Use of genetic resources in white straw and cereal crops breeding in the monsoon climate

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Abstract. In creating new competitive varieties, the leading role belongs to plant genetic resources. Researches are devoted to the study of 823 samples of domestic and foreign breeding of spring barley (Hordeum vulgare. L.), winter and spring soft wheat (Triticum aestivum L.), durum wheat (Triticum durum Dest.), and buckwheat (Fagopyrum esculentum Moench), buckwheat Tatar (Fagopyrum tataricum (L.) Gaertn.) buckwheat semi-umbrella (Fagopyrum cymosum Meissn.) from world collection of Russian National Institute of Plants Genetic Resources (VIR). High-yield source varieties, resistant to lodging, adapted to the conditions of the monsoon climate have been identified. A bioresource feature collection has been formed. As a result of targeted research, new varieties of spring wheat (Nikolskaya), spring barley (Primorets) and buckwheat (Ussurochka) adapted to the conditions of the monsoon climate of the Far East have been created.

1. Introduction
Ensuring food security is one of the strategic tasks of the agro-industrial complex of Russia, an important role in the solution of which belongs to grain as the most important, socially significant product [1-3].

In this regard, the need to increase production of own grain in the Far Eastern region is becoming especially urgent [4]. In the set of measures aimed at achieving this goal, an important role belongs to the variety, which accounts for up to 40% of the yield growth. The Far East of Russia is characterized by a monsoon climate with high air humidity, with frequent fogs, contributing to the enhanced development of diseases, lowering grain quality, and resistance to lodging [4-6]. To create competitive varieties, it is necessary to have genetically diverse and comprehensively studied source material [7-10].

The purpose of this work is to study the genetic resources of grain and cereal crops of the world collection of VIR in the monsoon climate, the selection of samples with economically valuable traits for use in practical breeding.

2. Research technique
The research was carried out in the laboratory for the selection of grain and cereal crops of the Federal State Budget Scientific Institution "A.K. Chaika Federal Research Center for Agrobiotechnologies of the Far East" in 2009-2019. The object of research was 823 samples of grain and cereal crops received in the bioresource collection from the world collection of N.I. Vavilov Russian National Institute of Plants Genetic Resources (VIR). The bulk of the material is represented by samples of the genus
**Triticum** L. (402 pcs.): Soft wheat (*Triticum aestivum* L.) - spring (280 pcs.) and winter forms (103 pcs.); durum wheat (*Triticum durum* Dest.) spring forms (19 pcs.). Cultivated barley *Hordeum vulgare* L. includes 175 samples: two-row (*Hordeum vulgare* L. subsp. distichum) - 128 pcs. and multirow forms (*Hordeum vulgare* L. subsp. vulgare) - 47 pcs. The genus Buckwheat (*Fagopyrum* Mill.) was represented by 246 samples: buckwheat (*Fagopyrum esculentum* Moench) - 229 pcs., Buckwheat Tatar (*Fagopyrum tataricum* (L.) Gaertn.) - 16 pcs. and (*Fagopyrum cymosum* Meissn.) - 1 pc. Accounting and observations were carried out according to the methodology of the State test of agricultural crops [11]. Statistical data processing - according to B.A. Dospekhova [12].

3. **Research results**

In recent years, the A.K.Chaika Federal Research Center for Agrobiotechnology of the Far East are conducting a focused study of global genetic resources and identifying sources of economically valuable traits in the monsoon climate. A bioresource collection of grain and cereal crops of various ecological and geographical origin was formed, represented by 30 countries of the world.

Analysis of the studied genetic resources showed that the largest number of samples of *Triticum aestivum* L. (299 pcs.) is represented by varieties lutescens (245 pcs.) and erythrospermum (76 pcs.), *Triticum durum* Dest. (19 pcs.) - hordeiforme (16 pcs.).

