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Phenology, Winter Hardiness, Productivity, Resistance to Diseases, And Pests of Garden Strawberry

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Abstract
Background: For the first time in the conditions of the Komi Republic, a berry crops variety comprehensive assessment is carried out, its interaction with biotic and abiotic factors, and its cultivation. *Objective:* The formation of adaptive agro phytocoenoses of garden strawberry in the conditions of the Komi Republic. *Methods:* The research was carried out in the fruit and berry nursery of FEDERAL STATE BUDGETARY SCIENTIFIC INSTITUTION RESEARCH INSTITUTE OF AGRICULTURE OF THE REPUBLIC OF KOMI. The work was carried out by the program and methodology for the various study of fruit and berry crops. Statistical processing of the research results was carried out following the Program and methodology for the study of fruit, berry, and nut crops, the method of field experiment, the method for state variety testing of crops, and methodological instructions for the statistical processing of yield data of the state variety testing of crops. *Findings:* Highly productive varieties of Kokinskaya Zarya (1.65 kg/rm), Vityaz (1.47 kg/rm) were identified, which significantly exceeded the indicator of the best standards for this indicator of the zoned variety of Festivalnaya (1.10 kg/rm). m) by 34.0 - 50.1% (HCP05 = 0.33). *Conclusion:* According to the research results, the Kokinskaya Zarya and Vityaz strawberries adapted to the conditions of the Komi Republic were revealed, which made it possible to increase the productivity of agro phytocoenoses by 34.0 - 50.1%.

Keywords: strawberry; berry farming; Komi Republic; phenology; productivity.

Introduction

Garden strawberry is a frost-resistant crop. Strawberry roots can withstand a drop in temperature down to -13 - 16°C, although they are damaged already at -7 - 9°C. Under a snow cover (20–30 cm thick), strawberries tolerate severe winters well (Federal State Statistics Service for the Komi Republic, 2015).

The stability of the manifestation of large-fruited strawberries in garden strawberries is not the same over the years and varies significantly. A relatively stable manifestation of the trait was noted in the varieties of Corrado, Surprise Olympiade, Nayden Dobraya, Relay, Troitskaya. Varieties Found Good, Relay and Troitskaya are very large-fruited with a relatively stable manifestation of the trait (Avdeeva, 2014a).

Literature Review

The success of growing berry crops, obtaining high yields are possible only with the correct selection of high-yielding varieties that are adaptable to low-temperature stresses, resistant to pests and diseases. It is also important to take into account the de-cert qualities of berries, their large-fruited, ripening timing. With the correct selection of the assortment of varieties, gardeners of the North will receive, at the lowest cost, the maximum possible, stable, guaranteed, and environmentally friendly harvest of berries for fresh consumption, the period of consumption of fresh berries, and the period for processing the crop will increase. Berries are a high-vitamin food product, which is especially important in the North. For the first time in the Komi Republic, a comprehensive assessment of the varieties of berry crops, their interaction with biotic and abiotic factors, and the determination of the prospects for the cultivation of the best of them is carried out.

Objective: To study adaptive agro phytocoenoses formation of garden strawberry in the conditions of the Komi Republic.

Methods

We assessed garden strawberry and red currants varieties of different ripening periods. The volume is given in Table 1.

Table 1

The volume of collectible plantings of garden strawberries and red currants

№	Collectible nursery	Planting year	Number of			Area occupied, ha	Plants placement scheme, m
			variety	plots	plants per plot		
1	Garden strawberry	2011	18	36	25	0.02	1.0x0.15 (during the making of)
2	Red currant	2007	23	23	3	0.04	2.8x1.5

The counts and observations were carried out according to the method of variety study of fruit and berry crops by ALL-RUSSIAN RESEARCH INSTITUTE OF FRUIT CROPS BREEDING (Federal State Statistics Service for the Komi Republic, 2015):

1. Phenological observations in garden strawberries, the beginning of flowering, the beginning of ripening of berries, in red currants, bud opening, the beginning of flowering, and the beginning of ripening of berries;
2. Winter hardiness;
3. General condition assessment in points from 5 to 1;
4. Plots of garden strawberries harvest in 6 - 8 takings, variety dependent; from each red currant bush in 1-2 takings;

5. Average and maximum weight determination, chemical composition, and taste of berries according to generally accepted methods;
6. Assessment of resistance to diseases and pests of garden strawberries to gray rot (%), of red currants to American powdery mildew (0-5 points), and bud currant mites (0-5 points).

