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VIRUSES OF CEREAL CROPS AND THEIR VECTORS IN THE SOUTH OF THE RUSSIAN FAR EAST

(review)

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Abstract

The review presents data on the current taxonomic status and ecology of 10 viruses infecting cereals (*Poaceae*) in the South of the Russian Far East. Barley stripe mosaic virus (BSMV) (*Virgaviridae*, *Hordeivirus*) is the most common virus affecting about a third of crops (with the exception of oat, which is slightly infected with BSMV). The maize chlorotic stripe disease occurring in Primorye is also etiologically linked with BSMV. Unlike the European part of Russia, Brome mosaic virus (BMV) (*Bromoviridae*, *Bromovirus*) is slightly represented among cultivated cereals in the South of the Russian Far East since there are no its numerous vectors from perennial plants-reservoirs. In the South of the Russian Far East Poa semilatent virus (PSLV) (*Virgaviridae*, *Hordeivirus*) was isolated from wheat (*Triticum* spp.), swamp (*Poa palustris*) and meadow (*P. pratensis*) bluegrass. Vectors for this virus have not yet been established. The epicenter of the Northern cereal mosaic virus (NCMV) (*Mononegavirales*: *Rhabdoviridae*, *Cytorhabdovirus*) strain diversity in the South of the Russian Far East is located in the Amur region whereas in the Primorsky and Khabarovsk territories this virus is much less common. Latently infected perennial wild grasses are a natural reservoir of NCMV that is effectively spread by small brown planthopper (*Laodelphax striatella*). In the body of planthopper NCMV is capable of replication as well as overwintering in larvae. Russian oat mosaic virus (ROMV) (*Bunyavirales*: *Phenuiviridae*, *Tenuivirus*) infects wide range of cereals and is known by several synonymous names. It is possible that at least some variants of this virus are a mixture with phytoplasma. In the Primorye territory this virus is mostly found together with NCMV and is also carried by small brown planthopper. The main vectors of Rice stripe virus (RSV) (*Phenuiviridae*, *Tenuivirus*) in the South of the Russian Far East are small brown and brown (*Nilaparvata lugens*) planthopper as well as rice beetle (*Oulema oryzae*). Rice beetle is a mechanical vector of Rice spotted mosaic virus (RSMV). Far Eastern aphid (*Hemiptera*: *Aphidoidea*) species are vectors of the Maize dwarf mosaic virus (MDMV) (*Potyviridae*, *Potyvirus*) and Barley yellow dwarf virus (BYDV) (*Luteoviridae*, *Luteovirus*). In the rice fields of Primorye 44 species of aphids were identified, among which green com (*Rhopalosiphum maidis*), bird cherry-oat (*Rh. padi*), English Grain (*Sitobion avenae*) and greenbug (*Schizaphis graminum*) aphids dominate. Large foci of diseases caused by Wheat streak mosaic virus (WSMV) (*Potyviridae*, *Tritimovirus*) were found in the far Eastern agrocenoses, which can be transmitted by herbivorous mites (*Trombidiformes*: *Eriophyoidea*). Spider mites (*Trombidiformes*: *Tetranychidae*) are presumably the carriers of BYDV, NCMV, MDMV, and WSMV. The basis of the presented review is the data of long-term (since 1962) regular monitoring of cereal crop viruses carried out by the Laboratory of Virology in the Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch RAS. The strains obtained during this monitoring are stored in the Russian Collection of East Asia viruses (the Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch RAS).

Keywords: plant viruses, cereals, taxonomy, vector, aphid, planthopper, gall mites

The southern part of the Far East is the area of a moderately monsoon extratropical climate, with a flat-ridged relief and accumulative depressions. Soils are of heavy granulometric composition with low water permeability, but regular over-moisture, a small amount of organic matter and phosphorus are common here [1].

Grain crop cultivation has a long history in the region. In the 7th century, commercial grain production was crucial in emergence of Bohai, the ancient state on the territory of Manchuria, Primorye and the northern part of the Korean Peninsula [2]. Since the 10th century, the Jurchen Jin state appears here and the land use system characteristic of China begins to form [3]. Zoning of European grain crops in the Far East began in the 17th century during its active development by the Russian Empire. The expansion of the area of grain crop cultivation falls on the period of P.A. Stolypin's agrarian reform (1906-1913) with a massive re-settlement of peasants to the Far East [4]. Changes in land use patterns were inevitably accompanied by the intensification of intra- and interpopulation interactions, the penetration of new pathogens into the local flora, and the adaptation of natural focal viruses to new crops [5, 6].

