

***Malva verticillata* L. and *Vicia hirsuta* (L.) S.F. Gray - invasive Species of Siberia (Overview)**

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The article provides an overview of information on the two invasive species of Siberia that are weeds of crops - *Malva verticillata* L. and *Vicia hirsuta* (L.) S.F. Gray. It provides information on the distribution of species, morphology, biological and ecological characteristics. Active ability of *Vicia hirsuta* to spread with the seed of oil plants and honey plants was revealed. The possible consequences of the introduction in natural plant communities are shown. The possibility of the practical use of these species as fodder, food and medicinal plants is considered.

Key words: invasive species, *Malva verticillata*, *Vicia hirsuta*, Siberia, distribution, speirochoria.

Currently, weed-field (segetal) plant species are an important component of agrocoenosis in Russia. Species composition and abundance of weeds in agricultural crops largely determine the efficiency and quality of the crop production. Weeds are an annual permanent factor that reduces the yield of economically valuable products, such as cereals - by 20-25%, and vegetables - by 50%. Major changes in farming systems and technologies of cultivation of agricultural crops in Western Siberia that have taken place in recent decades could not affect the change of segetal vegetation and especially the species composition of weeds (Vlasenko *et al.*, 2007). It should be noted that the recent extensive studies of weeds in agrocoenosis of Tomsk region were conducted in 50th of XX century (Polozhij, 1954). There is an acute problem of penetration in various ways new weeds, including invasive species.

The problem of invasive species is one of the most actual in the biology and ecology

(D'Antonio, Meyerson, 2002; Richardson *et al.*, 2007). It is known that invasion of the invasive species leads to a reduction of biological diversity (Hejda, Pysek, 2006; Winter *et al.*, 2009). However, the invasion of "harmful" alien species caused great damage not only to natural ecosystems, but also to the economies of developed and developing countries (Pimentel *et al.*, 2001, 2005; Nghiem *et al.*, 2013). In recent years, the interest to the study of invasive plant species in the European part of Russia has significantly increased. In particular, the evidence of this are the recently published monograph, "Black Book of flora of Central Russia" (Vinogradova *et al.*, 2010), "Black Book of flora of the Tver region" (Vinogradova *et al.*, 2012) and others. In the Asian part of Russia, including Siberia, such work is only beginning. One of the first results is a recently published list of invasive and potentially invasive plant species of the Siberian Federal District (Ebel *et al.*, 2014).

The present report summarizes two invasive species, previously widely grown in culture, and now actively spread over the southern regions of Siberia and often infests crops.

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MATERIALS AND METHODS

Review the information on the two types of invasive species in Siberia – *Malva verticillata* L. and *Vicia hirsuta* (L.) S.F.Gray is based on the analysis of the field data, herbarium material and literature databases on weedy and invasive plants. We studied herbarium materials of these types stored in the herbarium of Tomsk institutions (P.N. Krylov Herbarium, TK), Novosibirsk (Herbarium of the Central Siberian Botanical Garden, NS; M.G. Popov Herbarium, NSK), Barnaul (Herbarium of the Altai State University, ALTB), Kemerovo (Kuzbass Botanical Garden Herbarium, KUZ) and Krasnoyarsk (Herbarium of the Krasnoyarsk pedagogical University, KRAS). We collected and analyzed information about the new location that was discovered in the last decades on the territory of Siberia.

Field floristic studies were carried out in 1990-2015 years in Siberia (Tomsk Region, Kemerovo Region, Novosibirsk Region, Altai Territory, Republic of Altai, Republic of Khakassia).

Infestation of the 50 seed lots of oil plants and honey plants (*Brassica napus*, *Phacelia tanacetifolia*, *Sinapis alba*) by weeds was studied. Seeds from each batch of primary cultures were taken in average sample weight of 1 to 2 kg from which we allocated all weed seeds. Identification of weed species was carried out with the main morphological characters of fruits, whole seeds and partially collapsed seeds (Maisuryan, Atabekova, 1978; Brouwer, Shtelin, 2010).

