



Check for
updates



Research Article

Study on the Relationship between Anatomical Structure and Drought Resistance of Six *Prunus persica*

Zhang Chuji¹, Muhammad Saleem^{1*}, Urooj Rehmani², Mian Muhammad Ahmed³, Muhammad Wajahat Rasool⁴, Muhammad Masoom⁵, Aqsa Amjad⁶, Aitazaz Alam⁷, Abdul Hafeez Mastoi⁸, Aqsa E Zahra⁷, Xi Conglin^{1*}

¹ College of Agriculture, Shanxi Agricultural University, Taigu, 030801, P. R. China.

² Department of Agronomy, The University of Agriculture Peshawar, Pakistan.

³ National Key Laboratory for Germplasm Innovation and Utilization of Horticultural Crops, Huazhong Agricultural University, Wuhan, 430070, Hubei, China.

⁴ College of Life Science and Technology, Tarim University, Alar, China.

⁵ Institute of Agronomy, Bahauddin Zakariya University Multan, Pakistan.

⁶ Research officer at Directorate of Agriculture Research District Ziarat Balochistan, Pakistan.

⁷ Department of Entomology, College of Agriculture, University of Sargodha, Pakistan.

⁸ Department of Entomology, PMAS-Arid Agriculture University Rawalpindi, Pakistan.

⁸ Department of Entomology, faculty of Agriculture LUAWMS, 90150 Uthal, Balochistan, Pakistan.

ABSTRACT

Six main peach tree varieties in Shanxi Province were selected as the test materials. Branches of six peach tree varieties were sectionized in paraffin, and their anatomical structures were observed and analyzed. Anatomical structure characteristics such as epidermal thickness, thickness of thick horn tissue, vascular bundle, ratio of xylem to stem area, and number of catheterization were selected as evaluation indexes for drought resistance. The method of fuzzy mathematical membership function analysis was used to comprehensively evaluate its drought resistance. The results showed that the drought resistance of six main peach tree varieties were as follows: Pinggu 14> Qinwang> Jinyumi> Jinhongmi> Hongfenghuang, thus providing scientific reference for the breeding and management of peach tree varieties in our province.

Keywords: Peach Varieties, Paraffin production, Drought resistance, Anatomical characteristics.



Correspondence

Xi Conglin, Muhammad Saleem,
sxauxicl@126.com
msaleemkubar@yahoo.com

Article History

Received: November 24, 2024

Accepted: January 22, 2025

Published: February 10, 2025



Copyright: © 2024 by the authors.
Licensee: Roots Press, Rawalpindi, Pakistan.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license:
<https://creativecommons.org/licenses/by/4.0>

INTRODUCTION

Peach (*Prunus persica* L.) is a genus of peach in Liaceae of Rosaceae, mainly distributed in central Asia to the European and African Mediterranean regions, and its varieties can be found in cold temperate and warm temperate regions to subtropical regions (Fetouh et al., 2018). Peach, pear and apple trees are the three main fruit trees in China. Peach tree as an important economic tree species in Shanxi Province, the planting area has been gradually expanded in recent ten years. Peach is favored by the majority of people for its unique taste, various medicinal values and as an ornamental plant (Xu et al., 2018). In our country, there is a widespread drought conditions in the peach trees in north China region, the development of the regional water conservancy irrigation potential is smaller, especially in recent years, frequent extreme drought climate led to the decrease of the per unit area yield and fruit quality (Bhusal et al., 2020), for the plant diseases and insect pests of gum disease, SangBai shield pest (flow) has created favorable conditions, so as to restrict the healthy development of the peach industry, Therefore, to explore the drought resistance of peach trees is one of the main ways

