

Conference Paper

Seed Productivity of Coenopopulations of *Tulipa Gesneriana* L. (Liliaceae) on the Ergeninskaya Upland (Within the Boundaries of the Republic of Kalmykia)

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Abstract

This article presents results on the seed productivity of populations of *Tulipa gesneriana* L. in the Ergeninskaya Upland (within the boundaries of the Republic of Kalmykia). This species is listed in the Red Data Books of several regions of Russia, including Kalmykia. The research objects were 4 populations of *T. gesneriana* growing on the Ergeninskaya Upland, which extends across the Republic territory from north to southwest on light chestnut soils of solonetzicity. The potential seed productivity of these *T. gesneriana* plants was 161.8-181.5 pcs. seeds per plant; the actual seed productivity was 161.8-181.5 pcs. seeds per plant; and the formation of seeds was 34.4-75.6%. All indicators of seed productivity showed significant interpopulation differences when moving from the northern part of the Upland to its southern part. A potential reserve of mature seeds per 1 meter², formed during the growing season, in the coenopopulations of *T. gesneriana* was 253.2 - 3212.8 pcs. in 2018 and 368.0 - 1121.2 pcs. in 2017 on the Ergeninskaya Upland.

Keywords: *Tulipa gesneriana*, coenopopulation, seed productivity, seed reserve.

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1. Introduction

The reproduction nature of various plant species forming vegetable communities plays a crucial role in reflecting diverse aspects of their development. Viable seeds in the composition of species populations are perceived as indicators of the life strategy of plant species by many authors [1 - 5]. The role of seeds in the evolutionary process is very significant [6]. The seed productivity of plants can be used to characterize the species adaptability to a specific habitat [7].

In connection with the above, the purpose of our study was to determine the seed productivity of plants in the late tulip coenopopulations - *Tulipa gesneriana* L. [8] (T.

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fragrant – *T. suaveolens* Roth [9, 10]) (Liliaceae) on the Ergeninskaya Upland (within the boundaries of the Republic of Kalmykia).

2. Materials and Methods

The *T. gesneriana* species was studied during the growing seasons of 2017 and 2018 in vegetable communities on the Ergeninskaya Upland, which extends across the territory of the Republic from north to southwest. The species is included in the Red Data Books of many regions of Russia, including Kalmykia, with a category of rarity II [11]. The research objects were 4 species populations of *T. gesneriana*: coenopopulation No. 1 in the northern part of the Ergeninskaya Upland in the composition of the bulbous bluegrass-feather grass-wormwood communities (*Artemisia lerceana* - *Stipa lessingiana* - *Poa bulbosa*), and coenopopulation No. 2, associated with bulbous bluegrass-feather grass-wormwood community (*Artemisia lerceana* - *Stipa lessingiana* - *Poa bulbosa*); in the central part - coenopopulation No. 3 in the composition of grass-willow shrub-wormwood community (*Artemisia lerceana* - *Kocia prostrata* - *Poaceta*), in the southern part - coenopopulation No. 4, growing in grass-willow shrub-wormwood community (*Artemisia lerceana* - *Kocia prostrata* - *Poaceta*). Coenopopulations grew on light chestnut soils, which had varying degrees of solonetzicity. The assessment of the seed productivity and morphometric traits of *T. gesneriana* boll was carried out in the framework of the analysis of ecological and biological characteristics of species coenopopulations from the Tulipa sort [12, 13].

The study material was a random sample of 30 *T. gesneriana* plants from each species population. The potential seed productivity was considered as the sum of fully formed seeds and abortive seeds (which did not have a formed embryo) in the fetus, by which it was possible to estimate the total number of ovules in the flower. Actual seed productivity was understood as the number of fully formed ripe seeds in the fetus [7]. The potential seed reserve was taken into account as the number of seeds produced by plants per 1 m². This relative indicator, characterizing the reproductive potential of the coenopopulation, was determined as the product of the actual seed productivity of plants by the density per 1.0 m² in the generative period. Plants were counted at 10 registered platforms 1.0x1.0 m² located along transect to determine the density [14].