Statistical processing of the research results was carried out by the Program and methodology for the study of fruit, berry, and nut crops (Federal State Statistics Service for the Komi Republic, 2015; Avdeeva, 2014a; Kosolapova et al., 2015; Pysina, 2011).

The meteorological conditions of the growing seasons from 2008 to 2015 differed from the average long-term (Table 2).

Table 2

Brief description of the growing seasons from 2008 to 2015 (Syktyvkar)

Indicators	**Average long-term**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
The sum of the positive average daily air temperatures in the warm period (>0°C)	1903	1950	2022	2419	2343	2311	2314	2059	2147
Sum of effective temperatures (>5°C)	1066	1166	1251	1448	1402	1384	1422	2032	1291
um of active temperatures (>10°C)	1454	1343 (62%)	1589 (30%)	1734 (15%)	1799 (10%)	1682 (21%)	1866 (8%)	1702 (20%)	1828 (9%)
Average temperature in June, °C	13.8	14.6	14.5	14.0	15.9	15.8	17.4	13.4	16.2
Average temperature in July, °C	16.7	19.0	16.2	22.7	20.2	17.5	19.4	14.5	13.8
Minimum temperatures before snow sets in, °C		-6.3	-6.8	-6.2	-16.0	-5.3	-6.5	-24.0	
Minimum temperatures after snow melt, °C		-5.9	-4.5	-5.5	-4.0	-3.3	-3.7	-6.8	-4.9
Hydrothermal coefficient	1.5	3.0	2.4	1.4	1.2	2.1	0.8	1.9	1.7

The supply of heat for the growing seasons from 2009 to 2015 exceeded the long-term average, the frequency of recurrence of such conditions is 30, 15, 10, 21, 8, 20, 9%, respectively (Lukyanchuk, 2011). At the same time, the average temperature in July 2015 was 2.9°C below normal. The growing season of 2008 was characterized by a shortage of heat, such a deviation from the long-term average can add up in 62 years out of 100, but the average temperature in June and July 2008 was 0.8 and 2.3°C above the norm.

The growing seasons of 2008, 2009, 2012, 2014, 2015 were characterized by excessive moisture. But the hydrothermal coefficient of July 2015 did not exceed 1.0. The growing seasons of 2010, 2011, 2013 survived through dry conditions. 2013 stood out in particular, i.e. the hydrothermal coefficient in May was 0.2; June - 0.7; July - 0.5; August - 0.8. Such conditions affected the large-fruited strawberry and red currant. Arid conditions from 1 to 14 July 2015 (hydrothermal coefficient = 0.2) affected the large-fruited strawberry.

The conditions for wintering red currants from 2008 to 2015 and garden strawberries from 2011 to 2015 developed differently (Table 3).

Unfavorable conditions for overwintering of garden strawberry were noted from 2011 to 2014 before the establishment of snow cover when the air temperature dropped to -16.0 and -24.0°C. More favorable conditions for overwintering were formed in winters from 2012 to 2013, from 2013 / to 2014, the productivity of promising varieties was 1.60–1.85 kg/rm.

Table 3

Winter period characteristics from 2007 to 2015

Year	The sum of average monthly negative air temperatures, °C	Average temperature of winter months, °C	Minimum temperatures, °C			
			Early winter	Mid-winter	After thaws	Frosts
2007/2008	-1159.8	-8.1	-27.3	-28.5	-14.1	-26.2
2008/2009	-1061.0	-7.9	-16.3	-33.9	-19.7	-33.9
2009/2010	-1863.3	-12.0	-39.5	-36.4	-11.4	-36.4
2010/2011	-1800.0	-13.0	-31.9	-33.6	-17.0	-32.4
2011/2012	-1416.9	-8.8	-17.2	-32.6	-16.2	-30.2
2012/2013	-1795.1	-10.3	-31.9	-33.4	-10.0	-33.4
2013/2014	-1223.0	-8.3	-27.5	-35.6	-29.6	-31.9
2014/2015	-1263.5	-7.8	-29.6	-36.6	-13.6	-32.1

A variety of meteorological conditions from 2007 to 2015 studies made it possible to evaluate varieties of garden strawberries for adaptability to specific soil and climatic conditions of the Komi Republic.

