I. BİOLOJİ EHTİYATLAR və SELEKSİYA | BIOLOGICAL RESOURCES and BREEDING

UOT-633.31/.37; 635.65

STUDY OF CHLOROPHYLL AMOUNT AND PRODUCTIVITY INDICATORS IN SOYBEAN (*GLYCINE MAX* L.) GENOTYPES AT DIFFERENT DEVELOPMENT PHASES

ORKHAN BAYRAMLI*, ZEYNAL AKPAROV

Genetic Resources Institute, Ministry of Science and Education of the Republic of Azerbaijan, Baku, AZ 1106, Azadlig ave,155
bayramliorxan98@gmail.com

The research was conducted at the Saray Support Station of the Genetic Resources Institute in 2022-2023. As research material, soybean (*Glycine max* L.) genotypes were used, including (Kanada, CHU-11, Ген-8, БК-98, Kyota, Л-1, Л-12, Krasnodar-68, Л-3, Alexa, CHU-10, Л-4, Л-7, Л-9, Opus, CHU-14, Л-8, Anjelica, Л-2, Кол-6, Л-11, БК-82, Л-10, Кол27, Sinara, Asuka, Antonia, REGALE, Biyson, Umanskaya, Bravo, Kanada 4, Kanada 5, Kanada-6, Kanada 7, Л-5, БК-88, Л-6, БК-83, and БК-104). Analysis of soybean genotypes' chlorophyll content and productivity indices at various stages of vegetative growth was the main goal of the study. Different genotypes of soybeans were grouped using Ward's clustering technique. Strict adherence to crucial agro-technical practices during growing is necessary to boost the yield and chlorophyll content of soybean samples. This makes it possible to fully comprehend how the amount of chlorophyll present during the plant's development phase impacts productivity components. The study found that according on the stage of growth of the plant, the amount of chlorophyll in soybean genotype leaves varied considerably. In Cluster C, the genotypes with the greatest levels of chlorophyll and pod length were identified. Of these, the Uzbek-origin L-2 genotype, which is found in Group C's third sub-cluster, was notable for having an exceptionally high chlorophyll content. Genotypes with high productivity metrics, such as the weight of 1000 seeds and the number of pods per plant, were chosen for Cluster B. With the exception of Turkish genotypes, Cluster B similarly had the greatest chlorophyll content. The findings of this study contribute to a better understanding of the relative link between chlorophyll concentration and productivity in various stages of soybean plant growth. Therefore, increasing the amount of chlorophyll in soybean plants can help choose and use more productive genotypes for upcoming industrial production and scientific breeding.

Keywords: *soybean, SPAD-502, chlorophyll content, yield component*

INTRODUCTION

One of the most widely used raw foods in daily life is soybean, and the country's output of the crop has a direct impact on people's quality of life and food security (Liu et al., 2008). China's soybean market has seen sharp swings since 2012, imports of soybeans have surged dramatically, and the country is now more than 80% dependent on outside sources of soybeans (Wang et al., 2020). The national food security of soybeans is particularly threatened by this, so it is critical to address the problems of poor soybean production and variable quality. Because of the ability of crop leaves to photosynthesize, the chlorophyll concentration is a crucial indicator of crop growth (Zhang et al., 2019). It serves as the foundation for the interchange of materials and energy between crops and the surrounding environment, and the health and growth of the crops can be inferred from its value. Conventional techniques for measuring chlorophyll levels cause damage and produce