RESULTS

Malva verticillata L. (*M. pulchella* Bernh., *M. mohileviensis* Dvornar)

Annual plant 35-150 cm tall. Stems are solitary or few in number, straight or ascending, usually branched, glabrous or pubescent in the upper part. Leaves are long, petioles are usually 2-5 times the length of the plate, hairy. The plates are 3-7 cm long and 4-12 cm wide, kidney-shaped, at the basis deeply cordate, 5-7-lobed, crenate-toothed on margin, glabrous or sparsely hairy, usually in the bottom are along veins pubescent, rarely glabrous or with a few simple, bifurcated or stellate hairs. Flowers are numerous, almost sessile, clustered in the glomeruli in the leaf axils. Calyx is

divided into 5 ovate-triangular pointed stakes, covered with long simple and short stellate hairs. Corolla is 1.5-2 times higher than the calyx, purple and violaceous in the dry state. Petals are 6-8 mm long, obovate, notched, fringed at the basis. Staminate tube is with directed downward hairs. Fruitlets in number 10-11 are assembled in a circle with a diameter of 7-10 mm, with bare dorsally wrinkled walls (Vlasova, 1996).

It is a very polymorphic species, sometimes is divided into several intraspecific taxa, to which some researchers give the species rank (Danert, 1966). One of these taxa is *M. verticillata* var. *neurolooma* Schlecht. (= *Malva mohileviensis*) characterized by long petiolate leaves with shallow-cordate at the base plates and flat on the edge of the obtuse lobes S.K. Cherepanov (1995) considered *M. mohileviensis* as synonymous of the Linnaean species *Malva verticillata*. However, according to the “Flora of Eastern Europe”, the real *M. verticillata* in Siberia is missing: here is widely spread another species, formerly known as *M. mohileviensis*, but his priority name is *M. pulchella* (Olyanitskaya, Tzvelev, 1996). Later, one of these authors (Tsvelev, 2000), considered more appropriate to relegate *M. pulchella* to subspecies: *Malva verticillata* subsp. *pulchella* (Bernh.) Tzvel. In modern nomenclature databases (The Plant List, 2013; Tropicos..., 2015) and floristic reports (Majevski, 2006; Ya *et al.*, 2007; Majorov *et al.*, 2012) the name of *M. pulchella* is reduced to synonyms for the name *M. verticillata*.

The homeland of *M. verticillata* L. is probably China (Olyanitska, Tsvelev, 1996). Secondary area includes temperate and subtropical areas of Eurasia, North America, Africa, Australia (Kloot, 1983; Ya *et al.*, 2007; Randall, 2012). It is widely distributed in North America (PLANTS Database, 2015) where it is considered as an invasive species (Ya *et al.*, 2007).

In Europe, *M. verticillata* is one of the diagnostic species of class *Stellarietea mediae* Tx. *Et al.* ex von Rochow 1951 (Mucina, 1997), which includes segetal and ruderal communities of annual plants, representing the initial stages of restoration succession after disturbance of the soil cover.

In Siberia, the species was first found in 1896 in Tomsk (Krylov, 1933). In Western Siberia until recently it was known to relatively few locations in the Omsk, Novosibirsk, Tomsk,

Kemerovo and Altai regions (Koroleva *et al.*, 1973; Vlasova, 1996; Krasnoborov, 2001; Silantieva, 2006; Shaulo *et al.*, 2010). Now it is a fairly common weed in the south of Western Siberia, where it grows in gardens and orchards, landfills, wasteland, railway embankments, roadsides (Ebel, 2012).

In the last quarter of the XX century *M. verticillata* was found in Khakassia (Serykh, 1977, Ebel, Nekratova, 1996). Recently it was recorded for Tuva (Shaulo *et al.*, 2006). In addition, this mallow is quite widespread in the southern regions of Eastern Siberia (Vlasova, 1996), where it appeared near the middle of the XX century (Popov, 1957). Probably, now *M. verticillata* is actively expanding its range. There is a possibility of penetration with seeds of cultivated plants. In areas where *M. verticillata* is cultivated as a forage plant, it may run wild.