Wheat in the collection is represented by varieties of Russian selection - 261 samples and CIS countries - 38 (Kazakhstan - 13, Ukraine - 18, Tatarstan - 3, Bashkortostan - 2, Belarus - 2), Asian countries - 32 (India -8, China - 11, Syria - 3, Algeria - 6, Tunisia - 2, Egypt - 1, Iran - 1), the countries of America - 29 (USA - 10, Chile - 2, Mexico - 7, Argentina - 1, Canada - 9), countries of Western Europe - 21 (Netherlands - 1, Germany - 6, Poland - 3, Czechoslovakia - 2, Estonia - 2, Serbia - 1, France - 1, Portugal - 2, Norway - 1, Sweden - 1, Finland - 1), Australia - 2 (table 1).

| Variety                          | Origin               | Russia and CIS | Asis | Western Europe | Australia | North America |
|----------------------------------|----------------------|----------------|------|----------------|-----------|---------------|
| **Triticum aestivum** L.         |                      |                |      |                |           |               |
| lutescens                        | 219                  | 5              | 14   | –              | 7         |               |
| erythrospermum                   | 51                   | 10             | 2    | –              | 13        |               |
| albidum                          | 9                    | 9              | –    | –              | –         |               |
| ferrugineum                      | 6                    | 2              | 1    | –              | –         |               |
| milturum                         | 8                    | –              | 1    | –              | 1         |               |
| suberythrospermum                | –                    | –              | –    | –              | 1         |               |
| graecum                          | 3                    | 4              | 1    | 2              | 3         |               |
| subgraecum                       | –                    | –              | 1    | –              | –         |               |
| rufinflatum                      | –                    | 1              | –    | –              | –         |               |
| erythroleucum                    | –                    | 1              | 1    | –              | –         |               |
| barbarossa, pseudobarbarossa     | 1                    | –              | –    | –              | –         |               |
| caesium                          | 1                    | –              | –    | –              | –         |               |
| fulvocinereum                    | 1                    | –              | –    | –              | –         |               |
| vavilovii jakub                 | –                    | –              | –    | –              | 1         |               |
| Total                            | 299                  | 32             | 21   | 2              | 29        |               |
| **Triticum durum** Dest.         |                      |                |      |                |           |               |
| leucurum                         | 3                    | –              | –    | –              | –         |               |
| hordeiforme                      | 16                   | –              | –    | –              | –         |               |
| Total                            | 19                   | –              | –    | –              | –         |               |

The barley species represented by genus *Hordeum* L. are widespread and grow under various climatic conditions [13,14]. The most widespread and practical use has the form of cultivated barley *Hordeum vulgare* L. The bioresource collection is represented by two subspecies of cultivated barley: two-row
(Hordeum vulgare L. subsp distichum) and multi-row (Hordeum vulgare L. subsp. Vulgare) (table 2). The main part of the samples belongs to the nutans variety (71 pcs.): Russia (42 pcs.), CIS countries (24 pcs.), Western Europe (42 pcs.); pallidum 28 samples: Russia (10 pcs.), Countries of Western Europe (10 pcs.), Countries of Asia (4 pcs.), Countries of America (2 pcs.), Countries of Africa and the CIS (according to 1 sample).

Table 2. The origin of samples of Hordeum vulgare L. subsp distichum and Hordeum vulgare L. subsp. vulgare.

| Variety          | Origin         | Russia and CIS | Asia | Western Europe | Africa | North America |
|------------------|----------------|----------------|------|----------------|--------|---------------|
|                  | Hordeum vulgare L. subsp. vulgare |                |      |                |        |               |
| pallidum         |                | 11             | 4    | 10             | 1      | 2             |
| ricotense        |                | 2              | 1    | 1              | -      | 6             |
| horsfordianum    |                | -              | 1    | -              | -      | -             |
| paralleum        |                | 2              | 1    | 2              | -      | -             |
| coeleste         |                | -              | 1    | -              | -      | -             |
| trifurcatum      |                | -              | 1    | -              | -      | -             |
| Total            |                | 15             | 10   | 13             | 1      | 8             |
|                  | Hordeum vulgare L. subsp distichum |                |      |                |        |               |
| nutans           |                | 66             | 1    | 42             | -      | -             |
| tonsum           |                | -              | 1    | 1              | -      | -             |
| medicum          |                | 7              | -    | -              | -      | -             |
| persicum         |                | -              | 1    | 1              | -      | -             |
| subnudipyramidat |                | 1              | 1    | -              | -      | -             |
| submedicum       |                | 2              | -    | -              | -      | -             |
| nudum            |                | 1              | -    | 1              | -      | 2             |
| Total            |                | 77             | 4    | 45             | 0      | 2             |