3. Findings

A significant number of seeds, in which the embryo was absent or in its infancy, was noted in the nests of the *T. gesneriana* boll between the filled seeds along the entire length. Many such abortive seeds were found closer to the upper part and basis of the fetus, which is consistent with the literature data [15, 16] for other species of the genus *Tulipa*.

Assessment of the potential seed productivity gives an idea of the species ability to reproduce itself. The potential seed productivity of *T. gesneriana* plants averaged 181.5 pcs. in 2017. The highest value of the indicator was noted in coenopopulation No. 1 – 268.7 pcs., which is much more than in other studied coenopopulations: in coenopopulation No. 2 – by 91.3 ($t_{diff} = 5.37$, at $P < 0.001$), in coenopopulation No. 3 – by 121.9 ($t_{diff} = 10.07$, at $P < 0.0001$), in coenopopulation No. 4 - by 135.6 ($t_{diff} = 10.12$, at $P < 0.0001$) pieces of seeds in the boll (Table 1). The next year, the average potential seed productivity of *T. gesneriana* plants decreased to 161.8 pcs. seeds per plant. The highest value of the indicator was also noted in the coenopopulation No. 1 – 267.8 pcs. Interpopulation differences in potential seed productivity were also essential, as in 2017. There was a decrease in the indicator along the gradient from the north (from coenopopulation No. 1) to the south (to coenopopulation No. 4) of the Ergeninskaya Upland.

The reproductive capabilities of the coenopopulation depend on the actual seed productivity of species. The actual seed production of *T. gesneriana* plants is significantly lower than the potential seed production due to the presence of abortive seeds in the boll. At the same time, many abiotic and biotic factors affect this indicator, including weather conditions, pollination success, etc. In this regard, this indicator is characterized by significant variability. The variation coefficient during the research period for the actual seed productivity was 37.0-59.9%, whereas for the potential seed productivity – 14.8-48.7% (Table 1).

The highest value of the actual seed productivity was noted in coenopopulation No. 2: 132.1 pcs. – in 2017, 101.7 pcs. – in 2018. The least value of the actual seed productivity was found in coenopopulation No. 4 in the south of the Ergeninskaya Upland: 100.6 pcs. – in 2017, 72.9 pcs. – in 2018. A drop in the actual seed productivity was revealed in all studied *T. gesneriana* coenopopulations in 2018 compared to 2017: coenopopulation No. 1 - by 27.2 pcs. ($t_{diff} = 2.54$, at $P < 0.05$), coenopopulation No. 2 - by 30.4 ($t_{diff} = 2.15$, at $P < 0.05$), coenopopulation No. 3 - by 35.6 ($t_{diff} = 2.52$, at $P < 0.05$), coenopopulation No. 4 - by 27.7 ($t_{diff} = 2.29$, at $P < 0.05$) pieces of seeds in a boll (Table 1).

The percentage of seeds formation in *T. gesneriana* coenopopulations in 2017 varied from 44.4% in coenopopulation No. 1 to 75.6% in coenopopulation No. 4; in 2018 – from 34.4% to 66.0% in the same coenopopulations. Thus, the proportion of formed seeds in coenopopulations increased from north to south on the Ergeninskaya Upland, while the value of the potential seed productivity had the opposite dynamics (Table 1).

TABLE 1: Seed productivity of plants in *Tulipa gesneriana* coenopopulations on the Ergeninskaya Upland

