

Productivity characteristics of F₁ ornamental progenies between *Fragaria × ananassa* Duchesne ex Rozier. and *Potentilla nepalensis* Hook.

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Abstract. The current study presents the results of the evaluation of the productivity characteristics of pink-flowered F₁ progenies obtained as a result of hybridization between *Fragaria × ananassa* Duchesne ex Rozier. and *Potentilla nepalensis* Hook. Based on the selection results, a hybrid fund of four promising pink-flowered strawberries forms with increased winter hardiness was created. The samples possess stable fruit crop, form plentiful flower stalks, form rather large fruits with good taste, and are appropriate for further inclusion in breeding programs in order to obtain a culture of decorative and fruit purposes in the conditions of the Siberian region.

1 Introduction

The strawberry (*Fragaria × ananassa* Duchesne ex Rozier., $2n = 8x = 56$) occupies a leading place among berry crops in terms of area and yield in the world. This species possesses ecological and reproductive plasticity due to the high level of ploidy and heterozygosity and spontaneous hybridization between North American *F. virginiana* Mill. and South American *F. chiloensis* Mill. [1]. The modern assortment of this crop is represented by more than 5000 cultivars with mainly white color of the flower corolla. However, the introgression of the "pink corolla" trait of a flower into the gene pool of garden strawberries is of interest for breeding in order to obtain a culture for decorative berry purposes. However, the introgression of the "pink corolla" trait of a flower the gene pool of garden strawberries is of interest for breeding in order to obtain a culture for decorative and fruit purposes. Pink-flowered cultivars *F. × ananassa* are in great demand among gardeners and are widely used in landscape design [2]. Currently, the assortment of pink-flowered strawberries includes about 20 cultivars and hybrids. Major progress in the creation of pink-flowered strawberries has been made in Canada and Netherlands. In Russia, these studies were started in the late 90s of the last century, however, the number of cultivars registered in the State Register is insignificant yet [3, 4]. The obtaining cultivars are used mainly for decorative purposes in the southern regions with mild climate, but not in Siberia with a cold climate. In addition, pink-flowered strawberries, due to their

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intergeneric origin, often form deformed fruits as a result of the development of a small number of achenes per fruit. The low yields allow the originators of the variety to recommend its cultivation for decorative purposes only [5]. All these disadvantages of modern varieties of pink-flowered strawberries - poor winter hardiness, low productivity, moderate taste determine the relevance of the research in this work.

In the previous research, we have obtained the viable ornamental intergeneric progenies of *F. × ananassa* and *Potentilla nepalensis* Hook. by tissue culture technologies [6]. We selected over 50% of the pink-flowered samples that exhibited high winter hardiness in the conditions of Western Siberia with the degree of freezing 0 - 1 point on a five-point scale, where 0 is no signs of freezing, 5 is the complete death of all plant tissues.

The aim of the current work is to assess the productivity of pink-flowered F₁ samples obtained from the crossing of *F. × ananassa* and *P. nepalensis* with the subsequent study of samples promising for the selection of strawberries for decorative and fruit purposes in the Siberian region.

2 Materials and Methods

2.1 Plant material and growing conditions

The objects of study were 7 pink-flowered specimens of F₁ progeny with everbearing and short-day fruiting types obtained at the biotechnology laboratory of the Central Siberian Botanical Garden of the SB RAS (Novosibirsk) as a result of crossing *F. × ananassa* and *P. nepalensis* [6]. Plants were grown on the experimental plot of the laboratory (geographical coordinates 54°49'9.87"N and 83°6'6.95"E). For each F₁ specimen, 10 plants were studied in the second year of the growing season. Observations were carried out from 2012 to 2018. Plants were grown in spacing 60 cm × 25 cm in one row.

The experimental plot has a medium loam soil with a content of 2-4 % humus in the soil layer from 0 to 20 cm, at a depth of 50-60 cm - no more than 0.8 %. The reaction of soil is slightly acidic, pH 6.3-6.9. The total natural reserves of nutrients are low, therefore organic (humus) and mineral fertilizers were added.