The studied bioresource collection of buckwheat consists of 246 samples belonging to three species of the genus Fagopyrum Mill.: F. esculentum Moench (buckwheat sowing or ordinary); F. tataricum (L.) Gaertn. (buckwheat tatar); F. cymosum Meissn. (buckwheat semi-umbrella) [15]. The largest number of samples belong to the species Fagopyrum esculentum Moench (299 pcs.) - Russia and the CIS countries - 189 pcs., Asia - 36 pcs. and Europe - 4 pcs. (table 3).

Table 3. The origin of the studied samples of three species of genus Fagopyrum Mill.

| Type                  | Origin         | Russia and CIS | Asia | Europe |
|-----------------------|----------------|----------------|------|--------|
| Fagopyrum esculentum (L.) Moench |                | 189            | 36   | 4      |
| Fagopyrum tataricum (L.) Gaertn. |                | 4              | 3    | 9      |
| Fagopyrum cymosum Meissn. |                | -              | 1    | -      |
| Total                 |                | 193            | 40   | 13     |

As a result of multi-year selection assessment of grain samples in the collection nursery on the basis of the main economically valuable traits (productive bushiness, number of grains per ear, weight of grain per plant), source varieties that exceed the standards by 1.5-2 times were identified. They are of great interest for breeding: Triticum aestivum L. - Ishimskaya 98 (Russia), Favorit (Russia), In memory of Vavenkov (Russia), Lutescens 70 (Russia), Ingala (Russia), Tulaykovskaya 105 (Russia), Wold Seeds 1812 (USA), Long 94 -4081 (China), Triso (Germany); Hordeum vulgare L. - Keystone (Canada), Bruce (Canada), Kharkov 111 (Ukraine), Kolchan (Russia) Krinichny (Republic of Belarus), Kimberly (Canada), Runis (Mongolia) (table 4).
Table 4. Source varieties of *Triticum aestivum* L. and *Hordeum vulgare* L. isolated according to the main selection traits.

| Variety (origin),                      | Productive bushiness, pcs. | The number of grains in the ear, pcs. | The mass of grain from the plant, g |
|----------------------------------------|-----------------------------|---------------------------------------|------------------------------------|
| *Triticum aestivum* L.                 |                             |                                       |                                    |
| Primorskaya 39 (Russia) var. lutescens  | 2.8                         | 32.4                                  | 3.2                                |
| Latona (Russia), var. lutescens         | 3.8                         | 45.6                                  | 5.7                                |
| Erythrospermum 51/5 (Russia), var. erythrospermum | 3.9                         | 36.7                                  | 4.4                                |
| In memory of Vavenkov (Russia), var. lutescens | 6.4                         | 40.7                                  | 7.6                                |
| Tulaykovskaya 105 (Russia), var. lutescens | 5.6                         | 55.2                                  | 8.3                                |
| Ishimskaya 98 (Russia), var. lutescens  | 7.7                         | 44.0                                  | 7.9                                |
| Ingala (Russia), var. lutescens         | 5.8                         | 50.6                                  | 9.7                                |
| Lutescens 70 (Russia), var. lutescens   | 6.1                         | 36.7                                  | 6.1                                |
| Iren (Russia), var. miturum             | 5.4                         | 45.5                                  | 8.6                                |
| Favorit (Russia), var. lutescens        | 7.8                         | 41.2                                  | 8.6                                |
| Prokhorovka (Russia), var. lutescens    | 5.4                         | 39.8                                  | 6.2                                |
| Krasnoufimskaya 100 (Russia), var. lutescens | 7.0                         | 40.5                                  | 9.6                                |
| Spartanka (Russia), var. lutescens      | 2.9                         | 38.3                                  | 4.9                                |
| Zimznitsa (Russia), var. lutescens      | 2.9                         | 37.5                                  | 4.5                                |
| Kuma (Russia), var. lutescens           | 3.3                         | 39.6                                  | 4.2                                |
| Long 94-4081 (China) var. erythrospermum | 3.4                         | 53.9                                  | 6.3                                |
| Hubara 1 (Syria), var. graecum          | 4.0                         | 39.9                                  | 4.7                                |
| Triso (Germany), var. lutescens         | 4.2                         | 52.0                                  | 4.5                                |
| Wold Seeds 1812 (CIIIA), var. ferrugineum | 5.6                         | 37.9                                  | 5.8                                |
| Pin Chun 11 (China), var. erythrospermum | 4.8                         | 36.4                                  | 6.1                                |
| Ken Hong 14 (China), var. lutescens     | 3.9                         | 40.2                                  | 4.7                                |
| HCP 05                                  | 0.2                         | 3.2                                   | 0.2                                |
| *Hordeum vulgare* L. subsp. distichum   |                             |                                       |                                    |
| Primorsky 98 (Russia), var. submedicum  | 3.8                         | 19.8                                  | 3.7                                |
| Kharkovsky 111 (Ukraine), var. nutans   | 5.6                         | 26.1                                  | 5.2                                |
| Krinichny (Republic of Belarus), var. nutans | 3.5                         | 22.4                                  | 4.6                                |
| *Hordeum vulgare* L. subsp. vulgare     |                             |                                       |                                    |
| Kolchan (Russia), var. rikotense        | 5.0                         | 48.0                                  | 4.6                                |
| Kimberly (Canada), var. pallidum        | 3.1                         | 46.9                                  | 4.0                                |
| Keystone (Canada), var. rikotense       | 6.3                         | 47.0                                  | 4.7                                |
| Runis (Mongolia), var. pallidum         | 3.8                         | 44.5                                  | 5.1                                |
| Bruce (Canada), var. pallidum           | 5.2                         | 39.7                                  | 4.6                                |
| HCP 05                                  | 0.2                         | 2.0                                   | 0.2                                |