Caring for the plants consisted of top dressing, loosening the soil near the bushes, and inter-row cultivation.

Results

The collection of garden strawberries is represented by 18 varieties of different ripening periods. The following varieties were taken as standards Zarya (early ripening), Festivalnaya (mid-ripening), Zenga

Zengana (late ripening). The ranking of the studied varieties by ripeness groups was carried out according to the sources (Bogdanov, 2012; Yakovenko, 2013).

Varying the timing of the onset of phenological phases is associated with a different ratio of varieties to environmental factors, and especially to the temperature factor (Yakovenko and Lapshin, 2014).

From 2012 to 2015, the beginning of the flowering phase was observed from May 29 to June 18 (Appendix A, C = 6.2%). The variability of the needs of varieties in the sum of positive average daily air temperatures at the beginning of flowering is due to varietal differences by 50.5% (r = 0.71*); the reaction of varieties to the conditions of the growing and winter seasons - by 48.7% (r = 0.70*).

The early dates of the beginning of flowering of varieties were noted in 2015 (June 2; 534.2°C), late 2013 (June 12; 523.6°C), differences in the sums of positive average daily air temperatures over the years are not significant.

For 4 years of study, varietal differences in the required amount of positive average daily air temperatures at the beginning of flowering were revealed.

According to average indicators from 2010 to 2015, the varieties are divided into 3 groups. An increase in the need for the sums of positive average daily air temperatures for the onset of the beginning of flowering phase (and, accordingly, a delay in the timing of the beginning of flowering) by 11% (r = 0.33) was determined by the degree of freezing, by 15% (r = -0.39) by the general state in the spring period.

For 4 years of study, the phase of the onset of maturation was noted from July 1 to July 24 (Appendix B, C = 5.8%), the required sums of positive average daily air temperatures were 877.3–209.8°C.

From 2012 to 2015, in the studied group of cultivars, the variation coefficients of the dates and sums of positive average daily air temperatures in cultivars by years did not exceed 4.5–8.1% and 2.1–7.7%, respectively. The lowest provision of the beginning of maturation phase with the sums of positive average daily air temperatures was noted in 2013 (971.9°C), the highest - from 2014 to 2015 (1049.2-1052.7°C).

In the group of early and mid-early varieties, the beginning of ripening fell on July 04–09. In the group of medium varieties, for the beginning of ripening of the Feyerverk variety (July 12), a significantly greater accumulation of the sums of positive average daily air temperatures (1094.5°C) was required compared to the standard Festivalnaya variety (July 8, 1022.1°C). In the group of late varieties, for the beginning of ripening of the Vima Tarda variety (July 12), a significantly greater accumulation of the sums of positive average daily air temperatures (1094.3°C) was required compared to the standard Zenga Zengana variety (08.07; 1024.3°C). In 11.6% of cases (r = 0.34), an increase in the need for the sums of positive average daily air temperatures for the onset of maturation (and, accordingly, a delay in the start of flowering) is associated with freezing, in 31.4% (r = -0.56*) - with the general condition in the spring.

It is necessary to continue research to replenish the assortment of garden strawberries with adapted varieties of ultra-early and ultra-late ripening periods.

From 2012 to 2015 studies, the conditions for overwintering evolved in different ways. Unfavorable conditions for overwintering of garden strawberry developed in 2011 and 2014 before the establishment of snow cover, when the air temperature dropped to -16.0 and -24.0°C.

Winter periods, when strawberry plants were under a layer of snow of 30–85 cm, were characterized as follows: the winter of 2011 and 2012 with low temperatures in the middle of winter (-32.6°C), a sharp decrease

in temperature after thaws (-16.2°C), severe return frosts (-30.2°C); the winter of 2012 and 2013 low temperatures in the early winter period (-31.9°C) and in the middle of winter (-33.4°C), strong return frosts (-33.4°C); the winter of 2013 and 2014 low temperatures in the early winter period (-27.5°C), low temperatures in the middle of winter (-35.6°C), a sharp drop in temperature after thaws (-29.6°C), strong return frosts (-31.9°C); the winter of 2014 and 2015 with low temperatures in the early winter period (-26.9°C), low temperatures in the middle of winter (-36.6°C), strong return frosts (-32.1°C).