Population	Year	Potential seed productivity, pcs.	Actual seed productivity, pcs.	Formation of seeds, percentage
		$\frac{\bar{x} \pm S\bar{x}}{Cv \pm SCv}$	$\frac{\bar{x} \pm S\bar{x}}{Cv \pm SCv}$	
No. 1	2017	$\frac{268.7 \pm 6.49}{24.8 \pm 3.20}$	$\frac{119.4 \pm 8.69}{39.9 \pm 5.15}$	44.4
	2018	$\frac{267.8 \pm 7.24}{14.8 \pm 1.91}$	$\frac{92.2 \pm 6.29}{37.4 \pm 4.83}$	34.4
No. 2	2017	$\frac{177.4 \pm 15.71}{48.5 \pm 6.26}$	$\frac{132.1 \pm 12.45}{59.9 \pm 7.73}$	74.5
	2018	$\frac{151.1 \pm 13.40}{38.4 \pm 4.76}$	$\frac{110.8 \pm 12.59}{40.0 \pm 6.71}$	63.3
No. 3	2017	$\frac{146.8 \pm 10.22}{21.4 \pm 2.76}$	$\frac{67.8 \pm 2.59}{21.0 \pm 2.71}$	74.9
	2018	$\frac{117.9 \pm 7.49}{27.7 \pm 4.49}$	$\frac{75.2 \pm 6.38}{37.0 \pm 6.00}$	63.8
No. 4	2017	$\frac{133.1 \pm 11.74}{32.7 \pm 4.23}$	$\frac{100.6 \pm 10.66}{40.4 \pm 6.41}$	75.6
	2018	$\frac{110.5 \pm 6.85}{26.8 \pm 4.02}$	$\frac{72.9 \pm 5.73}{38.0 \pm 5.78}$	66.0

It is known that the reproduction of organisms in nature occurs in a geometric progression. In this regard, the seed stock, which constitutes a reserve for the subsequent resumption of populations, is formed in natural species populations. Identification of the potential seed stock, which is formed in natural populations, seems interesting to us. The density of generative plants was taken into consideration to determine the seed reserve of *T. gesneriana*, which is formed in natural vegetable communities with the species participation (Fig. 1). The lowest density of generative plants was noted in coenopopulation No. 2: 4.6 pcs. per 1 m² – in 2017, 2.6 pcs. per 1 m² – in 2018, the highest – in the coenopopulation No. 3 – 7.0 and 5.7, respectively (Fig. 1).

The accounting results of the occurrence frequency of generative plants and the actual seed productivity were used to determine the relative potential seeds reserve that is formed in natural populations of both species. The potential reserve of mature seeds in *T. gesneriana* coenopopulations varied from 788.04 in coenopopulation No. 1 to 513.1 in coenopopulation No. 4 in 2017, averaging 670.14 seeds per 1 m². In 2018, the

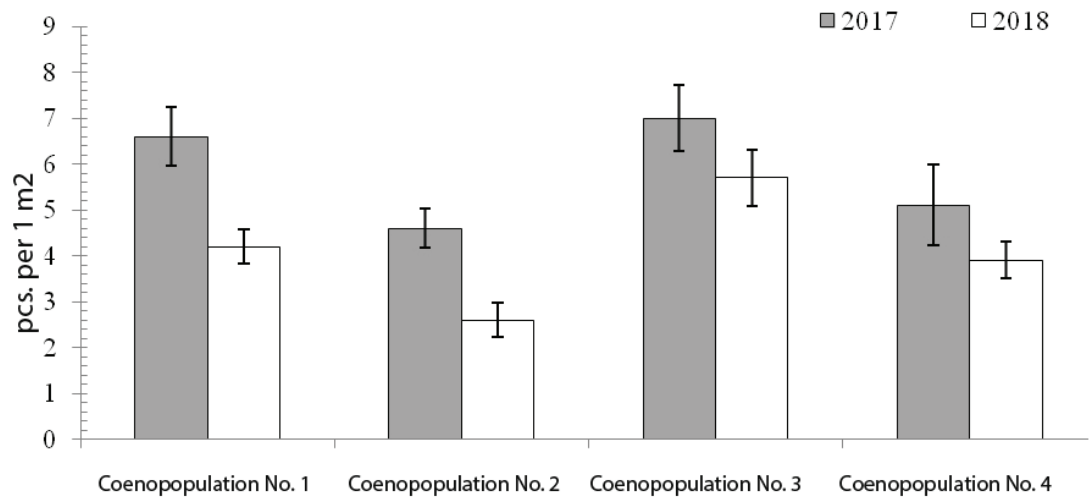


Figure 1: Density of plants of generative age state (per 1 m²) in *Tulipa gesneriana* coenopopulations.

potential reserve of mature seeds in *T. gesneriana* coenopopulations was significantly less - 341.16 per 1 m² (Fig. 2).