The fundamentals of grain production in the Far East developed and put into practice in the USSR, to this day not only provides local needs for grain, but also allows the territory to enter the grain market of the Asia-Pacific region. Spiked cereals (*Poales* Small, 1903: *Poaceae* Barnhart, 1895) cultivated in the Russian Far East are wheat (*Triticum* L., 1753), barley (*Hordeum* L., 1753) and rye (*Secale cereale* L., 1753), and paniculate cereals are rice (*Oryza* L., 1753), millet (*Panicum* L., 1753), oats (*Avena* L., 1753), sorghum (gaoliang) (*Sorghum bicolor* Moench, 1794 subsp. *chinense*), corn (*Zea mays* L., 1753) and plague (*Setaria italica* P. Beauv., 1812 subsp. *italica*). The advanced development of the Far East is associated with an increase in the regional grain production, particularly due to control of viral infections of cereals.

This review uses the data of the multi-year (since 1962) regular monitoring of viruses in cereal crops carried out by the Laboratory of virology of the Federal Research Center of Biodiversity of Terrestrial Biota, Far East Branch RAS (until 2018, the Biology and Soil Institute, the Far Eastern Branch RAS). Isolated viral strains are deposited in the Russian collection of viruses in East Asia (FSC Biodiversity FEB RAS) [7-9].

From 1962 to 2019, the prevalence of virus-like diseases in plot crops and breeding nurseries of the Primorsky and Khabarovsk territories was significantly higher than in industrial crops: 0.2-1.9% vs. 0.01-0.03% for wheat, 0.3-2.5% vs. 0.02-0.8% for barley, 0.3-6.0% vs. 0.05-0.4% for oats, 0.7-14.0% vs. 0.06-0.7% for corn, and 0.02-0.1% for rye (no industrial rye crops in the south of the Far East). The differences are associated with more favorable conditions for infection spreading in plots due to small area, thinness of crops, easier access for insects, increased risk of mechanical spread of infections. The maximum infection extensiveness both in nurseries and in row crops is typical for the Amur Region, where the most common members of the *Virae* kingdom that infect cereals are Barley stripe mosaic virus (BSMV) (*Virgaviridae*, *Hordeivirus*), Brome mosaic virus (BMV) (*Bromoviridae*, *Bromovirus*), Russian oat mosaic virus (ROMV) (*Bunyavirales*: *Phenuiviridae*, *Tenuivirus*) and Northern cereal mosaic virus (NCMV,) (*Mononegavirales*: *Rhabdoviridae*, *Cytorhabdovirus*). In some agrocenoses, large foci of diseases caused by Wheat streak mosaic virus (WSMV) (*Potyviridae*, *Tritimovirus*) and Poa semilatent virus (PSLV) (*Virgaviridae*, *Hordeivirus*) are found. Mixed infections of up to three or four viruses are widespread [10-15].

BSMV is the most common cereal virus in the south of the Russian Far

East, with about a third of crops (especially a small area) affected. In plots, the rate of BSMV infection in wheat is 2-5 times less than in barley. Oats are slightly affected by BSMV, regardless of the variety. BSMV is easily spread through contacts and seeds [13, 15]. A wide variety of strains of this virus is noted in both wild and cultivated phytocenoses [16, 17]. It has been shown that BSMV is the etiological agent of maize chlorotic stripe disease widespread in the Far East; damage of plants by BSMV results in a decreased seed setting and ugly ears [18-20].

Reconstruction of BSMV molecular evolution using barley seeds from archaeological excavations shows that at least 2000 years ago, the predecessor of this virus emerged in North Africa and the Middle East [21]. Apparently, it initially circulated in the natural area of wild barley (*Hordeum vulgare* L., 1753) [22]. Smith et al. [21], basing on the data of phylogenetic position analysis of modern Chinese line BSMV [23-26] widespread in East Asia, assumed that medieval BSMV strains penetrated here in the 13th-15th centuries due to intensified traffic along the Great Silk Road under the control of Mongol Empire [27]. Note, however, that barley was known on the Korean Peninsula in the ancient Ko Choson state at the beginning of the 1st millennium [28, 29]. Possibly even more ancient BSMV genetic lines have survived in East Asia, and their detection is most likely in the south of the Russian Far East, which historically was somewhat isolated although influenced by China [2, 3].