Malva verticillata is an annual plant of a spring type. It is a mesoxerophyte. The plant developed slowly during germination - booting stage, which lasts 35-40 days. Since the phase of budding the growth is accelerating. In the flowering period (July-September) it generates greater assimilation surface (41.8 thousand. m²/ha) and has a high rate of net photosynthetic productivity (4.22 g/m²) (Rakhmetov, 1993). The species is cross-pollinated, and is propagated by seeds. Under the conditions of forest-steppe of Ukraine it is necessary 64-69 days for fruiting. Under the conditions of the south of Tomsk region, the length of the vegetation period is 80-90 days. Seeds have a large embryo and endosperm. Freshly harvested seeds are in a state of physical dormancy caused by water resistance of the seed coat (Nikolaev *et al.*, 1985). To interrupt the dormancy it is necessary processing them through scarification. According to our data the seeds of *M. verticillata* collected in Khakassia in 2014 (Shirinsky district, village Efremkino) after 6 months of a dry storage at room temperature have a high viability (95%). Germination of non-scarified seed was 29%, and scarified ones - 84%.

M. verticillata is actively spreading on fallow lands. High seed production and the presence of physical dormancy ensure the creation of long-term soil seed bank.

Because of its high yields of aboveground mass and capacity for intensive wear of soil nutrients (nitrogen, potassium, calcium and

phosphorus), this species can greatly impoverish the soil (Kasarin *et al.*, 2009).

Along with the negative consequences of the spread of *M. verticillata* in Siberia, it should be noted also the possibility of practical use of this species. *M. verticillata* is a promising fodder crop; it can be used for hay, hay meal and grass meal (Kasarin *et al.*, 2009). The grass meal contains a lot of carotene (11-20 mg%), protein (20%) and minerals and nutritional value of 1 kg of the flour is 0.7-0.8 feed units. 100 kg of green mass contains up to 22-24 fodder units and about 3-4 kg of digestible protein, or from 116 to 180 g per fodder unit. The digestibility of the protein is 75.0%, fat - 28.6%, fiber 33.0%, nitrogen-free extractive substances - 65.6%, and organic substances - 57.6%. Mallow seeds containing 20% oil are used as cattle feed. Milled or steamed seeds are recommended in as feed for pigs, and dry intact seeds - for birds. In its pure form mallow ensiled bad, especially in the early stages of the plant development, so for silage it is suitable only in fruiting stage when the actual sugar content exceeds the minimum sugar. Inclusion in the diet of lactating cows to 20 kg of the mallow silage increases milk production (0.4-0.5 kg per day), milk fat, and weight gain of the animals. Mallow is an excellent protein component for making different kinds of mixed silage (Kshnikatkina *et al.*, 2005).

In the N.N. Grishko National Botanical Garden of National Academy of Sciences of Ukraine the biological basis for the introduction and cultivation of mallow were developed, as well as highly resistant sorts based on this species and its hybrids were created - these are 'Silva' (*M. pulchella*), 'Ryuzana' (*M. meluca* Graebn. × *M. pulchella*), 'Nicka' (*M. pulchella* × *M. crispa* L.). These sorts are characterized by high yield aboveground biomass (from 54.6 to 99.8 t/ha), a valuable chemical composition (protein content - 12,1-25,6%, ascorbic acid - 181,7-353,0 mg%) and provide a way out of absolutely dry matter from 11.46 to 21.33 t/ha of fodder units - 10,08-17,49, protein - 1,92-2,64 t/ha. Species have high seed yield (1,23-2,13 t/ha) and a reproduction rate (242-355) (Rakhmetov, 2001).

The aboveground portion of *M. verticillata* is rich in polysaccharides. Seeds contain fatty oil, polysaccharides, flavonoids, tannins and terpenoids (Vegetable..., 1986;

Enkhmaa, 2005).

Medications from the above-ground portion of *M. verticillata* have anti-inflammatory activity, immune stimulating and diuretic (Enkhmaa, 2005). Mallow herb is a part of traditional Tibetan recipes: Jamba-6, Sema-3, Altan els-8, Buurnii arur-18, Jamba-2, Sojid, Sugmel-10, Umodeujin-24, Vanlag-37, Goui-5, Zagtar-7, Sembu-11, Serjijima-13, Arur-15 (Medicinal..., 2013).