After the winters of 2011 and 2012, 2013 and 2014, and 2014 and 2015, 89 - 100% over-drilling of leaves was noted; the degree of overwintering of the leaves was 4.0–5.0 points. In 2013, cultivars Zarya and Vityaz retained up to 50% of green leaves after overwintering (the degree of overwintering of leaves 3.0 points), in 13 cultivars up to 75% of green leaves turned brown (degree of overwintering of leaves 4.0 points).

Over the years of research, in 10 studied varieties, the degree of freezing in regrowth and development of plants did not exceed 1.0 point - weak freezing was noted: the plants were delayed in growth, later developed and bore fruit normally.

For 4 years of observations on winter hardiness, carried out before flowering, 10 varieties were identified, on which only for 4 years of observations after extreme conditions of overwintering of plants in 2014 and 2015 weak freezing was noted - the degree of freezing is 1.0 points.

According to the results of 2012 and 2015 studies, the varieties according to the degree of winter hardiness were identified in 4 groups: winter-hardy (very weak freezing - the degree of freezing up to 1.0 points) - 10 varieties (56%) - Zarya, Timiryazevka, Kokinskaya Zarya, Festivalnaya, Vityaz, Fireworks, Zenga Zengana, Tsarskoye Selo, Troitskaya; medium winter-resistant - Eternal spring, First kiss, Nastena is sweet, Lord; low-winter - Elvira, Rus, Vima Tarda and non-immune - Moscow early.

Discussion

According to the research results, 10 winter-hardy varieties of garden strawberry with weak freezing in unfavorable winter were revealed (the degree of freezing is 1.0 points).

Over the years of research, the general condition of strawberries in spring was estimated from 2.0 to 5.0 points. The cultivars reacted differently to the conditions of the growing and winter seasons - the coefficients of variation over the years ranged from 10.0 (Feyerverk cultivar) to 38.9% (Moskovskaya early cultivar). The assessment of the general condition of 12 varieties was not inferior to the indicators of the standard varieties of its group; the varieties Moskovskaya Rannyaya, Elvira, Vima Tarda were characterized by lower indicators relative to the standards. In the first two years of fruiting - in 2012 and 2013, the general condition of the varieties was assessed higher. Freezing worsened the general condition of plants in spring: the correlation coefficient was -0.82*.

During the study period, the general condition in the fall was estimated from 3.0 to 5.0 points. The varieties reacted differently to the conditions of the growing season - the coefficients of variation over the years ranged from 0.0 (67% of varieties) to 16.5% (variety Vima Tarda). The studied varieties during the autumn assessment were not inferior to the general state of the standards of their group. Above, the general condition of plants was assessed at the end of the growing seasons of 2012, 2014, and 2015.

So, from 2012 to 2015 studies, the general condition of plants of varieties like Zarya, Junia Smides, Kokinskaya Zarya, Festivalnaya, Vityaz, Fireworks, Zenga Zengana, Tsarskoselskaya, Troitskaya was assessed as good and excellent (4.0 - 5.0 points).

Relatively the best of the standards of the zoned variety Festivalnaya (1.10 kg / running meter), the varieties are distributed as follows: the highly productive variety like Kokinskaya Zarya (1.65 kg/running meter), which significantly exceeded productivity by 50.1% (HCP05 = 0.33); productive varieties like Vityaz (1.47 kg/running meter; by 34.0%), Lord (1.35 kg/running meter; by 23.3%), Junia Smides (1.31 kg/running meter; by 19.1%); unproductive varieties like Zarya (1.00 kg/rm), Zenga Zengana (0.86 kg/rm), Troitskaya (0.96 kg/rm), inferior to the indicator of the variety like Festivalnaya by 8.6 - 21.5%; low-productivity of 10 varieties with a productivity of 0.31 - 0.57 kg / running meter (47.7 - 72.0% lower than the standard).

Thus, according to the results of the research, highly productive varieties like Kokinskaya Zarya (1.65 kg/rm), Vityaz (1.47 kg/rm) were identified, which reliably exceeded the indicator of the best of the standards for this indicator of the zoned varieties like Festivalnaya (1.10 kg/rm) by 34.0 - 50.1% (HCP05 = 0.33).

