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Fruiting estimation of the potentially invasive species *Amorpha fruticosa* L. in the south of the Russian Far East

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Abstract. In the south of Russian Far East *Amorpha fruticosa* (Fabaceae Lindl.) is used as ornamental plant. It actively blooms and fruits here and successfully spreads by suckers, rarely by seeds. There are another ways of *Amorpha fruticosa* application in Primorsky Krai – as melliferous and technical plant for reclamation of disturbed lands and formation of protective field belts. These activities requires a great amount of quality seeds and, in turn, investigation of *Amorpha fruticosa* seed propagation. The study of the morphological characteristics of fruits from 12 different places in the Primorsky Krai showed that the linear characteristics of the fruits have minor differences but length of racemes and seed germination vary greatly. The longest racemes are detected in the city of Bolshoy Kamen (17.8 cm), the shortest ones – in Nekruglovo settlement (12.7 cm). The largest fruit number has racemes from Partizansk city (152). The weight of 100 fruits varies from 1.16 g (Kraskino settlement) to 0.94 g (city of Bolshoy Kamen). Highest germination capacity is observed in plants at Lake Soldatskoe (91%), the smallest in plants from Strugovka settlement and the city of Bolshoy Kamen (43%). Absence of germination of seeds from Vadimovka settlement is probably caused by pest – American seed beetle, *Acanthoscelides pallidipennis*.

1. Introduction

Anthropogenic impact on the environment leads to the introduction of alien plant species into natural phytocenoses. Invasive species of the legume family (Fabaceae Lindl.) have a significant influence on the transformation of natural communities [1]. It should be noted that many of them have economically valuable traits [2]. In many regions of the world, they are widely used in human economic activities as decorative, fruit, technical and medicinal [3] plants.

One of the invasive species of the family is false indigo-bush, *Amorpha fruticosa* L. [4] which has a number of valuable properties.

It is most popular as ornamental plant [5] due to big compound leaves and deep purple inflorescences. Besides, it is widely used as a melliferous plant [6-10]. It produces reddish honey (up to 113 kg per 1 ha) which has medicinal properties [11]. In relation to medicinal application the most studied are antidiabetic effects of *Amorpha fruticosa* [12]. It also has antimicrobial [13], antioxidant [14], hepatoprotective activity [15].

Extensive root system of the plant provides its anti-erosion role. In Northwest China it is traditionally used for sand control [16], in terrace bio-embankments [17], in Bulgaria – in protective forest belts against dry winds [18]. It may grow on poor soils and use in disturbed lands reclamation [19].



All these properties are based on the chemical composition of *Amorpha fruticosa* [20-24] and its physiological features [25-27].

In the Far East of Russia, *Amorpha fruticosa* has been observed since the beginning of the 20th century. Now it's used in the landscaping of settlements in the Primorsky Krai. The northernmost point of its distribution is the city of Lesozavodsk (45°28' N, 133°24' E).

Currently, *Amorpha fruticosa* is regarded as a potentially invasive species that has naturalized in disturbed habitats [28-29]. Recently its invasive pest, North American seed beetle *Acanthoscelides pallidipennis* (Motschulsky, 1874) was found in the Primorsky Krai [30]. A survey of the territory of Primorsky Krai showed that North American seed beetle occurs in 21 settlements. The pest damages fruits of *Amorpha fruticosa* but it does not reduce its decorativeness.

The plant is used mainly in landscape design as a fast-growing shrub that successfully recovers after winter damage. However, regarding the development of agriculture and industry in the region, such ways of using the plant are possible – the creation of protective belts in the fields, for anti-erosion purposes and for the restoration of disturbed lands, particularly coal dumps. So it is necessary to study the seed reproduction of the plant in order to obtain a large amount of planting material.

Here we present data on fruiting of *Amorpha fruticosa* in the Primorsky Krai in different cultivation places with different ecological conditions.