https://doi.org/10.61642/20241
Available online 26 December 2024

inaccurate findings (Steele et al., 2008). The benefits of hyperspectral technology include wide information gathering, non-destructiveness and efficiency, and high spectral resolution (Wu et al., 2008). It can identify and analyze the spectral characteristics of a target object and is now increasingly used in the quantitative estimation of vegetation parameters and growth monitoring. Several spectral feature extraction methods have previously been proposed to effectively extract plant information in vegetation monitoring. The spectral index is the most commonly used variable parameter for establishing spectral estimation models, and combining it with various extraction methods for modeling has become a common research method (Wang et al., 2018). Plant physiological factors can be more effectively monitored by modeling and calculating the vegetation index using hyperspectral technology. A novel approach to tracking the dynamic variation of chlorophyll content in crop leaves is offered by the combination of hyperspectral technology and chlorophyll content measurement. There have been recent investigations on the inversion of crop chlorophyll content using hyperspectral data. Liu et al. (2021) observed the spectral characteristics and chlorophyll content of winter wheat at different growth stages and found that there was a significant correlation between the chlorophyll content and part of the spectral range as well as the remote sensing vegetation index. They also found that their model was highly accurate (Liu et al., 2021). In order to achieve better monitoring effects, Yuan et al. (2017) reversed the hyperspectral data and chlorophyll content from leaves during the soybean flower bud differentiation stage using mathematical models (Yuan et al., 2017). The majority of current research create mathematical inversion models of the chlorophyll content using the original crown height spectral reflectance data; yet, the accuracy and prediction power are not very good (Xia et al., 2021). In order to enhance the modeling accuracy and reduce the amount of background noise in the spectral data, the integer order differential transformation approach is proposed to handle the original hyperspectral reflectance data (Leyden et al., 2018). Strong relationships between chl content and areal leaf mass (ALM) and SPAD readings were noted by Thompson et al. (1996) in their study of soybeans. They proposed that genotypes varying in ALM may be selected for using a portable SPAD chl meter. Screening large plant populations for genotypic variations in leaf N content would also be made more attractive by the ease and speed with which chl meter evaluations of soybean N status can be performed. Previous research that used both the original hyperspectral data and the first-order differential transformation spectral data to invert crop chlorophyll content discovered that the mathematical model established using the first-order differential transformation data was more accurate than the initial data inversion results, and the inversion results had a higher ability to predict chlorophyll content (Tang et al., 2022). The conventional approach builds the mathematical model using a fixed band, which prevents it from effectively utilizing the spectrum information included in the spectral index (An et al., 2016). In order to create the best spectral index, the correlation matrix method chooses the bands with the highest correlation between soybean chlorophyll content and other factors. This effectively addresses the issue of spectral characteristics being readily influenced by variations in the crop's physiological information (Ge et al., 2021). and greatly increases the utilization of spectral data. With the use of hyperspectral remote sensing technology, which more accurately separates the spectrum, the optimal spectral index that is closely associated with the amount of chlorophyll in each of the possible spectral bands may be chosen (Tang et al., 2023).

MATERIALS AND METHODS

The research was conducted at the Genetic Resources division of the Ministry of Science and Education of Azerbaijan spanning the years 2022 to 2023. A total of 40 varieties, namely *Kanada, CHU-11, Ген-8, БК-98, Kyota, Л-1, Л-12, Krasnodar-68, Л-3, Alexa, CHU-10, Л-4, Л-7, Л-9, Opus, CHU-14, Л-8, Anjelica, Л-2, Кол-6, Л-11, БК-82, Л-10, Кол27, Sinara, Asuka, Antonia, REGALE, Biyson, Umanskaya, Bravo, Kanada 4, Kanada 5, Kanada-6, Kanada 7, Л-5,* *БК-88, Л-6, БК-83, and БК-104,* were utilized as the subjects of the study. The experimental material comprised 40 distinct genotypes.

Table 1.

