ARTICLE

UDC 634.75.574

INVESTIGATION OF THE RESISTANCE OF STRAWBERRY GENOTYPES TO STRESS FACTORS THROUGH VARIOUS DIAGNOSTIC METHODS

Hajiyeva A.F., Majidova G.S., Huseynzadeh Z.N., Karimova Kh.I.

Genetic Resources Institute of MSE of Azerbaijan Republic, Baku, e-mail: mxanim@gmail.com

The article uses various diagnostic methods to investigate the salt and drought resistance of five strawberry genotypes (Reddekut, Carmen, Fakhraly F/14, Barda B/13, XQI 1/18). The water-holding capacity, one of the diagnostic indicators of resistance, in the studied samples ranges from 66% to 57%, whereas the total water content in the leaves varies from 77% to 71%. Based on the results obtained, the genotypes of the strawberry varieties Reddekut and Carmen, which exhibit lower water loss, can be classified as resistant. Another diagnostic method involves assessing the resistance of plants to stress factors by measuring changes in the amount of chlorophyll (a + b) under their influence. The Reddekut variety and the strawberry form XQI/18 demonstrated an increase in chlorophyll content under drought conditions by 8.16% and under salinity by 18.21%. According to the research results, these strawberry samples can be considered highly resistant to both salinity and drought. It was determined that exposure to stress factors disrupts metabolic processes, resulting in the accumulation of proline and various other amino acids without being consumed, thereby increasing their levels compared to the control. Consequently, the amino acid proline is utilized as a biochemical marker of resistance. In our study, following exposure to stress factors, the amount of the amino acid proline increased in all strawberry varieties and forms. However, in one form (Fakhraly F/14), a decrease in this indicator was observed compared to the control under drought conditions. This fact can be associated with the consumption of the proline reserves that the plant utilizes when resisting stress.

Keywords: strawberry, salt, drought, chlorophyll, proline

Introduction

Recent climate changes have exacerbated ecological issues, leading to soil salinization and a decline in agricultural productivity. Consequently, breeding scientists are focused on developing economically productive varieties and forms that exhibit resistance to environmental stressors. The quality and yield of high-value products depend on the physiological processes of plants during their growing period, as well as their genetic potential and resilience to environmental conditions. Therefore, identifying genotypes that are resistant to adverse environmental factors is a critical and current priority.

Materials and methods of research

In the study, five strawberry genotypes from the experimental field of GRI were analyzed. Samples were collected from leaves located near the flowers during the flowering phase. The analysis involved determining the total water content, water retention capacity, chlorophyll (a + b), and protein and amino acid levels in these samples. The water-holding capacity of the leaves was assessed by measuring the amount of water lost after a 4-hour period, using the initial leaf weight and the weight after the water loss. Genotypes that lost less water were considered more resistant.

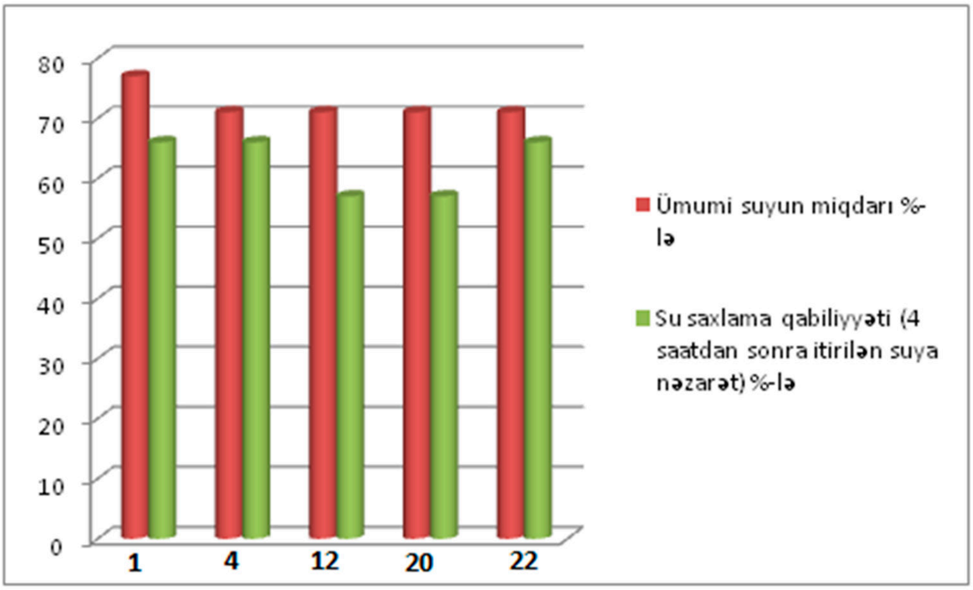
To evaluate the durability of the genotypes, changes in the pigment system under stress factors were examined. The ratio of chlorophyll (a + b) concentration to water content in both salt and drought conditions was used as a unit of measurement for selecting resistant forms [1-3].