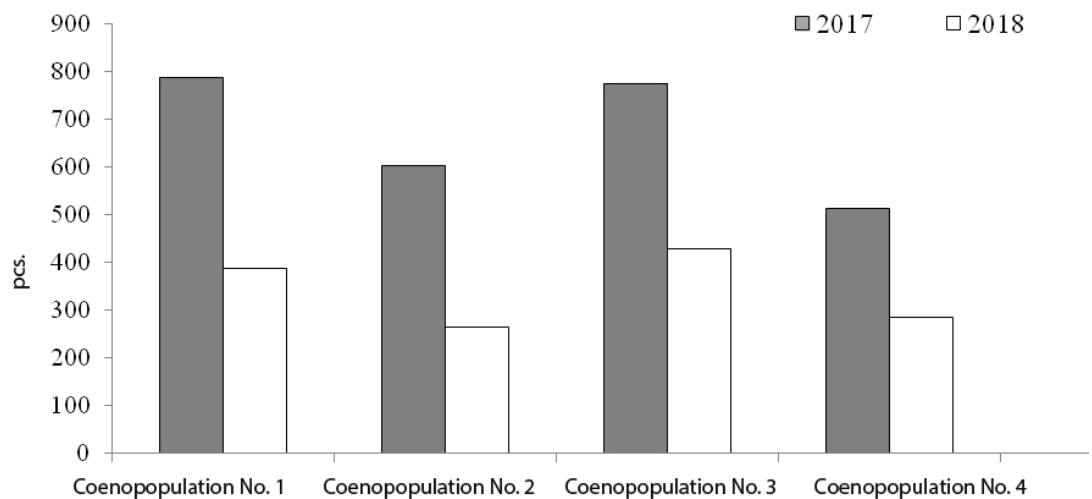


Figure 2: Potential reserve of mature seeds in *Tulipa gesneriana* coenopopulations.

Indicators of the seed productivity revealed clinal variation in natural species populations of *T. gesneriana* on the Ergeninskaya Upland. Thus, when moving from the northern to the southern part of the upland, the potential seed productivity decreased, while the actual seed productivity, on the contrary, increased. The latter was reflected in the percentage of seed formation, which in both years of the study also showed a clinal increase when moving in the northern part of the Ergeninskaya Upland to its southern part. Similar dynamics of the above indicators of the seed productivity is apparently

determined by the specificity of ecological and phytocenotic conditions in vegetable communities in which the studied coenopopulations grow.

All indicators of the seed productivity in *T. gesneriana* coenopopulations on the Ergeninskaya Upland differed by the years of study. Weather conditions significantly affect the formation of generative organs, especially during the period of active plant vegetation.

TABLE 2: Weather conditions in *T. gesneriana* habitat during the study period

Coenopopulation	Total precipitation, mm				Average monthly t, °C			
	2017		2018		2017		2018	
	March	April	March	April	March	April	March	April
No. 1 and No. 2	33.4	38.1	58.8	3.2	4.0	9.4	-1.6	10.0
No. 3	20.8	10.6	46.0	14.6	3.8	9.0	0.0	10.2
No. 4	24.2	29.1	49.1	3.7	4.5	9.7	1.8	11.0

It is early spring for *T. gesneriana*. Weather conditions in 2018 with a decrease in seed productivity, compared to the previous year of the study, were noted by the fact that a large share of precipitation fell in March, while lower temperatures were noted this month (down to -1.6 °C) (Table 2).

4. Conclusion

The potential seed productivity of *T. gesneriana* under the conditions of the Ergeninskaya Upland was 161.8-181.5 pcs. seeds per plant during the research years; the actual seed productivity – 161.8-181.5 pcs. seeds per plant, the formation of seeds – 34.4-75.6% revealing considerable interpopulation differences when moving from the northern part of the upland to its southern part.

The potential stock of mature seeds per 1 m², formed during the growing season, in *T. gesneriana* coenopopulations on the Ergeninskaya Upland was 253.2-3212.8 pcs. in 2017, and 368.0-1121.2 pcs. in 2018.

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