to solve the drought problem in this region (Zhang et al., 2023) and (Peng et al., 2018). At present, researches on drought resistance of peach trees mainly focus on various physiological and biochemical indexes of peach trees, such as electrical conductivity, membrane permeability, enzyme activity (superoxide dismutase, peroxidase, catalase), endogenous hormones (abscisic acid, gibberellin), etc Liu et al., 2010; and Li et al., 2017). However, there are few studies on the relationship between the anatomical structure of peach branches and drought resistance Pantelidis et al., 2021; and salah et al., 2022). Peach tree stems as plants connected to the roots and leaves the ground axial vegetative organs, counseling and support, and other important role, the peach tree branches not only supports all branches make its spread in the air, and to resist wind, rain, snow, natural disasters such as drought stress on plant stress, affected by the external environment and their own genetic characteristics of comprehensive. Anatomical structural characteristics of peach branches, such as epidermal thickness, thick horn tissue, vascular bundle, xylem/stem area ratio, number of vessels and other indexes, can comprehensively reflect the influence of various environmental factors, and these indexes can be used as an important basis for evaluating drought resistance among peach varieties (Zhao et al., 2022). This article selects six local peach cultivars were used as material, cold-resistance to paraffin section of annual branches, through the CX31 binocular microscope observation and analysis of anatomical structure, the fuzzy mathematics method of subordinate function analysis of peach tree branches anatomical characteristics, preliminary discussion from the branches of the peach varieties anatomic structure and the relationship between the drought resistance, It provided theoretical and practical basis for the introduction and popularization of drought resistant varieties and the utilization of germplasm resources of peach trees in this area.

MATERIAL AND METHODS

The experimental materials were collected from Taigu County (Houcheng Town, Xiaobai Township, Beiwang Township, Shuixiu Township, Yangyi Township) of Shanxi Province (112°E, 37°N). The altitude is 803 meters, and the annual precipitation is 360-621mm, mainly from June to August. However, the average precipitation from 2017 to 2019 is only 350-400mm, and the annual average temperature is 11-23°C. The four seasons have distinct climate: windy and dry in spring, cold and dry in winter, and it belongs to temperate continental climate, mainly semi-arid climate. The collection time was from November 2019 to February 2020. The main peach tree varieties in Taigu region were selected as the test materials, and the varieties were as follows: The annual fresh branches of Pinggu 14, Hongfenghuang, Dajiubao, Qinwang, Jinyumi and Jinhongmi were cut with pruning shears, marked and wrapped in plastic bags and brought back to the laboratory. The branches of each variety were cut into small sections of 1.8-2.7cm in diameter and 0.4-0.7cm in length with a single-side blade. At the same time, the soil moisture content of 15-30cm in the collection site was measured, and the results showed that the relative moisture content of the soil was 20%-30%, belonging to moderate drought

Softening and fixing

First, plant tissue material softener (mixed hydrogen peroxide and glacial acetic acid, 1:1) was used to soften the test material. Cut 5 to 6 portions of each variety and put them into a small test tube filled with softener. After softening for 3-5d, a transition solution (70% tert-butanol: glycerol 1:1) was added and soaked for 12h.

Dehydration

Then to dehydration branches (during this period in advance will be homemade melt wax box open, dissolve the paraffin in advance), put the branches in 70% tert-butyl alcohol solution under ZDF type vacuum drying oven, vacuum suction to the table shows 0.08 Mpa after off pump placed an hour (extraction is for the material internal gas extracted, facilitate subsequent permeability wax etc.); Then put the branches into 85% tert-butanol, pure tert-butanol solution, the operation steps are the same as the above, in which pure tert-butanol solution should be replaced 3 times.

Permeability wax

After the dehydration is completed, take out the test tube containing pure tert-butyl alcohol solution and add the pre-melted paraffin (melting point: 58 ~ 60°C) in the proportion of (tert-butyl alcohol: paraffin 1:1) and place it in a vacuum drying oven for one hour at 60°C. Then it was transferred to the osmotic solution II (tert-butanol: paraffin 25%: 75%) and kept at 58 ~ 60°C for 1 h. Finally, it was transferred into pure paraffin solution at 58 ~ 60°C and repeated for 2 ~ 3 times (Sun et al., 2018).

The embedding

Pour the pure paraffin solution into the small carton, then use the preheated forceps to pick up the material and place it at the bottom of the carton. Put it in the right position and place it for 30 s. Then put the carton into ice water for rapid cooling. After the paraffin solidifies, the embedded material can be obtained.