The stripe mosaic, etiologically associated with BMV and widespread on cereals in the south of the European Russia [30, 31], is insignificant in the south of the Far East (no more than 5% of the total plot number) [32]. Since the virus is mainly transmitted mechanically, without a massive vector, the efficiency of BMV spreading from perennial reserve plants to cultivated cereals is low. In the Far East, such reserve plants are awnless rump (*Bromopsis inermi*s Leyss., 1761), creeping wheatgrass (*Elytrigia repens* Desvaux ex Nevski, 1933), Siberian graybeard (frost grass) (*Spodiopogon sibiricus* Trinius, 1820), Langsdorf's reed grass (*Calamagrostis langsdorfii* Trinius, 1824), cock's millet (*Echinochloa crus-galli* Beauvois, 1812), and timothy grass (*Phleum pratense* L., 1753). Wheat is most affected by this virus (up to 50% of diseased plants), barley and oats are affected insignificantly [32].

PSLV was first discovered in slender wheatgrass (*Elymus trachycaulus* Gould ex Shinners, 1833) and fowl bluegrass (*Poa palustris* L., 1759) in Canada [33]. Wheatgrass (*Elymus* L., 1753) and bluegrass (Poa L., 1753) are widespread in the extratropical zones of both hemispheres of the Earth. In the south of the Russian Far East, PSLV was isolated from wheat, fowl bluegrass, and Kentucky bluegrass (*P. pratensis* L., 1753). The virus was identified immunochemically with polyclonal antibodies (provided by the Department of Virology of the Lomonosov Moscow State University). Given possible serological cross-reactivity between various members of *Hordeivirus*, the independent taxonomic status of the Far Eastern PSLV strains cannot be ruled out. The PSLV vectors have not been identified, and its distribution occurs by contact [13, 14].

The NCMV strain diversity epicenter in the Far East is in the Amur Region while in Primorsky and Khabarovsk territories, this virus is much less common [11, 12]. NCMV is effectively spread by small brown planthopper (*Laodelphax striatellus* Fallen, 1826). Complex relationships between thee planthoppers and the plant communities determine how the virus spreads. NCMV replicates directly in the vector, making the infected insect a permanent (up to death) source of infection; in addition, due to high mobility of the vector species, each individual can infect a large number of plants [11, 34, 35]. The pathogen overwinters in infected larvae. A significant part of perennial grasses is resistant to NCMV. So, according to Mamaev [11], in a latent form and to an insignificant

extent, redtop (*Agrostis gigantea* Roth, 1788), creeping bentgrass (*A. stolonifera* L., 1753), meadow foxtail (*Alopecurus pratensis* L., 1753), American sloughgrass (*Beckmania syzigachne* Fernald, 1928), chee reedgrass (*Calamagrostis epigeios* Roth, 1788), and blue-joint reedgrass [*C. canadensis* (Michx.) P. Beauv. var. *langsdorffii* (Link) Inman]. The NCMV spreading largely depends on the characteristics of agrocenoses. For example, in the Amur Region, where cereals are grown on vast areas without natural barriers, the infection is restrained only by entomophages and agrotechnical methods that reduce the number of small brown planthopper [36]. In Primorsky and Khabarovsk Territories, the NCMV spreading is limited by natural barriers, as the fields are located among forests, their areas are significantly inferior to those in the Amur Region, and the planthoppers-vectors reproduce much less intensively. If in the Amur Region in August 1000-1500 planthoppers are caught for 100 strokes of the net on annual cereals and fodder oats, while in the Primorsky and Khabarovsk territories there are only 30-40 individuals [11]. The low NCMV prevalence in Primorye is apparently due to the less favorable pronounced monsoon climate conditions. In addition, in most parts of the Primorsky and Khabarovsky territories, winter forms of cereals are absent. This undermines the food supply of the coastal aphids in the early spring and late autumn periods.