2.2 Evaluation of the samples by characteristics of the productivity

Evaluation of the productivity included an assessment of the number of the peduncles (pieces/plant), the number of the fruits (pieces/plant), the average fruit weight (g). To determine the average weight of one fruit, the total weight for all collections was divided by their number.

In accordance with the average weight of the fruit, the samples were evaluated according to the degree of large-fruited, using the following scale [7]:

5 - very large fruits, average weight - more than 12 g;

4 - large fruits, from 9 to 12 g;

3 - medium-sized fruits, from 6 to 9 g;

2 - small fruits, from 3 to 6 g;

1 - very small fruits, weight less than 3 g.

The analysis of the main morphological characteristics of fruits in the samples was carried out according to the accepted test methodology for strawberries [7]. The assessment was carried out for 18 characteristics of the fruit, such as shape, color, calyx shape, the position of the achenes on the surface of the fruit, the color of the fruit pulp, the presence of a cavity in the fruit, and the taste of the fruit, etc.

The fruit index, characterizing its size and shape, was calculated on the base of the linear parameters of the fruit (cm), as the ratio of the greatest length to the greatest width. Depending on the value of the index, the fruits were divided into flattened ($K < 0.9$), oblong ($K > 1.1$), and rounded - $0.9 < K < 1.1$.

The palatability of the fruit was determined by a tasting assessment and was assessed by points:

- 5 - excellent taste, with a harmonious combination of sugar and acid or a slight predominance of one of the quiet components, with a strong pleasant aroma;
- 4 - good taste, with a harmonious combination of sugar and acid or with some predominance of one of the components, with a weak or medium aroma;
- 3 - moderate taste, unbalanced in sugar and acid, low in sugar or both;
- 2 - bad taste, with a sharp predominance of acid or tasteless;
- 1 - very bad taste, very sour, with bitterness, other off-flavors.

The analysis was carried out during the entire period from the beginning of flowering to the end of fruiting.

2.3 Statistical analysis

All the data were processed in the Statistica 10.0 software (Statsoft Inc., Tulsa, OK, USA), were reported as mean \pm standard error (SE) of three replicates.

3 Results

The creation of cultivars of decorative and berry garden strawberry culture in the Siberian region is restricted by the practical lack of high-quality breeding material. Similar work is being carried out at the Institute of Cytology and Genetics of the SB RAS (Novosibirsk), where the decorative cultivar 'Pink Panda' (England) and hybrids created by the Dutch company "ABZ Seeds - Gourmet Strawberries" are used as donors of the pink color of the flower petals. A gene pool of pink-flowered large-fruited strawberries from 5 cultivars of European selection and 30 experimentally obtained hybrids was established [8].

However, for the successful introduction of this culture in the Siberian region, it is necessary to create genotypes that combine high productivity with resistance to extreme growing conditions. In this regard, we used a highly winter-resistant productive everbearing hybrid No. 96 / 10-78-4 from the collection of strawberries of the laboratory of plant population genetics of the ICG SB RAS in crosses with *P. nepalensis* as the maternal form of *F. × ananassa*.

When analyzing the morphological characteristics of the fruit in the pink-flowered progenies of F_1 , variability in shape, color, position of achenes on the surface, and taste of fruits were revealed (Table 1). The shape of the fruit in 50% of the progenies was oblong. For the rest offspring, it was rounded, as in the maternal specimen. Fruit color in progenies varied from red (in 33% of the samples) to light red (in 50% of the samples). In 33% of the offspring, the color was dark red, like the mother sample.