The extract derived from seeds of *M. verticillata* is promising for the treatment of metabolic diseases, including type II diabetes and hyperlipidemia (Tomoda *et al.*, 1991; Jeong *et al.*, 2011). Leaves and flowers should be used as an emollient, for gargling and poultices (Vegetable ..., 1986).

Vicia hirsuta(L.) S.F. Gray

Annual plant 20-90 cm in length. Stems are quadrangular, branched from the base, prostrate or ascending, pubescent, thin. Leaves having 4-8 pairs of linear leaflets 5-20 mm long, 1-3 mm wide, on the top truncated, with a wide tip, notched or rounded, bare or hairy beneath. The axis of the leaf ends with branched tendril. Lateral veins are inconspicuous. Stipules semisagittate, its lobes are narrow linear or broadly lanceolate. Peduncles are longer than leaves, from sinuses of which they emerge. Raceme is 3-5-flowered. Flowers are small, 3-4 mm long, whitish with purple spots. Calyx teeth are of equal long, subulate, acute, nearly equal to the corolla. Banner is widely clawed, bent from the keel and is slightly longer than the latter. The column is compressed from the back, bared. Mature beans are brown-black 8-10 mm long, 3-4 mm wide, rhombic, densely hairy, 2-seeded (Nikiforova, 1994). Seed is 2-2,8 mm in length and width 1.8-2 mm thick, round-flattened or thickened-lenticular. Cicatrix is linear, 2 mm in length equal to 1/3 of the circumference of the seed. Often there is a brown cicatrix cord with a length of 2 mm. The surface is a light-gray-green, dark brown and black spots, shiny, smooth (Brouwer, Staehelin, 2010).

Vicia hirsuta has a Western Palearctic area covering Europe, West Asia and North Africa (Fedtschenko, 1934). To date the species is distributed almost all over the globe due to its introduction in the culture as fodder plant, as well as by inadvertent penetration with the seeds of cultivated plants. So, in the northeast of North America (Canada, Quebec) this species was

recorded already in 1861, but the way of its penetration is unknown (Lavoie *et al.*, 2012). The most likely way to spread is by speirochoria. *Vicia hirsuta* was widespread in crops of winter crops in Belarus in the 30s of the last century, virtually disappeared in 50 years. Its disappearance of crops is associated with the improvement of treatment of seeds and farming. It was also affected by the changes in the structure of sown areas in the post-war years (reduction of grain and flax, the expansion of cultivated) and increased use of herbicides 2,4-D group, 2M-4Ch, simazine and others (Soroka *et al.*, 2011).

In Central Europe *Vicia hirsuta* is one of the diagnostic species of alliance Scleranthion annui (Kruseman et Vlieger 1939) Sissingh in Westhoff *et al.* 1946 - community of crop weeds that are usually formed in acidic nutrient-poor soils in cool areas with high rainfall (Lososova *et al.*, 2006; Chytrý, 2009). The species is a widespread weed in the European part of Russia (AgroAtlas, 2009). In some areas of the European part of Russia (for example, in the Ryazan region) *V. hirsuta* belongs to the group of adventitious species that actively settled and naturalized by anthropogenically disturbed habitats (Khorun, Kazakova, 2013). In the eastern part of Primorye Territory (Far East) in secondary habitats far from human dwellings (slopes of roads, quarries, etc.) many communities of different species *Vicia* («the kingdom of vetches») including *V. hirsuta* are widespread (Ulyanova, 2005).

In Siberia, the species was first found in 1885 in Tyumen Region. In 1912, the species was found in the Tomsk Region, and later - in the Omsk Region and Irkutsk Regions (Krylov, 1933). By the 60th years of XX century *V. hirsuta* was found in the Novosibirsk Region, Krasnoyarsk Territory and Buryatia (Sergievskaja, 1964).