As to ROMV, the history of its study and common synonyms should be taken into account. The virus was described by Sukhov [37] in 1940 as a cereal pupation (pseudo-roset) virus. Later Fedotina [38] found bacilli-like viral particles and phytoplasmas (*Acholeplasmatales*: *Acholeplasmataceae*) in diseased plants and assumed a mixed etiology of the disease. Further studies did not add the understanding of the pathogen taxonomic affiliation (some authors attributed it to tenuiviruses, others to phytorabdoviruses), and, moreover, further confused the situation due to using synonymous names, e.g. oat pupation (pseudo-roset) virus, barley pupation (pseudo-roset) virus, wheat pupation (pseudo-roset) virus, etc. At present, this virus, which infects a wide range of cereals, causing dwarf bushiness, is called ROMV [39]. However, a mixed infection of ROMV with phytoplasmas cannot be ruled out, for which a plant bushiness (multi stemmed plants) is characteristic. In the Primorsky Territory, ROMV mostly occurs together with NCMV and is also transmitted by small brown planthopper [12, 38, 40]. A distinctive feature of tenuiviruses is the synthesis of a large amount of the so-called soluble antigen, a low-molecular-weight protein that forms loop-shaped intracellular inclusions [41]. Therefore, the isolation by Sukhov [37] of a “soluble antigen” from plants “sick with bulging” (according to the author’s definitions) indicates that the pathogen he studied belongs to tenuiviruses, while different morphology of the particles indicates a concomitant infection. Since the symptom complex of cereal diseases does not allow an unambiguous identification of the pathogen (especially in mixed infections common for this group of plants), viral isolates can differ significantly.

Another tenuivirus, Rice streak virus (RSV) (*Phenuiviridae*, *Tenuivirus*), was discovered in Primorsky Krai [10]. In the lab tests, RSV was successfully transmitted by small brown planthopper. Among the vectors in the Primorsky Territory, brown planthoppers (*Nilaparvata lugens* Stal, 1854) are of great importance. In total, 47 species of planthoppers (*Hemiptera* L., 1758: *Cicadellidae* Latreille, 1802) were identified in the rice paddies of Primorye. It is known that tenuiviruses can reproduce in insect tissues and are transmitted transovarially [42, 43].

Rice leaf beetle (*Oulema oryzae* Kuwayama, 1931) which in the south of the Russian Far East for a long time was mistakenly associated with red-throated cereal leaf beetle (*Oulema melanopus* L., 1758), is apparently another RSV vector

in the region. In this case, the virus is transmitted by a non-persistent route. In addition, this leaf beetle is a vector of another and yet unidentified Rice spotted mosaic virus (RSMV) which causes panicle deformation (axial shortening and pubescence) [10].

Aphids (*Hemiptera*: *Aphidoidea* Latreille, 1802) have been pests of cultivated crops and effective vectors of plant viruses since the beginning of arable farming. The richest species diversity of cereals and various ecological condi-tions for their growth have been the prerequisites for the equally diverse aphid fauna of cereal plants [44, 45]. These insects have moved to grain crops from their wild relatives, the natural reservoirs of many plant viruses, and retained trophic links with them [46, 47]. However, there are few cereal viruses transmitted by aphids. Of these, the most well-known and harmful are Maize dwarf mosaic virus (MDMV) (*Potyviridae*, *Potyvirus*) and Barley yellow dwarf virus (BYDV) (*Luteoviridae*, *Luteovirus*), causing large losses in cereal crops in the south of the Russian Far East [48-51] and neighboring countries, i.e. China and Japan [52-55]. Fifteen to twenty species of the Far Eastern aphid fauna are vectors of these viruses, among which the most significant are bird cherry-oat aphid (*Rhopalosiphum padi* L., 1758), corn leaf aphid, or corn aphid (*Rh. maidis* Fitch, 1856), wheat aphid (Sitobion avenae Fabricius, 1775), and greenbug (*Schizaphis graminum* Rondani, 1852). Currently, we have found BYDV in oats and barley plants in all regions of the south of the Russian Far East [7-9].