Wax trimming and sectioning

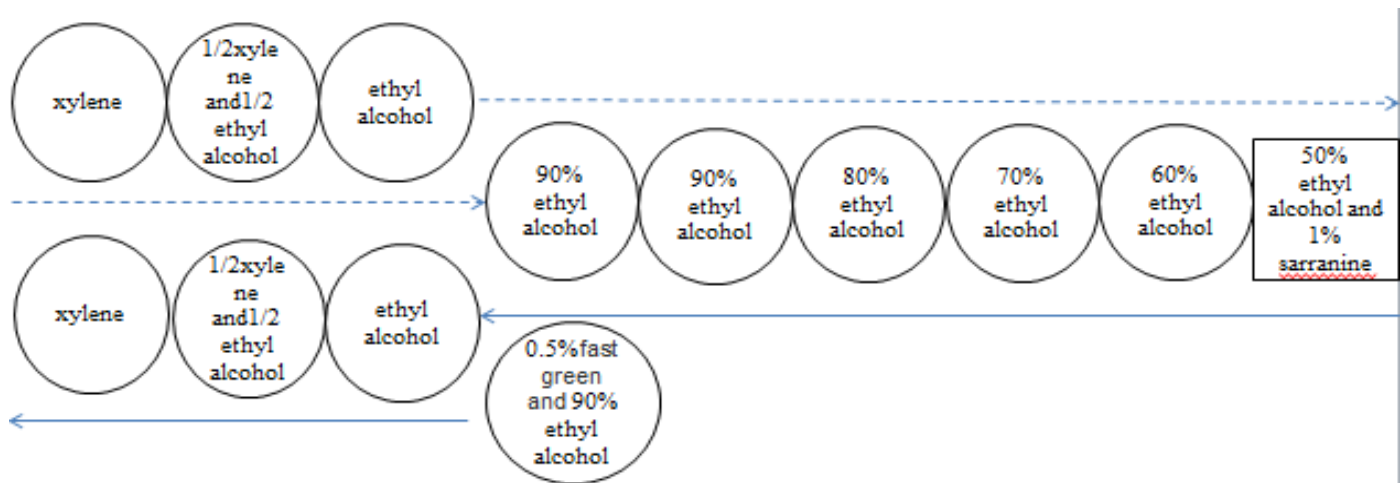
The embedded wax block is further repaired, and the paraffin on the surface of the cut surface is carefully cut off to expose the sample (avoid the slicing knife to do a lot of ineffective work to affect the sharpness of the blade); Then the slices were sliced with LS-2045 paraffin slicer with the thickness of 12 ~ 14 μm

Baked pieces

The cut wax pieces are placed in the HH-S digital constant temperature water bath, the temperature is 40°C, and then the wax pieces after the water bath are removed to the special adhesive glass slides with the method of scraping. After the excess water is drained, the glass slides are put into the paraffin slice toaster (TEC2500) for baking for 24 h, the temperature is 45°C.

Dyeing and sealing

After the baking piece is taken out, the material is dyed. Here, we use the double dyeing method of saffron and solid green (Zhou et al., 2018). After dyeing, the material is quickly sealed with Canada gum to isolate it from the air. After marking, take photos for observation and retention. (Follow the flowchart below)



Determination of anatomical structure of branches

The stained glass slides were observed under an optical microscope with an eyepiece micrometer and their Epidermis thickness was measured. (ET), Cortical thickness (CT), Vascular bundle (VB), Sclerenchyma, Catheter diameter (CD), Medullary diameter (MD), Stem diameter (SD), Cell length of lower epidermis (CLL) and Cell width of epidermis (CWL). Among them, the diameter of the catheter was taken from the round position of the catheter, and 6 groups of data were measured to get the average value. Five groups of data were measured to determine the range of the lower epidermal cells ($\pm 1\mu\text{m}$).

Record and data processing

Excel 2009 is used to calculate the data. The comprehensive evaluation of the required indicators is mainly converted by using the fuzzy mathematics membership function^[15] calculation formula. The membership function formula is as follows:

$$Z(\mu) = \frac{Z - Z_{\min}}{Z_{\max} - Z_{\min}} \quad Z(\mu) = 1 - \frac{Z - Z_{\min}}{Z_{\max} - Z_{\min}}$$

In the formula, Z_i is the measured value of a class index of the tested varieties, and the maximum and minimum values of a class index of all tested varieties are selected to be represented by Z_{\max} and Z_{\min} respectively. After the values of all membership functions are calculated, the average values are compared (the average value is positively correlated with drought resistance).