For the study of pigment complex changes under stress, leaf discs taken from near the generative sapmles were placed in water, salt (2% NaCl), and sucrose (20 atm) solutions for 24 hours. Afterward, the samples were dried with filter paper and then transferred to 96% ethanol. Chlorophyll transition from the leaf discs to ethanol was completed within 4-5 days. Chlorophyll content changes were measured using a spectrophotometer (UV-3100 PC) at wavelengths of 665 nm and 649 nm [4].

The amount of proline amino acid was determined using the method described by Bates et al. (1973) at a wavelength of 520 nm.

Results of the research and discussions

It is well established that various physiological and biochemical processes occur in plants during stress [1]. Many of these processes are defensive, enabling plants to adapt to their environment. A variety of diagnostic techniques are used to investigate morphological and biochemical alterations brought on by stress causes, one of which is the examination of water regime parameters. The leaves' ability to retain water as well as their overall water content in the strawberry samples were examined.



Water balance in the leaf of five genotypic strawberries

Table 1

Changes in the amount of chlorophyll (a+b) after 24 hours of drought and salt stress in the flowering phase of five strawberry genotypes

Code	Accession	Amount of chlorophyll (a+b) in µg per unit leaf area			Depression rate in %	
		Control	Drought	Salinity	Quraqlıq	Duz
1	Reddekout	3.20	3.72	3.86	116	121
4	Carmen	3.37	2.8	2.8	83	83
12	Fakhralı F/14	5.4	4.74	4.81	88	89
20	Barda B/B	3.79	3.67	4.06	96	107
22	XQI/18	3.98	4.3	4.4	108	118

As shown in Figure, the total water content in the leaves of the samples studied ranged from 77% to 71%, while the water holding capacity ranged from 66% to 57%. According to the literature, resistant varieties tend to have a lower water loss capacity. Based on these results, the strawberry varieties Reddecut and Carmen, which have lower water loss, can be classified as resistant.

The study also investigated the effects of stress factors on physiological parameters, in particular chlorophyll (a+b) content, under laboratory conditions. This diagnostic approach was used to evaluate the tolerance of the samples to drought and salinity.

Chloroplasts play a crucial role in oxygen transport, oxidative and photosynthetic phosphorylation, and overall plant metabolism. Stress factors lead to a decrease in chlorophyll content, which in turn reduces the intensity of photosynthesis.

Therefore, in order to assess resilience, it is important to analyse changes in the pigment system under drought and salinity conditions. The ratio of pigment density to water (control) under these stress conditions was used as a measure for selecting resistant forms. A higher ratio indicates a greater likelihood that the sample is a stable form. The study evaluated the salt and drought resistance of five strawberry genotypes and identified the resistant forms. The results are shown in Table 1.

The table shows that salt and drought had a limited effect on the pigment system of the samples studied. In all cases, the amount of chlorophyll (a+b) varied, but the extent of this variation differed compared to the control. For example, in the Reddecut strawberry variety, the chlorophyll content was 3.20 mg in the control, increasing to 3.72 mg under drought and 3.86 mg under salinity.

Table 2

Changes in carotenoid levels after 24 hours of drought
and salt stress during the flowering phase in five strawberry genotypes

Code	Accession	Carotinoid (mkg)		
		Control	Drought	Salinity
1	Reddekout	0.41	0.57	0.57
4	Carmen	0.5	0.75	0.69
12	Fakhraly F/14	0.45	0.52	0.55
20	Barda B/B	0.42	0.52	0.55
22	XQI/18	0.42	0.45	0.40

Table 3

Changes in proline amino acid levels after 24 hours of exposure
to stress factors during the flowering phase in five strawberry genotypes

Code	Accession	Proline amount mm/mg		
		Control	Drought	Salinity
1	Reddekout	1.94	1.87	3.35
4	Carmen	0.86	1.77	2.94
12	Fakhralı F/14	1.55	0.90	2.22
20	Barda B/B	0.70	2.73	3.34
22	XQI/18	1.02	3.10	2.85

This represents a 16% increase in chlorophyll content under drought and a 21% increase under salinity, highlighting the high tolerance of this variety to both stresses. Similarly, the XQI/18 strawberry cultivar showed strong resistance to both stresses, with chlorophyll content increasing by 8% under drought and 18% under salinity.

Some researchers interpret an increase in chlorophyll content during plant adaptation to stress as a «phytohormone protection phase». According to their findings, this period involves intensive restoration of cellular structures, including chlorophyll, leading to higher chlorophyll levels in stressed leaves compared to control samples. This phenomenon is observed mainly in varieties with a high resistance to stress.