The conducted researches indicate the breeding importance of such productivity elements as productive bushiness, the number of grains per ear, and the mass of grain per plant; therefore, source varieties were purposefully used in hybridization based on these characters [4-5].

As a result of the selection process with the participation of selected varieties sources, highly productive varieties were obtained that provide an increase of 10-20% to the standards: *Triticum aestivum* L. - Nikolskaya (Latona x Eritrospermum 51/5), Primorskaya 222 (Spartanka x Primorskaya 39), Primorskaya 235 (Seaside 50 x Kuma), Seaside 239 (Olympia x Ken Hong 14); *Hordeum vulgare* L. - Seaside 167 (Seaside 5097 x K-19907 x Runis), Primorets (Seaside 5021 x Krinichny), Seaside 212 (Seaside 44 x Keystone) (table 5). The greatest breeding value is represented by the varieties: spring wheat - Nikolskaya, spring barley - Primorets.
Table 5. Characteristics of the varieties *Triticum aestivum* L. and *Hordeum vulgare* L. according to the main breeding and economic characteristics.

| Variety                  | Crossbreeding combination                                                                 | Plants Height, cm | Productive bushiness, pcs. | Number of grains in the ear, pcs. | Mass of grain from a plant, g | Mass 1000 grains, g | Resistance to lodging, score | Yield, t / ha |
|--------------------------|--------------------------------------------------------------------------------------------|-------------------|-----------------------------|-----------------------------------|-------------------------------|---------------------|-----------------------------|---------------|
| Primorskaya39 (st),      | transformation of winter wheat Ilyichevka into spring form                                  | 115.0             | 1.2                         | 28.8                              | 1.2                           | 34.6                | 7                           | 3.7           |
| var. lutescens           | Nikolskaya, var. erythrospermum                                                            | 91.0              | 1.2                         | 27.0                              | 1.4                           | 35.4                | 9                           | 4.0           |
| Primorskaya222, var.     | Spartanka x Primorskaya 39                                                                | 87.9              | 1.5                         | 26.0                              | 1.2                           | 36.8                | 9                           | 4.1           |
| lutescens                | Primorskaya 50 x Kuma                                                                     | 95.0              | 1.3                         | 26.6                              | 1.5                           | 43.0                | 9                           | 4.1           |
| Primorskaya 239, var.    | Olimpiyax Ken Hong 14                                                                     | 74.1              | 1.6                         | 28.0                              | 1.3                           | 37.8                | 9                           | 3.9           |
| lutescens                | HCP 05                                                                                   | 8.0               | 0.1                         | 3.0                               | 0.1                           | 3.0                 | 0                           | 0.2           |
| Primorskii 98 (st),      | K-19362 Sumerimoti (Japan) x Прым 3474) x (K-2938 Shikokunadaka №1 (Japan) x Prim 3541     | 89.4              | 1.9                         | 19.6                              | 1.2                           | 42.3                | 7-8                         | 3.7           |
| var. submedicum          | Primorskii 5097 x K 19907 x Runis                                                         | 91.8              | 2.1                         | 24.0                              | 1.6                           | 40.2                | 7-8                         | 4.0           |