Our surveys of the aphid fauna in rice fields with the identification of vectors and the pathways for their possible migration in the Primorsky Territory (Far Eastern Experimental Rice Station, Spassky District; Sivakovskoe Rice Farming, Khorolsky District) and in forbs near rice fields revealed 44 species. Of these, 35 species (80%) are occasional visitors to rice plants and rice field weeds, and the 10 species are direct inhabitants and crop pests, i.e. dogwood-grass aphid (*Anoecia corni* Fabricius, 1775), rose-grass aphid (*Metopolophium dirhodum* Walker, 1849), apple-grass aphid (*Rhopalosiphum insertum* Walker, 1849), green corn aphid (*Rh. maidis*), waterlily aphid (*Rh. nymphaeae* L., 1761), Bird cherry-oat aphid (*Rh. padi*), greenbug (*Schizaphis graminum*), grain aphid (*Sitobion avenae*), elm sack gall aphid (*Tetraneura ulmi* L., 1758), and mealy plum aphid (*Hyalopterus pruni* Geoffroy, 1762). In rice plants, four of these aphidids dominate, the *Rh. maidis*, *Rh. padi*, *S. avenae*, and *Sch. graminum*. As for *H. pruni*, the species is not the most abundant in rice crops, but, apparently, can colonize it. By chance, polyphagous aphids, which generally develop on other fodder plants, can occasionally appear on rice plants, e.g. green peach aphid (*Myzodes persicae* Sulzer, 1776), cabbage aphid (*Brevicoryne brassicae* L., 1758), melon aphid (*Aphis gossypii* Glover, 1877), cowpea aphid (*A. craccivora* C.L. Koch, 1854). All of these aphids are virophorous (transmitting RSMV), which aggravates their harmfulness [13, 56, 57].

Currently, in the Primorsky Territory, the rice crops lost in the 1980s and 1990s are being restored. However, on abandoned rice paddies, wild phytocenoses with their vectors of plant viruses have formed, and in each case, special approach is required to assess harmfulness and prevalence of infectious agents [58]. The constantly increasing cargo and passenger flow between the Russian Federation and the People's Republic of China creates additional risks of the penetration of Chinese rice viruses into the Russian Far East [59-61]. Therefore, ecological and virological monitoring must be more strict, including tracking diversity of the rice viruses that have not yet been detected in the south of the Russian Far East, i.e. the Rice dwarf virus (RDV) (*Reoviridae*, *Phytoreovirus*) (62), Rice gall dwarf virus (RGDV) (*Reoviridae*, *Phytoreovirus*) [63], Rice bunchy stunt virus (RBSV) (*Reoviridae*, *Phytoreovirus*) [64], Rice ragged stunt virus (RRSV) (*Reoviridae*, *Oryzavirus*)

Taxonomic description and ways of spreading viruses of cereal crops in the south of the Russian Far East

Taxonomic position			Name	Typical transmission ways
order	family	genus		
Incerti ordinis	*Bromoviridae*	*Bromovirus*	Brome mosaic virus (BMV)	By contacts
Incerti ordinis	*Luteoviridae*	*Luteovirus*	Barley yellow dwarf virus (BYDV)	By aphids *Rhopalosiphum padi*, *Rh. maidis*, *Schizaphis graminum*, *Sitobion avenae*
Bunyavirales	*Phenuiviridae*	*Tenuivirus*	Russian oat mosaic virus (ROMV)	By small brown planthopper (*Laodelphax striatella*)
			Rice stripe virus (RSV)	By small brown planthopper (*Laodelphax striatella*), brown planthopper (*Nilaparvata lugens*), and rice leaf beetle (*Oulema oryzae*)
Incerti ordinis	*Potyviridae*	*Potyvirus*	Maize dwarf mosaic virus (MDMV)	Via seeds, by contacts and aphids (*Myzodes persicae*, *Brevicoryne brassicae*, *Aphis gossypii*, *A. craccivora*)
		Tritimovirus	Wheat streak mosaic virus (WSMV)	By contacts and mites *Aceria tosichella*, *A. tulipae*, *A. tritici*
Mononegavirales	*Rhabdoviridae*	*Cytorhabdovirus*	Northern cereal mosaic virus (NCMV)	By small brown planthopper (*Laodelphax striatella*)
Incerti ordinis	*Virgaviridae*	*Hordeivirus*	Barley stripe mosaic virus (BSMV)	Via seeds, by contacts
			Poa semilatent virus (PSLV)	By contacts
Incerti ordinis	*Incertae familiae*	*Incerti genus*	Rice spotted mosaic virus (RSMV)	By rice leaf beetle (*Oulema oryzae*) and aphids *Myzodes persicae*, *Brevicoryne brassicae*, *Aphis gossypii*, *A. craccivora*

N o t e. Taxonomic groups are sorted in alphabetical order of family names, since not all viruses have order-level taxonomic status. Rice spotted mosaic virus (RSMV) that is not currently classified is the last in the list.

