome 7D or onto both arms of this chromosome (Leonova 2018). It can be hypothesized that the more pronounced compensatory effect of the 7DS-7DL-7Ae#1L translocation in the case of Arkhat is associated with a larger representation of the ryegrass segment in this variety.

Further evidence supporting the compensatory effect of other introgressions or introduced genes on the presumed negative manifestation of the 1RS.1BL translocation comes from data on the medium-late variety Raduga (1RS.1BL + *Sr57/Lr34/Yr18/Pm38*), which demonstrated significant pre-harvest sprouting resistance compared to the medium-late variety Uralosibirskaya (Filippova et al. 2024a). However, overcoming the presumed negative effect of the 1RS.1BL translocation through wheat–ryegrass introgressions or the pleiotropic gene *Sr57/Lr34/Yr18/Pm38* may negatively affect the main agronomically valuable trait of bread wheat – baking quality. Thus, as the PHS resistance of the discussed varieties increases, a decline in their quality class is observed: Uralosibirskaya (strong wheat) < Omskaya 38 (strong wheat) < Arkhat (valuable wheat). The same trend is observed in the pair "Uralosibirskaya (strong wheat) < Raduga (filler/weak wheat)."

Therefore, based on a comparison of our data on the prevalence of the translocation among the most in-demand varieties with published data and our own observations on their PHS resistance, as well as with known information on the effect of 1RS.1BL on falling number and late alpha-amylase activity, we propose the hypothesis that the presence of this introgression may limit the long-term competitiveness of spring bread wheat varieties in production by reducing pre-harvest sprouting resistance, especially in the absence of effective compensatory genetic factors in the variety's genome. This hypothesis undoubtedly requires further experimental validation and underscores the importance of comprehensively investigating all possible effects of using alien genetic material in bread wheat breeding.

In addition to the 1RS.1BL translocation, the SCM9 marker used in this study also allows detection of the 1RS.1AL translocation (Weng et al. 2007). This translocation, first identified in the cultivar Amigo (Schlegel and Kynast 1987), has been reported to occur tens of times less frequently than 1RS.1BL and is largely confined to the American continent (Moskal et al. 2021). Consistent with previous studies showing its extremely low prevalence outside the Americas, we did not detect the 1RS.1AL translocation in any of the 27 cultivars analyzed here. This finding confirms that in the Russian Federation, as in other non-American wheat-growing regions, the 1RS.1AL translocation remains negligible and has not contributed to the competitiveness of modern spring bread wheat cultivars.

Conclusion

The totality of our results together with the data available in the literature suggests that the low prevalence of the 1RS.1BL translocation among the most competitive spring bread wheat cultivars in the Russian Federation during 2012–2025 is not due to its negative effect on baking quality, nor to the overcoming of key resistance genes associated with this introgression by phytopathogens. A possible limiting factor for the use of the 1RS.1BL translocation in developing competitive spring bread wheat cultivars may be related to its negative impact on resistance to pre-harvest sprouting – a critically important trait for spring wheat, especially in Russian conditions. The mechanisms underlying this effect are likely complex and include both the introduction, via the rye chromosome 1RS, of genetic factors that increase late alpha-amylase activity and reduce falling number, and the loss, from the wheat chromosome 1BS, of wheat genes potentially associated with pre-harvest sprouting resistance, such as *Rg-B1*.

The presence of additional introgressions, namely 7DS-7DL-7Ae#1L and 7DL-7Ai, may partially compensate for the putative negative effect of the 1RS.1BL translocation by enhancing pre-harvest sprouting resistance in spring bread wheat. However, such compensation is likely accompanied by a reduction in grain baking quality, which may also limit the commercial attractiveness of cultivars in environments where consistently high quality is required. Consequently, the use of the 1RS.1BL translocation in breeding competitive spring bread wheat cultivars for Russia requires careful weighing of its benefits (conferred by complex resistance to phytopathogens) against the potential risks to grain

quality and pre-harvest sprouting resistance, especially in regions where humid conditions prevail during the harvest period.

Declarations

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DATA AVAILABILITY

All the data related to this work can be sourced from the corresponding author

CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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