The first mention of the species growing in the Altai, without specifying the exact location, was appeared in "Flora of the USSR" (Fedtschenko, 1948). Now the species is found in the western part of the Altai Territory albeit rarely. In the eastern part of the region until recently it was known only in the Altai district (Silantieva, 2006). The new location of *V. hirsuta* in Altai Territory and Republic of Altai, discovered in recent years (Zykova, 2012, 2015), indicate a further dispersal of the species in Altai. Now this species

is distributed in all regions of Siberia, except the Arctic (Nikiforova, 1994; Yakovlev, Sytin, Roskov, 1996). In the north-western part of the Altai-Sayan province species grows in a number of botanical-geographical districts: common in the Kuznetsk Basin and Kolyvan-Tomsk plateau; rarely - in the Northwest Altai, Nazarovsky-Minusinsk Basin and Salair Ridge (Ebel 2012).

At the beginning of the XX century, only two locations of this species on the territory of the Tomsk region were known (Krylov, 1933). In 50s of XX century, it was first discovered in the territory of Shegarsky and Molchanovskiy districts, where it was stated as a rare weed in cereal crops (Kachaeva, 1950). A.V. Polozhij (1954) listed it among weed species of the Tomsk region that occurring sporadically in agricultural crops. In our study of households of Tomsk Region in 2003-2005, *Vicia hirsuta* was detected in several administrative districts in the crops of oilseeds (Rape, Camelina, Wild Turnip, White Mustard). Currently, it is quite common in all parts of the Tomsk region, where there is the development of crop production. As invasive weed it is found in crops of spring and winter crops, on the outskirts of the fields on deposits, roadsides. In the south of Tomsk Region it has been repeatedly noticed in the meadows.

Now in Siberia a regularly penetration of seeds of *V. hirsuta* by the seed lots of different cultures is happening. Resulting to the gerbological analysis its seeds were found in seed of honey plants, oil plants, and forage crops (Wild Turnip, Rape, Camelina) cultivated in the Tomsk region. One of the factors contributing to the spread of this species on the territory of the Tomsk Region is actively developing of beekeeping in the last decade. Permanent demand for seeds of honey crops such as *Sinapis alba* and *Phacelia tanacetifolia*, and the delivery of them from different regions of Siberia and the European part of Russia, promote regular bringing of seeds of *Vicia hirsuta* into Tomsk region (Mikhaylova, 2011).

Vicia hirsuta is a spring or winter annual plant. Flowers and fruits are from July to August. Seeds are ripening not simultaneously. Seed production is low - no more than 100 seeds per plant (Kurdyukova, Konoplia, 2014). The features of dissemination offer the completion of the soil

seed bank by barohoria and spread by speirochoria. The populations of the species confined to the meadow and steppe phytocoenoses seeds germinate in unison only conducive to the good for seedlings years with high humidity. Such coenopopulations are characterized by changing an active state at rest when they consist only (or mainly) of viable seeds in the soil (Kurkin, 1976; Rabotnov, 1983). The species is characterized by polyalternativeness of the ontomorphogenesis associated with the ability of seeds to germinate throughout the growing period (Sheipak, 2001).

The species is characterized by seed solidity. Seeds are characterized by physical dormancy, for interrupting of which the treatment by scarification is necessary. In uncontrolled conditions in laboratory storage seeds can remain viable for more than 10 years. According to our data, the viability of seeds stored for 12 years, is 90%.

Vicia hirsuta relates to a small number of aggressive species. Growing in segetal and ruderal communities, this species does not form continuous thickets oppressing other. However, in field of such thin-stalked crops like Flax and Camelina, *Vicia* sprouts can cause mechanical damage, criss-crossing the cultivated plants, and create difficulties in harvesting. The most harmful is the ability to clog the seeds of cultivated plants. This is a typical speirochorous weed (Kucewicz *et al.*, 2010). Its seeds are difficult to separate of the fine-seeded cultures (Rape, Mustard, Camelina, Phacelia, etc.). Seeds of *Vicia hirsuta* during the First World War were used in Germany for food (after soaking in soda). It is used as a fodder plant and green manure (Wolfe, Maleeva, 1969).

CONCLUSION

The review of information on two invasive species of Siberia – *Malva verticillata* L. and *Vicia hirsuta* (L.) S.F. Gray gives an idea of intensive resettlement of these species in Siberia, which began in the late twentieth century. Particular attention should be paid to the active distribution of these species in Siberia agrocoenoses with seeds of field crops (oil and honey). These plants appropriate to examine as a model of invasive species.

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