| Primorskii 167, var.     | Primorskii 5021 x Krinichny                                                              | 91.2              | 1.8                         | 22.5                              | 1.8                           | 38.2                | 9                           | 4.6           |
| nutans                                                               | Primorskii 4699 x Kimberly                                                               | 79.2              | 1.5                         | 24.5                              | 1.2                           | 38.1                | 9                           | 4.0           |
| Primorskii 197, var.     | Primorskii 44 x Keystone                                                                   | 78.2              | 1.7                         | 20.8                              | 1.2                           | 40.4                | 9                           | 4.2           |
| nutans                                                               | HCP 05                                                                                   | 8.2               | 0.2                         | 1.8                               | 0.2                           | 2.9                 | 0                           | 0.2           |

In the Far East, buckwheat is cultivated under various environmental conditions; therefore, varieties adapted to abiotic and biotic environmental factors are needed [16].

In this regard, the A.K. Chaika Federal Research Center for Agrobiotechnology of the Far East carries out selection of buckwheat in the direction of obtaining a black-fruited variety with high quality cereals (protein, fat, amino acids, rutin) adapted to waterlogging in the second half of the growing season [16, 17]. For hybridization, valuable *Fagopyrum esculentum* samples were selected from the bioresource collection for fruit coloration, large-fruited, productivity, lodging resistance, high flavonoid content: Bashkir Krasnostebelnaya (Russia), Kitavase (Japan), Krasnotsvetkova (Ukraine), Cheroplodnaya (Republic of Belarus). Particular attention is paid to the selection of the combination of the use of cell breeding in *vitro* culture with hybridization. As a result of multi-year selection work, a promising Ussurochka variety was obtained by the method of hybridization and tissue culture. The new variety is characterized by high productivity (1.4 g), resistance to lodging (table 6).
4. Conclusion

Thus, as a result of studying the genetic resources of spring wheat, spring barley and buckwheat from the VIR world collection, source varieties with valuable breeding and economic characteristics and properties that were selected for use in hybridization to create new highly productive varieties lodging adapted to the conditions of the monsoon climate have been selected. Using the sources and new varieties that were created: spring wheat - Nikolskaya (the variety was obtained by hybridization followed by individual selection of Laton x Erythrospermum 51/5, a variety of erythrospermum). The variety is mid-season, the vegetation period is 83-88 days, resistant to smut and powdery mildew, the average yield is 4.0 t / ha, potential 5.8 t / ha; spring barley - Primorets (variety obtained by hybridization and tissue culture) x Sanle (obtained by hybridization and tissue culture followed by negative selection from the population (Pri7 x Kazan large-fruited) x Sanle -2). It is a mid-season variety, vegetation period is 77 days, resistant to lodging, average yield of 4.6 t / ha, potential - 6.1 t / ha; buckwheat - Ussurochka (obtained by hybridization and tissue culture followed by negative selection from a complex population (Emerald x Chokeberry) x (Emerald x Kitawase in vitro on a selective medium with copper ions) a variant of alata). It is a mid-season variety, vegetation period is 70-75 days, yield - 1.5-1.8 t / ha. Grain color is black and dark brown, the content of rutin in cereal is 9.7 mg / 100g. In 2018, new varieties were transferred to the State variety test in the Far Eastern zone.

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