List of studied genotypes

Genotypes		AZGR	Origin	Genotypes		AZGR	Origin
1	Kanada	13566	Canada	21	Л-11		Uzbekistan
2	CHU-11	13898	Turkiye	22	БК-82		Uzbekistan
3	Ген-8		Uzbekistan	23	Л-10		Uzbekistan
4	БК-98		Uzbekistan	24	Кол-27		Uzbekistan
5	Kyota	13565		25	Sinara	13904	Austria
6	Л-1		Uzbekistan	26	Asuka	13570	Japonia
7	Л-12		Uzbekistan	27	Antonia	13215	Australia
8	Krasnodar-68	13902		28	REGALE	13216	Italia
9	Л-3		Uzbekistan	29	Biyson	13878	
10	Alexa	13241	Australia	30	Umanskaya	13906	
11	CHU-10	13897	Turkiye	31	Bravo	13879	
12	Л-4		Uzbekistan	32	Kanada 4	13883	Canada
13	Л-7		Uzbekistan	33	Kanada 5	13884	Canada
14	Л-9		Uzbekistan	34	Kanada-6	13885	Canada
15	Opus	13568		35	Kanada 7	13886	Canada
16	CHU-14	13901	Turkiye	36	Л-5		Uzbekistan
17	Л-8		Uzbekistan	37	БК-88		Uzbekistan
18	Anjelica	13214	Australia	38	Л-6		Uzbekistan
19	Л-2		Uzbekistan	39	БК-83		Uzbekistan
20	Кол-6		Uzbekistan	40	БК-104		Uzbekistan

A self-calibrating Minolta chlorophyll meter (SPAD-502) was used to measure leaf chlorophyll content, which was recorded in Minolta company-defined SPAD values (Minolta 1999). Flag leaves on the 10 randomly tagged main leaves were used for scoring SPAD measurements (Rosyara, 2007). Minolta (1999) ‘Chlorophyll meter SPAD-502: instruction manual.’ (Minolta Co Ltd: Osaka)(16).The chlorophyll content was measured at the four-node (V4), complete flowering (R2), full pod (R4), and drum-grain stages (R6) of the soybean. Chlorophyll content was measured using a SPAD-502 handheld chlorophyll meter. Since the SPAD-502 reading was closely related to the chlorophyll content, its value directly represented the chlorophyll content.Ten soybean plants were randomly selected from each plot at different stages, and the SPAD values of the top 1, top 2, top 3, and top 4 leaves were measured from top to bottom along the main stem. At the same time, for the leaves at the four above leaf positions, from the base of the leaves, according to their length, every 1/3 was divided into intervals, which were defined as the base (B), middle (C), and top (R). The SPAD values were measured and the average values in the same experimental plots were calculated (Rosyara et al., 2007).

RESULTS AND DISCUSSION

The structural components of yield in soybean varieties of various origins as well as the amount of chlorophyll in physiologically active leaves were investigated.Several soybean varieties chlorophyll content and productivity indices were grouped using the Ward technique.

Using the dendrogram derived from the study, it was feasible to see the genetic variations between the genotypes. Among all the genotypes, the L-2 variety was distinguished by having the highest chlorophyll content and a unique genetic profile.