The varieties are divided according to the degree of large-fruitiness into three groups by the average weight of one berry. The varieties with large berries (9.23 - 11.27 g) include 4 varieties such as Kokinskaya Zarya, Vityaz, Lord, Troitskaya (22%). For varieties with medium-sized berries (6.48 - 8.99 g) - 9 varieties such as Zarya, Elvira, Junia Smides, Festivalnaya, Rus, Feyerverk, Zenga Zengana, Tsarskoselskaya, Vima Tarda (50%). 5 varieties (28%) have small berries - from 4.08 to 5.91 g.

Thus, in the studied group of varieties, the varieties Kokinskaya Zarya (11.27 g), Vityaz (10.27 g), Lord (9.23 g), Troitskaya (10.24 g) were distinguished in terms of large-fruitiness; the difference is not significant (HCP05 = 2.51).

Over the years of research, the maximum weight of one berry varied from 5.30 g for the Vima Tarda variety (2013) to 23.50 g for the Kokinskaya Zarya variety in 2012 (Appendix H, C = 25.3%). In 2012 and 2014, the varieties were characterized by larger berries. There was a strong positive correlation between the average and maximum weights of one berry - r = 0.88*.

So, in the studied group of varieties according to the large-fruited berries of the first - second collections, the varieties like Kokinskaya Zarya (20.42 g), Vityaz (19.20 g), and Yuniya Smides (18.22 g) were distinguished, the difference between the indicators is not significant (HCP05 = 1.93). The varieties like Elvira, Festivalnaya, Lord, Troitskaya were characterized by the mass of berries of the first harvest not less than 15 g.

According to several authors in the berries of garden strawberries, depending on the cultivation zone and the variety, the sugar content can vary from 4.0 to 10.0%, dry matter up to 19.4%, vitamin C up to 100 mg% (Avdeeva, 2014b; Sokerina, 2014).

The sugar content varied from 5.28% in the Junia Smides variety in 2014 to 9.23% in the First Kiss variety in 2014 (C = 11.8%). The variability of the trait by 99.9% (r = 0.9995 *) was determined by the variety. In the studied group of varieties, no statistically significant differences in sugar content were found. The First Kiss (8.25%), Rus (8.54%), Fireworks (8.25%) varieties met the requirements for modern varieties in terms of sugar content (at least 8 - 9%).

The dry matter content varied from 10.10 to 15.33% (C = 6.2%). The variability of the trait was determined by the variety by 68.0% (r = 0.82 *). Increased content of dry substances relative to the standards of the corresponding ripening group was noted in the varieties like Pervy Kiss (13.93%), Rus (14.13%), Vima Tarda (13.62%), the differences between the indicators of varieties are not significant.

The vitamin C content varied from 38.37 mg% in the Zenga Zengana variety in 2012 to 81.14 mg% in the Elvira variety in 2012 (C = 10.3%). The variability of the trait by 99.95% (r = 0.9997*) was determined by

the variety. The accumulation of vitamin C at the level of the standards of the corresponding ripening group was noted in the varieties like Timiryazevka, Elvira, Kokinskaya Zarya, Vityaz, Lord, Rus, Troitskaya, Vima Tarda (48.84 - 68.82 mg%). No cultivars were meeting the requirements for vitamin C content in garden strawberries of more than 80 mg%.

The acidity indices of garden strawberries varied within 1.04% for the Perviy Kiss variety in 2014 - 1.63% for the Vityaz variety in 2012 (C = 10.7%). The variability of the trait by 49.5% (r = 0.70*) was determined by the variety, by the weather conditions of the year by 43.4% (r = 0.65*). The studied varieties met the requirements for modern varieties in terms of acid content (no more than 2%). No statistically significant varietal differences in acid accumulation were found. The most complete characteristic of taste consists of a combination of the sum of sugars and titratable acidity - the ratio of sugars to acidity - the sugar-acid index.