2. Methods

Samples of *Amorpha fruticosa* (racemes, fruits) were collected at 12 different points in the Primorsky Krai (figure 1). The coordinates of the settlements are: Kraskino (Khasansky district) – 42°42'30" N, 130°46'55" E; Lake Soldatskoe (Ussuriysk urban county) – 43°48'00" N, 131°57'00" E; Pokrovka (Oktyabrsky district) – 43°57'00" N, 131°38'05" E; Gornotezhnoye (arboretum of the Mountain-Taiga Station, Ussuriysk urban county) – 43°42'00" N, 132°09'00" E; Chernyatino (Oktyabrsky district) – 43°58'00" N, 131°29'00" E; Strugovka (Oktyabrsky district) – 43°59'00" N, 131°40'00" E; city of Spassk-Dalny (Spassky district) – 44°36' N, 132°49' E; Partizansk city – 43°08' N, 133°08' E; Bolshoy Kamen – 43°07' N, 132°21' E; Novogeogievka (Oktyabrsky district) – 44°01' N, 132°24' E; Nekruglovo (Mikhayovskiy district) – 43°58'44" N, 132°03'54"E; Vadimovka (Chernigovsky district) – 44°24'19" N; 132°23'03" E.



Figure 1. *Amorpha fruticosa* samples points

For each sample, 10 racemes were taken from the each bush. The length of the fruit stems was measured and the number of fruit in each raceme was counted. The length of the fruit was measured along the concave side of the fruit, and the width was measured in the most extended part of the fruit. The sample size is 50 from each sample.

The determination of the quality of seeds was carried out according to the method of M.S. Zorina and S.P. Kabanov [31]. The following indicators were analyzed: weight of 100 fruits, laboratory germination of seeds. The arithmetic mean and standard error were determined [32]. The data were processed using the Microsoft Excel 2007 software package.

3. Results and discussion

In the Primorsky Krai *Amorpha fruticosa* reaches the size inherent in its homeland. On average, the height of the plant is 1.5-2.5 m but we have noted specimens up to 3.7 m (in Bolshoy Kamen city) and 5 m (Nakhodka city) height and 10 cm trunk diameter at the base. This can be explained by the growing conditions (closeness to residential buildings and heating main).

In the Primorsky Krai, *Amorpha fruticosa* actively blooms and fruits, spreads by vegetative means. In the studied territories, the species is absent in natural phytocenoses and inhabits anthropogenic landscapes. By the degree of naturalization, the species can be attributed to the group of epiphytes. The studies carried out show the potential of the species for wider distribution through vegetative reproduction [15]. In recent years, the author has observed a rare seed propagation of *Amorpha fruticosa*. This indicates the initial stage of naturalization of the species.

To study the features of the reproductive biology of *Amorpha fruticosa* and predict its invasive ability, we studied some morphological features of the generative organs.

The length of racemes and fruit number in single raceme is shown in table 1.

Table 1. Morphological features of *Amorpha fruticosa* racemes.

Sample site	Raceme length, cm		Number of fruits in raceme	
	M±m	min-max	M±m	min-max
Kraskino	12.9±0.87	10.5-15	133.88±23.1	53-225-
Lake Soldatskoe	14.00±0.91	10.5-17.4	151.90±17.4	95-239
Pokrovka	13.56±1.09	10-18.4	133.5±19.7	100-231
Gornotezhnoye	14.43±1.25	10.5-18.7	166±19.0	104-203
Chernyatino	15.46±3.0	8.8-18.5	149±18.3	100-175
Strugovka	13.0±1.54	10.5-16.5	154.6±33.2	82-216
Spassk-Dalny	15.46±1.38	10.5-20.9	158.7±20.3	73-245
Partizansk	14.27±1.95	10.4-19	106.5±15.55	69-158
Bolshoy Kamen	17.86±1.88	12.5-24	143.66±34.25	45-211
Novogeorgievka	15.2±1.17	12-19	203.14±18.04	152-254-
Nekruglovo	12.77±0.84	10.5-15	198.75±21.9	135-242
Vadimovka	14.78±2.26	10.5-15.5	133.25±26.5	86-244

The length of the racemes of *Amorpha fruticosa* varies from 8.8 to 17.86. The longest ones are detected in the city of Bolshoy Kamen, Chernyatino and Novogeorgievka settlements. The shortest racemes are found in Nekruglovo. The largest fruit number has racemes in plants from Partizansk city (152).

Linear parameters of fruits are shown in table 2.