Oryzavirus) [65], Rice black streaked dwarf virus (RBSDV) (*Reoviridae*, *Fijivirus*) [66], Southern rice black streaked dwarf virus (SRBSDV) (*Reoviridae*, *Fijivirus*) [66], Rice grassy stunt virus (RGSV) (*Bunyavirales*: *Phenuiviridae*, *Tenuivirus*) [67], Rice yellow stunt virus (RYSV) (*Mononegavirales*: *Rhabdoviridae*, *Nucleorhabdovirus*) [68], Rice tungro bacilliform virus (RTBV) (*Caulimoviridae*, *Tungrovirus*), Rice tungro spherical virus (RTSV) (*Picornavirales*: *Secoviridae*, *Waikavirus*) [69].

Gall four-legged mites (due to reduction of the posterior pair of limbs at postembryonic stages) (*Trombidiformes* Reuter, 1909: *Eriophyoidea* Nalepa, 1898) [70] are vectors of WSMV. The mites themselves are microscopic in size (~ 0.1 mm), but the colonies they form are clearly distinguishable visually. The main vector for WSMV is wheat curl mite (*Aceria tosichella* Keifer, 1969) [71-73] (synonyms dry bulb mite *A. tulipae* Keifer, 1938 and wheat curl mite *A. tritici* Shevtchenko, 1970) [73].

Among vectors of cereal viruses, spider mites (*Trombidiformes*: *Tetranychidae* Donnadieu, 1875) should be noted [74]. Robertson and Carroll [75] described the transmission of Barley yellow streak mosaic virus (*Mononegavirales*: *Rhabdoviridae*, *Cytorhabdovirus*) by brown wheat mite (*Petrobia latens* Muller, 1776) in barley crops in Canada and the United States. Later Smidansky and Carroll [76] confirmed rapid reproduction of the virus in imagoes and preimagoes of *P. latens*, and also showed the transovarian transmission.

The field detection of spider mites is difficult due to their small size (~ 0.5 mm), whereas the symptoms they cause per se resemble a virus-induced pathology (chlorotic spots, yellowing of veins, twisting of the leaf blade). In Primorsky and Khabarovsk territories, strawberry spider mite (*Tetranychus turkestanicus* Ug. et Nik.) and European red spider mite (*Panonychus ulmi* Koch, 1836) are widespread, which, being polyphagous, often invaded cereal plants and can presumably be BYDV, NCMV, MD and WSMV vectors. Spider mites are easily moved by the wind, which enhances spread of plant viruses [5]. It cannot be ruled out that a deeper study of tetranichids will contribute to our understanding of their role as pathogen vectors during viral infections in plants.

Summarizing, we note that in phytocenoses of the southern Russian Far East, 10 viruses have been described that infect cereal plants (Table). Their strains have been deposited and preserved in the Russian collection of viruses in East Asia (Laboratory of virology of the Federal Research Center of Biodiversity of Terrestrial Biota of East Asia, Far East Branch RAS) [7-9].

Thus, in the southern part of the Russian Far East, cereal viruses have been regularly monitored since 1962. The strains isolated during the monitoring are stored in the Russian collection of viruses in East Asia (FSC of Biodiversity of Terrestrial Biota of East Asia, FEB RAS). In this review, we mainly focused on data on the current taxonomic status and ecology of the following viruses infecting cereals in the region: Barley stripe mosaic virus (BSMV), Brome mosaic virus (BMV), Poa semilatent virus (PSLV), Northern cereal mosaic virus (NCMV), Russian oat mosaic virus (ROMV), Rice stripe virus (RSV), Rice spotted mosaic virus (RSMV), Maize dwarf mosaic virus (MDMV), Barley yellow dwarf virus (BYDV), and Wheat streak mosaic virus (WSMV). Prevalence of the viruses and their vectors shows that in the agrocenoses of Primorye, the epiphytotic situation for cereals is relatively favorable, while in the Khabarovsk Territory and in the Amur Region it is much more tense. Special attention should be paid to monitoring of both agro- and wild phytocenoses for preventing the spread of viral diseases.

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