The sugar-acid index of garden strawberries varied within the range from 4.18 for the Festivalnaya variety in 2012 to 8.88 for the Perviy Kiss variety in 2014 (C = 11.6%). The variability of the trait by 63.4% (r = 0.80*) was determined by the variety, by the weather conditions of the year by 35.7% (r = 0.60*). In the studied group of varieties, statistically significant differences in the indicators of the sugar-acid index were not revealed.

The taste of strawberries, for the most part, is determined by the genetic characteristics of the variety and depends on the ratio of sugars, acids, salts, aromatic compounds in berries. The taste of berries is also influenced by the conditions and the way they are grown (Bogdanov, 2012).

From 2012 to 2015, the taste of berries was rated 2.0 - 5.0 points (Appendix P, C = 8.8%). The variability of the trait by 75.2% (r = 0.88*) was determined by the variety, by the weather conditions of the year by 24.1% (r = 0.49*).

Varieties Zarya, Kokinskaya Zarya, Vityaz, Zenga Zengana, Tsarskoselskaya, Troitskaya - 33% of varieties had a dessert taste.

Thus, berries of the Rus variety with a sugar content of 8.54%, dry matter 14.13%, vitamin C 58.43 mg%, and acidity of 1.21% were characterized by good biochemical indicators.

The loss of berry yield from gray rot is possible up to 40% (Yakovenko, 2013). The degree of harmfulness depends on the weather conditions of the growing season and the resistance of the variety. Plants weakened by stress are more affected. Under the conditions of the Komi Republic, the maximum yield loss in experiments from 2005 to 2008 was 11.7% (Bogdanov, 2012).

The percentage of berries affected by gray rot over the years of research varied from 0.0 to 10.9 (Appendix P, C = 157.8%). The variability of the trait was determined by the conditions of the year by 60.8% (r = 0.78*), the reaction of varieties to the conditions of the year by 26.6% (r = 0.52*). During the study period, a statistically significant yield loss in most varieties was noted in 2013. It should be noted that the varieties that gave a significant increase in yield showed a tendency for an increase in yield losses from gray rot (r = 0.37).

Thus, during the growing seasons from 2012 to 2015, seventeen varieties (94%) showed resistance to gray rot, yield losses due to the defeat of berries by gray rot did not exceed 10% and amounted from 0.59 to 9.21%.

So, according to the research results, the Kokinskaya Zarya and Vityaz strawberry varieties adapted to the conditions of the Komi Republic were revealed, which made it possible to increase the productivity of agro phytocoenoses from 34.0 to 50.1%.

Kokinskaya Zarya is winter hardy of high-yielding, the average yield is 16.46 t/ha, the maximum is 18.45 t/ha (1.65 and 1.85 kg/rm, respectively, with a narrow-lane arrangement with a row spacing of 1 m). The berries are large, with a dessert taste. The average weight of berries is 11.27 g, the maximum is 20.42 g. The content of dry matter is 12.52%, sugars 7.34%, vitamin C 54.91 mg%, and acids 1.35%.

Vityaz is winter hardy, of average yield is 14.70 t / ha, the maximum is 15.99 t/ha (1.47 and 1.60 kg/rm, respectively, with a narrow-lane arrangement with a row spacing of 1 m). The berries are a large, sweet, and sour refreshing taste. The average weight of berries is 10.47 g, the maximum is 19.20 g. The content of solids 11.51%, sugars 6.60%, vitamin C 55.62 mg%, acids 1.47%.

Conclusion

From 2012 to 2015, 18 varieties of garden strawberry were evaluated according to a complex of characteristics.

10 varieties are classified as frost-resistant.

Highly productive varieties of Kokinskaya Zarya (1.65 kg/rm) and Vityaz (1.47 kg/rm) were identified, which significantly exceeded the indicator of the best of the standards for this indicator of the zoned variety of Festivalnaya (1.10 kg/rm) by 34.0 - 50.1%. HCP05 = 0.33.

Large-fruited varieties of Kokinskaya Zarya (11.27 g), Vityaz (10.27 g), Lord (9.23 g), Troitskaya (10.24 g) were distinguished. HCP05 = 2.51.

Seventeen varieties (94%) showed resistance to gray mold.

According to the research results, the Kokinskaya Zarya and Vityaz strawberry varieties adapted to the conditions of the Komi Republic were revealed, which made it possible to increase the productivity of agro phytocoenoses by 34.0 - 50.1%.

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