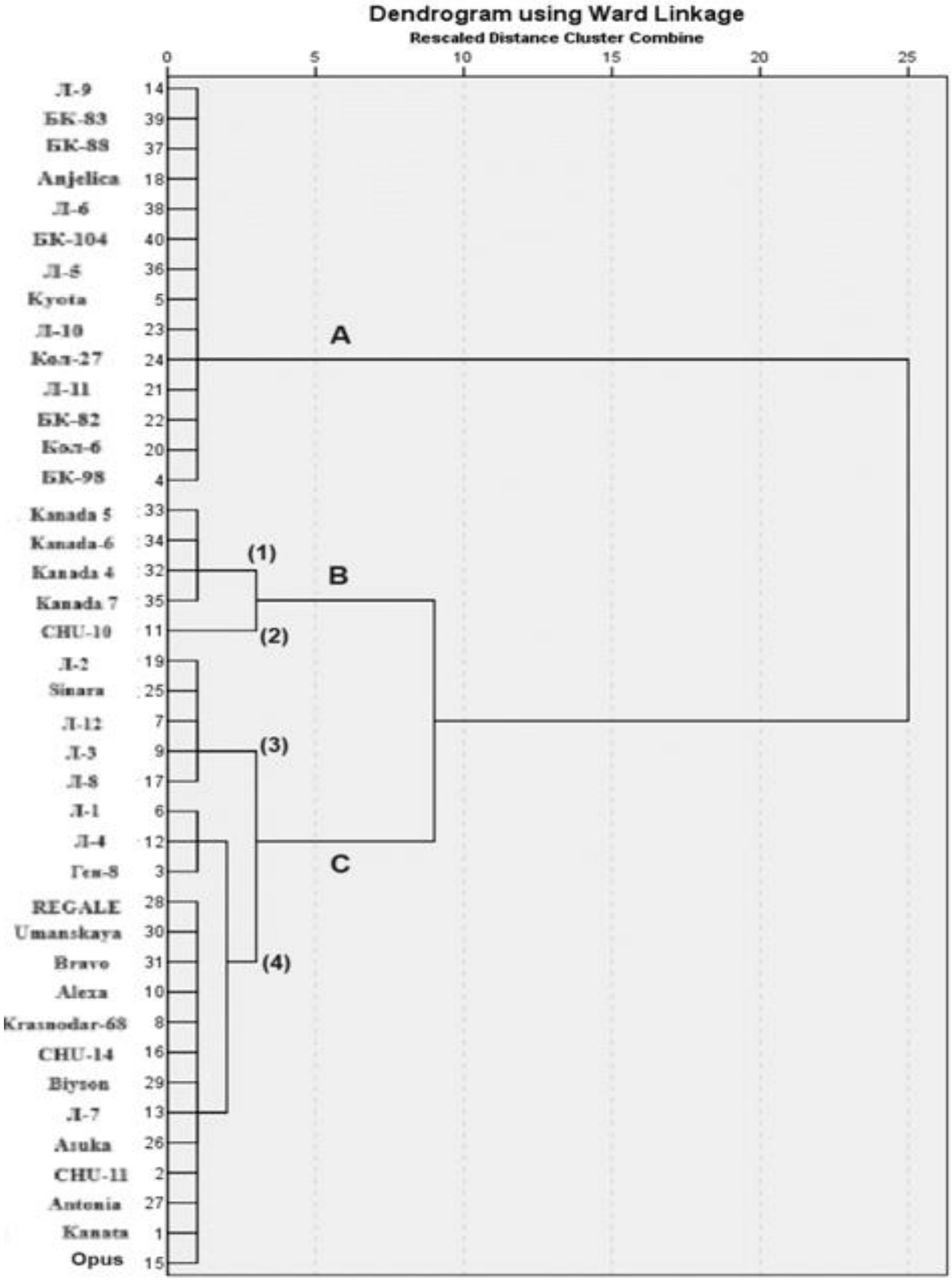

Figure 1. Analysis of the Dendrogram Using Ward's Linkage Method for Clustering Soybean Species

Three separate clusters were formed from the genotypes based on the dendrogram. It was discovered that the majority of the genotypes in Cluster A were Uzbek. Two subclusters were created from Cluster B. In the first subcluster, four genotypes were Canadian, but in the second subcluster, the genotypes were Turkish. It's interesting to note that, despite being separately assigned to Cluster B's second subcluster, the Turkish CHU-10 genotype was more similar to the Canadian genotypes in terms of production metrics and chlorophyll content. In the meanwhile, Cluster C contained the remaining Turkish genotypes. In Cluster B, the genotypes exhibited a high 1000-seed weight, and it was observed that the number of pods per plant varied within the same range. Cluster C contained the genotypes with the highest values for chlorophyll content and productivity indicators. The L-2 genotype of Uzbek origin stood out particularly for its chlorophyll content. Among all the genotypes, the L-2 variety had the highest chlorophyll content, demonstrating a unique genetic profile.

CONCLUSION

In conclusion, this study demonstrates the significant influence of plant growth stage and levels on the productive elements and chlorophyll content of soybean. The results show that the highest chlorophyll content was recorded in cluster C, which comprised genotypes with high pod length and chlorophyll content. The study also found that genotypes in cluster B exhibited high 1000-seed grain weight and a high number of pods per plant. The findings of this study have important implications for soybean breeding programs. The results suggest that breeding programs should consider the plant growth regulators and levels to improve the productive elements and chlorophyll content of soybean. Additionally, the study highlights the importance of using a combination of plant growth regulators and levels to achieve optimal results. Overall, this study provides valuable insights into the effects of plant growth stage and levels on the productive elements and chlorophyll content of soybean. The results of this study can be used to develop more effective breeding strategies for soybean and to improve the productivity of soybean crops.