Table 2. Characteristics of fruits *Amorpha fruticosa*

Sample site	Fruit length, mm		Fruit width, mm		Ratio length/width	
	M±m	Min-Max	M±m	Min-Max	M±m	Min-Max
Kraskino	7.9±0.16	7-9	2.2±0.05	1.9-3	5.9±0.15	4.1-7
Lake Soldatskoe	7.5±0.01	6-8	2.5±0.06	2.1-3	4.9±0.11	4.3-5.8
Pokrovka	7.4±0.10	7-8	2.2±0.04	2-2.6	5.2±0.08	4.5-5.8
Gornotezhnoye	8.6±0.14	8-10	2.5±0.07	2-3.2	6.09±0.12	5-7
Chernyatino	7.0±0.07	6.2-9	2.1±0.03	1.9-2.6	4.8±0.08	4-6.8
Strugovka	8.3±0.17	7-10	2.4±0.08	1.9-3	5.89±0.11	4.8-7
Spassk-Dalny	8.0±0.12	7-9	2.6±0.04	2.2-3	3.0±0.08	2.6-3.7
Partizansk	7.5±0.10	6.8-8	2.5±0.06	2.1-3	2.9±0.08	2.4-3.6
Bolshoy Kamen	7.3±0.15	6.8-9	2.2±0.04	2-2.5	3.3±0.08	2.7-4.2
Novogeorgievka	9.4±0.33	7-10	2.3±0.1	2-3	4.1±0.17	3.2-5.2
Nekruglovo	8±0.05	7.5-8.5	2.01±0.02	1.9-2.5	3.4±0.06	2.8-3.9
Vadimovka	7.8±0.06	7.5-8.2	2.01±0.02	1.9-2.5	3.7±0.08	3.1-4

The maximum values of the length and width of the fruits are observed in plants from Novogeorgievka, Gornotaezhnoye, minimal – in plants from the Chernyatino. The ratio of the length of the fruit to the width of the fruit varies considerably, from 2.9 in Partizansk city to 6.09 in the Gornotezhnoye.

Indicators of fruit weight and germination of seeds are shown in table 3.

Table 3. Characteristics of fruit weight and germination of *Amorpha fruticosa* fruits

Sample site	Weight of 100 fruits, g	Laboratory germination, %
Kraskino	1.16±0.13	80
Lake Soldatskoe	1.11±0.09	91
Pokrovka	1.01±0.05	79
Gornotezhnoye	1.14±0.17	80
Chernyatino	0.97±0.08	69
Strugovka	1.12±0.15	43
Spassk-Dalny	1.22±0.08	68
Partizansk	1.11±0.03	90,3
Bolshoy Kamen	0.94±0.03	43
Novogeorgievka	1.1±0.04	90,6
Nekruglovo	1.1±0.012	90
Vadimovka	0.9±0.02	-

The weight of 100 fruits varies slightly: the heaviest fruits in Kraskino (1.16 g), the lightest in the city of Bolshoy Kamen (0.94 g). Seed germination varies widely. The highest percentage of germination is observed in plants at Lake Soldatskoe (91%), the smallest in plants from Strugovka settlement (43%) and the city of Bolshoy Kamen (43%). Seeds from Vadimovka settlement did not germinate and rotted very quickly. It is possible that the rotting of the seeds is associated with the defeat by *Acanthoscelides pallidipennis*. In general, all investigated plants have a high seed germination capacity.

4. Conclusion

In the south of the Russian Far East, *Amorpha fruticosa* is used in landscape design. Here it actively blooms and fruits, gives viable seeds, and quickly recovers after winter damage.

It may be used in agriculture for anti-erosion purposes and reclamation of disturbed lands that require a great amount of planting material. So it's important to study seed propagation of the plant.

The study of the morphological characteristics of plants from 12 different places in the Primorsky Krai showed that the linear characteristics of the fruits have minor differences, while the indicators of the length of the racemes and the germination of seeds vary greatly. Highest germination capacity is observed in plants at Lake Soldatskoe (91%), the smallest one in plants from Strugovka settlement and the city of Bolshoy Kamen (43%). Absence of germination of seeds from Vadimovka settlement is probably caused by pest – American seed beetle *Acanthoscelides pallidipennis*. And although at present this pest does not reduce the ornamental properties of *Amorpha fruticosa*, it can lead to seed damage.

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