Productivity is the main indicator in assessing the quality of a sample, determining its adaptive capabilities. For breeding, the most interesting are those genotypes that are distinguished by a consistently high level of productivity components. A larger number of peduncles per plant (from 11.43 ± 0.36 to 14.60 ± 0.45 pieces) was observed in three samples (86 / 28-10, 86 / 29-10, 88 / 1-10) in comparison with the maternal form with an average 9.0 ± 0.24 peduncles per plant. The revealed increase in this characteristic of productivity resulted in the rise of the decorative value of these progenies and can be used in subsequent crosses in order to obtain the decorative berry forms (Table 2).

Table 1. Major morphological features of the fruit of F₁ ornamental progenies between *F. × ananassa* and *P. nepalensis*

Sample	Form	Color	Fusion calyx with fruit	Position of the achenes	Density of the pulp	Taste of the fruit
96 / 10-78-4 (maternal sample)	Rounded	Dark-red	Weak	At the same level as the skin	Medium density	4.0
86 / 11-10	Rounded	Dark-red	Weak	At the same level as the skin	soft	4.0
86 / 29-10	Oblong	Light-red	Weak	Above the skin	soft	3.5
86 / 28-10	Oblong	Red	Weak	Above the skin	Medium density	4.0
86 / 30-10	Rounded	Dark-red	Weak	Above the skin	Medium density	3.5
87 / 3-10	Rounded	Light-red	Weak	Above the skin	Medium density	4.0
87 / 11-10	Oblong	Light-red	Weak	Under the skin	soft	3.5
88 / 1-10	Rounded	Red	Weak	At the same level as the skin	Medium density	4.0

Table 2. Productivity characteristics of F₁ ornamental progenies between *F. × ananassa* and *P. nepalensis*

Sample	Number of peduncles per plant, pcs	Number of fruits per plant, pcs	Average fruit weight of the 1 st order, g	Average fruit weight, g	Fruit category
96 / 10-78-4 (maternal sample)	9.00 ± 0.24	87.00 ± 0.62	10.96 ± 0.48	9.35 ± 0.66	Large-sized
86 / 11-10	10.00 ± 0.39	51.67 ± 0.32	6.55 ± 0.26	5.15 ± 0.13	Small-sized
86 / 28-10	11.43 ± 0.36	64.14 ± 0.81	13.62 ± 0.89	10.04 ± 0.51	Large-sized
86 / 29-10	13.67 ± 0.51	64.67 ± 0.45	7.63 ± 0.36	6.23 ± 0.28	Medium-sized
86 / 30-10	9.40 ± 0.50	43.20 ± 0.51	5.88 ± 0.50	4.49 ± 0.24	Small-sized
87 / 3-10	9.00 ± 0.60	54.75 ± 0.22	10.36 ± 0.98	7.89 ± 0.98	Medium-sized
87 / 11-10	4.80 ± 0.24	23.60 ± 0.55	13.13 ± 0.51	9.97 ± 0.40	Large-sized
88 / 1-10	14.60 ± 0.45	90.40 ± 0.39	5.55 ± 0.39	4.65 ± 0.24	Small-sized

The same samples formed the largest number of fruits per plant (from 64.14 ± 0.81 to 90.40 ± 0.39 pieces), which corresponds to modern requirements for strawberry cultivars. The cultivars have to annually form at least 50 fruits per plant and have an average berry weight of more than 9 g [4]. Two samples (86 / 28-10, 87 / 11-10) were selected according to the degree of large-sized fruit (Fig). The rest of the progenies formed medium-sized and small fruits.



Fig. Fruiting pink-flowered sample 87 / 11-10

In conclusion, the F_1 progenies 86 / 28-10, 86 / 29-10, 88 / 1-10, 87 / 11-10 obtained as a result of hybridization between *F. × ananassa* and *P. nepalensis* should be considered promising for further breeding and genetic work on improving the combinational efficiency of crosses in order to create the strawberries cultivars for decorative and berry purposes in the Siberian region. Selected samples are easily cloned during vegetative propagation and, accordingly, conserve their advantages in vegetative offspring, which makes it possible to isolate promising hybrids - candidates for cultivar study.

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