REFERENCES

Əkpərov Z.İ. Azərbaycanın bitki genetik ehtiyatları.Bakı: 2021; 496 [Akparov Z.I. Plant genetic resources of Azerbaijan. Baku: 2021; 496 (in Azerbaijani)]

Əkpərov Z.İ. Soya əkinlərinin quruluşu, fotosintez əlamətləri və məhsuldarlıq. AMEA-nın Xəbərləri (biologiya elmləri seriyası), N1-6, "Elm", Bakı, 2002, s. 421-429 [Akparov Z.I. Soybean plant structure, photosynthesis traits and productivity. AMEA-nin xabarlari (biologiya elmlari seriyasi) = News of ANAS (biological sciences series). N1-6, "Elm", Baku, 2002, p.421-429 (in Azerbaijani)]

Əliyev C.Ə., Əkpərov Z.İ., Nəbiyev M.H. Azərbaycanda suvarma şəraitində soyanın becərilməsi .Azərnəşr 1982; 54. [Aliyev J.A Akparov Z.I Nabiyev M.H. Cultivation of soybean under irrigation conditions in Azerbaijan. Azernashr 1982; 54 . (in Azerbaijani)]

An, D.; Zhao, G.; Chang, C.; Wang, Z.; Li, P.; Zhang, T.; Jia, J. Hyperspectral field estimation and remote–sensing inversion of salt content in coastal saline soils of the Yellow River Delta. *Int. J. Remote Sens*. 2016;37:455–470.

Ge, X.; Ding, J.; Jin, X.; Wang, J.; Chen, X.; Li, X.; Liu, J.; Xie, B. Estimating agricultural soil moisture content through UAV–based hyperspectral images in the arid region. *Remote Sens*. 2021;13:1562.

Leyden, K.; Goodwine, B. Fractional–order system identification for health monitoring. Nonlinear. Dynam. 2018;92:1317–1334.

Liu, C.; Hu, Z.; Islam, A.T.; Kong, R.; Yu, L.; Wang, Y.; Chen, S.; Zhang, X. Hyperspectral characteristics and inversion model estimation of winter wheat under different elevated CO2 concentrations. *Int. J. Remote Sens*. 2021;42:1035–1053.

Liu, X.; Jin, J.; Wang, G.; Herbert, S. Soybean yield physiology and development of high–yielding practices in Northeast China. *Field Crop*. Res. 2008;105:157–171.

Rosyara U.R., Duveiller E., Pant K. and Sharma R.C. Variation in chlorophyll content, anatomical traits and agronomic performance of wheat genotypes differing in spot blotch resistance under natural epiphytotic conditions. *Australasian Plant Pathology*, 2007;36:245–251

Steele, M.R.; Gitelson, A.A.; Rundquist, D.C. A comparison of two techniques for nondestructive measurement of chlorophyll content in grapevine leaves. *Agron. J*. 2008;100: 779–782.

Tang, Z.; Guo, J.; Xiang, Y.; Lu, X.; Wang, Q.; Wang, H.; Cheng, M.; Wang, H.; Wang, X.; An, J.; et al. Estimation of Leaf Area Index and Above–Ground Biomass of Winter Wheat Based on Optimal Spectral Index. Agronomy 2022;12:1729.

Tang, Z.J.; Xiang, Y.Z.; Wang, X.; An, J.Q.; Guo, J.J.; Wang, H.; Li, Z.J.; Zhang, F.C. Comparison of SPAD Value and LAI Spectral Estimation of Soybean Leaves Based on Different Analysis Models. *Soyb. Sci*. 2023;42:55–63, (In Chinese with English abstract).

Wang, C.; Linderholm, H.W.; Song, Y.; Wang, F.; Liu, Y.; Tian, J.; Xu, J.; Song, Y.; Ren, G. Impacts of drought on maize and soybean production in northeast China during the past five decades. *Int. J. Environ. Res*. Public Health 2020;17:2459.