In Bard form B/13, a 4% decrease in chlorophyll content (a+b) was recorded under drought, whereas an increase of 7% was recorded under salinity. The effects of drought and salinity were more performed in Carmen and Fakhrali F/14, where chlorophyll content (a+b) decreased by 12-17% under drought and by 11-17% under salinity.

Based on these results, both Bard form B/13 and Carmen can be classified as tolerant to both salt and drought. In addition, the amount of carotenoids in the samples studied also varied under stress conditions (see Table 2).

In some cases an increase in carotenoid levels compared to the control was observed, in others a decrease. This variability can be attributed to the protective role of carotenoids, which help to restore chlorophylls damaged by stress to their original state, resulting in increased carotenoid concentrations. Consequently, carotenoid levels are typically higher in stressed leaves of less resistant cultivars than in control samples.

One diagnostic method for assessing plant resistance to stress is to analyse the level of the amino acid proline. Under normal physiological conditions, proline is transported to the plant's reproductive organs and is essential for seed and pollen formation. Under stressful conditions, proline acts as an antioxidant, mitigating the negative effects of environmental stressors. Thus, proline levels serve as a biochemical marker of resistance.

In our study, we examined changes in proline levels following exposure to stressors to assess the resistance of the samples under investigation [5,6]. The results are shown in Table 3.

The results showed that in five strawberry samples, the level of the amino acid proline increased under both drought and salinity conditions compared to the control. However, in one sample, the Fakhrali F/14 form, a decrease in proline levels was observed under drought conditions. This decrease can be attributed to the plant using up its existing proline reserves to cope with the stress, with no new proline synthesis taking place. In contrast, proline levels in the other samples increased under stress conditions, indicating proline accumulation without consumption. This accumulation acts as a protective mechanism for the plant as stress slows down metabolic processes. Such a response is characteristic of resistant forms. Thus, proline can be used as a biochemical marker of resistance, serving as a valuable diagnostic tool for selecting resistant genotypes and incorporating them into breeding programmes [7,8].

Conclusion

The article studied various diagnostic methods to investigate the salt and drought resistance of five strawberry genotypes (Reddekut, Carmen, Fakhraly F/14, Barda B/13, XQI 1/18). With the help of diagnostic indicators, continuous patterns are determined as a result of studying the water retention capacity of the leaves, changes in the amount of chlorophyll (a+b) under the influence of stress factors, as well as changes in the amount of the amino acid proline. in the case of metabolic disorders.

Among the samples studied, the Reddekut and Carmen varieties proved to be more resistant due to their ability to retain water in the leaves.

Based on the changes in the amount of chlorophyll (a + b) and the amount of the amino acid proline under the influence of stress factors, the Reddekut variety and the XQI 1/18 form were considered to be highly resistant to both salinity and drought, and it is recommended that they be used as donors in future breeding work.

References

1. Kadıoghlu A. Plant physiology. Turkey: Trabzon, 2018, 120 p.

2. Tugaj Kalefetoghlu, Yasemin Ekmekchi. Effects of drought stress and resistance mechanisms in plants. G.U. // Journal of Science. 2019. № 18(4), P. 723-740.

3. Avdeyeva Z.A. Comparative analysis of drought resistance of strawberry varieties in the conditions of the Orenburg region // Steppes of Northern Eurasia: Mater. IV Intl. symp. Orenburg. 2006. P. 54-56.

4. Assessment of resistance to various stresses of fruit, berry and vegetable crops. Diagnostics of plant resistance to stress: мethodological instructions. Leningrad, 1998. 60 p.

5. Kolupayev Yu.E., Vainer A.A., Yastreb T.O. Proline physiological functions and regulation of content in plants under stress conditions // Visnik Kharkov National Agrarian University series biology. 2014. Vol. 2(32). P. 6-22.

6. Majidova G.S., Garaybayova N.A., Rahimova O.H., Kerimova F.R., Shafizadeh S.I. Diagnostics of resistance to stress factors by morphology, physiology and biochemical parametrs // European Journal of natural history. 2019. № 5. P. 9-14.

7. Izvestiya Nationalnoy Akademii Nauk Belarusi // Biological sciences. 2018. Vol. 63, № 1. P. 20-27.

8. Kalatskaya J.N., Laman N.A., Filatova I.I., Frolova T.V., Lyushkevich V.A., Chubrik N.I., Potter S.V. Influence of plasma wave treatment of maize seeds and their subsequent storage under unfavourable conditions on the physiological and biochemical characteristics of sprouts // Izvestiya Nationalnoy Akademii Nauk Belarusi. Biological sciences. 2018. Vol. 63, № 1. P. 7–19.