Wu, C.; Niu, Z.; Tang, Q.; Huang, W. Estimating chlorophyll content from hyperspectral vegetation indices: Modeling and validation. Agr. Forest Meteorol. 2008;148:1230–1241.

Wang, J.; Wu, W.; Wang, T.; Cai, C. Estimation of leaf chlorophyll content and density in Populus euphratica based on hyperspectral characteristic variables. Spectrosc. Lett. 2018;51: 485–495.

Xia, K.; Xia, S.; Shen, Q.; Yang, B.; Song, Q.; Xu, Y.; Zhang, S.; Zhou, X.; Zhou, Y. Moisture spectral characteristics and hyperspectral inversion of fly ash–filled reconstructed soil. Spectrochim. Acta. A. 2021;253:119590.

Yuan, H.; Yang, G.; Li, C.; Wang, Y.; Liu, J.; Yu, H.; Feng, H.; Xu, B.; Zhao, X.; Yang, X. Retrieving soybean leaf area index from unmanned aerial vehicle hyperspectral remote sensing: Analysis of RF, ANN, and SVM regression models. Remote Sens. 2017;9:309.

Zhang, F.; Zhou, G. Estimation of vegetation water content using hyperspectral vegetation indices: A comparison of crop water indicators in response to water stress treatments for summer maize. BMC Ecol. 2019;19:18

MÜXTƏLİF İNKİŞAF FAZALARINDA SOYA (*GLYCİNE MAX L.*) GENOTİPLƏRİNDƏ XLOROFİLİN MİQDARI VƏ MƏHSULDARLIQ GÖSTƏRİCİLƏRİNİN ÖYRƏNİLMƏSİ

Bayramlı Orxan*, Zeynal Əkpərov

Azərbaycan Respublikası Elm və Təhsil Nazirliyi Genetik Ehtiyatlar İnstitutu

Tədqiqatlar Genetik Ehtiyatlar İnstitutunun Saray Dayaq Məntəqəsində 2022-2023-ci illərdə aparılmışdır. Tədqiqat materialı kimi soyanın(*Glycine max* L.) genotiplərindən (*Kanada, CHU-11, Ген-8, БК-98, Kyota, Л-1, Л-12, Krasnodar-68, Л-3, Alexa, CHU-10, Л-4, Л-7, Л-9, Opus, CHU-14, Л-8, Anjelica, Л-2 , Кол-6, Л-11, БК-82, Л-10, Кол27, Sinara, Asuka, Antonia, REGALE, Biyson, Umanskaya, Bravo, Kanada 4, Kanada 5, Kanada-6, Kanada 7, L-5, BK-88, L-6, BK-83 və BK-104*) istifadə edilmişdir. Tədqiqat işi vegetasiyanın müxtəlif inkişaf fazalarında soya genotiplərinin məhsuldarlıq göstəriciləri və xlorofilin miqdarının öyrənilməsinə həsr edilmişdir. Bu məqsədlə müxtəlif soya genotiplərini qruplaşdırmaq üçün Ward-ın klaster analizindən istifadə edilmişdir. Soya nümunələrində xlorofilin miqdarını və məhsuldarlığını artırmaq üçün becərmə zamanı mühüm aqrotexniki tədbirlərə ciddi əməl edilməlidir. Bu zaman soya nümunələrinin böyümə mərhələsində xlorofilinin miqdarının məhsuldarlıq elementlərinə necə təsir etdiyi barədə dolğun məlumat əldə etmək olar. Tədqiqat zamanı soya genotiplərinin yarpaqlarında xlorofilin miqdarının bitkinin inkişaf fazalarından asılı olaraq əhəmiyyətli dərəcədə dəyişdiyi aydınlaşdırılmışdır. Ən yüksək xlorofilin miqdarına və paxla uzunluğuna malik olan genotiplər C klasterində qeydə alınmışdır.C qrupunun 3-cü yarım-klasterində yerləşən Özbəkistan mənşəli L-2 genotipi xlorofilin miqdarına görə digər genotiplərdən xüsusilə fərqlənmişdir. B klasterindəki genotiplər əsas məhsuldarlıq göstərici olan 1000 dənin kütləsi və hər bitkiyə düşən paxla sayının yüksək qiyməti seçilmişdir. Bunların arasında Türkiyə genotipləri istisna olmaqla, ən yüksək xlorofilin miqdarı B klasterində qeydə alınmışdır.Bu tədqiqatların nəticələri soya bitkisinin inkişaf fazalarında məhsuldarlıq və xlorofilin miqdarı arasında müqayisəli tədqiqatları daha dərindən başa düşməyə imkan verir.Beləliklə, tədqiqat nəticələri, soya bitkisində xlorofilin miqdarını optimallaşdırmaqla məhsuldarlığı artırmaq, gələcəkdə elmi seleksiya və istehsalat üçün daha səmərəli genotiplərin seçilərək istifadə olunmasına kömək edə bilər.

Açar sözlər: *soya, SPAD-502, xlorofil miqdarı, məhsuldarlıq elementləri*

ИЗУЧЕНИЕ СОДЕРЖАНИЯ ХЛОРОФИЛЛА И ПОКАЗАТЕЛЕЙ ПРОДУКТИВНОСТИ ГЕНОТИПОВ СОИ (GLYCINE MAX L.) НА РАЗНЫХ ФАЗАХ РАЗВИТИЯ

Орхан Байрамлы*, Зейнал Акпаров
Институт генетических ресурсов Министерства науки и образования Азербайджанской Республики

Исследования проводились в 2022-2023 годах на Сарайском Опорном пункте Института генетических ресурсов. В качестве материала для исследования были использованы генотипы (*Kanada, CHU-11, Ген-8, БК-98, Kyota, Л-1, Л-12, Krasnodar-68, Л-3, Alexa, CHU-10, Л-4, Л-7, Л-9, Opus, CHU-14, Л-8, Anjelica, Л-2 , Кол-6, Л-11, БК-82, Л-10, Кол27, Sinara, Asuka, Antonia, REGALE, Biyson, Umanskaya, Bravo, Kanada 4, Kanada 5, Kanada-6, Kanada 7, L-5, BK-88, L-6, BK-83 и БК-104)* сои (*Glycine max* L.). Исследование посвящено изучению показателей продуктивности и содержания хлорофилла у генотипов сои на различных фазах вегетационного развития. Различные генотипы соевых бобов были сгруппированы с использованием метода кластеризации Уорда. Для увеличения содержания хлорофилла и урожайности в образцах сои необходимо при выращивании строго соблюдать важные агротехнические мероприятия. Это позволяет получить полную информацию о том, как содержание хлорофилла в фазе роста растений влияет на элементы продуктивности. В ходе исследования было выявлено, что содержание хлорофилла в листьях генотипов сои существенно варьирует в зависимости от фаз развития растения. Генотипы с наибольшим содержанием хлорофилла и длиной бобов были зафиксированы в кластере C. Генотип L-2 узбекского происхождения, расположенный в третьем подкластере группы C, особенно выделялся среди других генотипов по содержанию хлорофилла. Генотипы кластера B были отобраны по высоким значениям массы 1000 зерен и количества бобов на растении, которые являются основными показателями продуктивности. Среди них, за исключением турецких генотипов, самое высокое содержание хлорофилла было зарегистрировано в кластере B. Результаты этих исследований позволяют глубже понять сравнительные исследования между урожайностью и содержанием хлорофилла в фазах развития растений сои.

Таким образом, результаты исследований могут помочь повысить продуктивность за счет оптимизации содержания хлорофилла в растениях сои, способствовать отбору и использованию более продуктивных генотипов для научной селекции и промышленного производства в будущем.

Ключевые слова: *соя, SPAD-502, содержание хлорофилла, элементы продуктивности*

Çapa təqdim etmişdir: redaktor Saleh Məhərrəmov AMEA-nın müxbir üzvü, b.e.d., professor
Redaksiyaya daxil olma tarixi: 04.07.2024
Təkrar işlənməyə göndərilmə tarixi: 11.08.2024
Çapa qəbul edilmə tarixi: 10.09.2024