RESULTS

Microstructural characteristics of branches of different peach cultivars

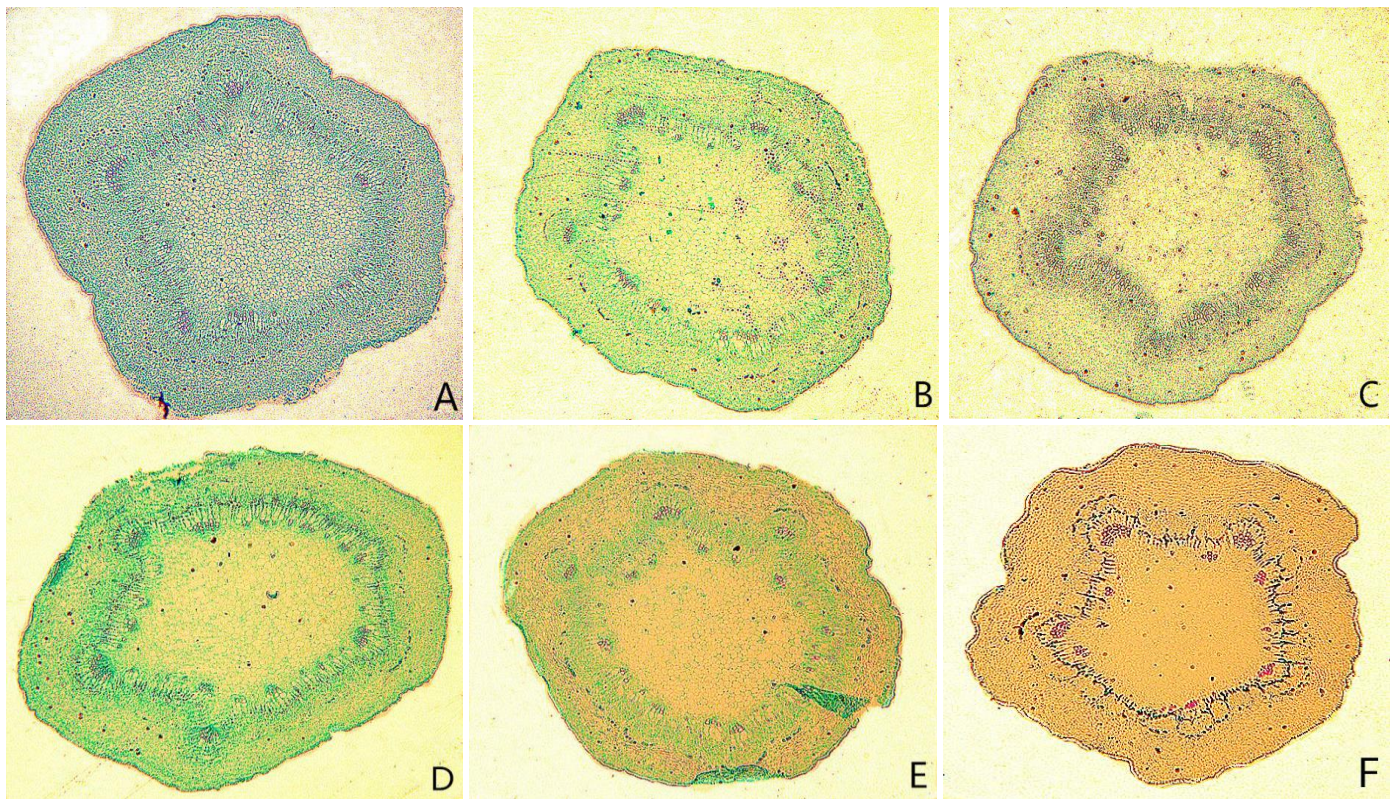


Figure 1. Anatomical structure of branches of six peach varieties.

A. pinggu144X B. Hongfenghuang4X C. Dajubao 4X D. Qingwang 4X E. Jinyumi4X F. Jinhongmi4X

It can be seen from Figure 1 that the common characteristics of the anatomical structure of the six peach cultivars are as follows: the branches of peach tree are composed of three tissue systems: dermal tissue system, basic tissue system and vascular system; The epidermis is composed of monolayer cells, rectangular or irregular in shape, and closely arranged, with a few stomata; The outer layer is covered with cuticle, which can enhance the toughness of the epidermis and control transpiration. The epidermis is composed of a layer of cells, rich in parenchyma cells and sclerochyma tissues, with obvious cell space. The sclerochyma tissues are ridged and distributed at the edges and corners of the stem, with 8 ~ 12 layers of cells, half surrounded by the more developed vascular bundles. In the middle of the cortex and cambium is the secondary phloem, containing phloem rays, but the cambium is not easily distinguished; Most of the vessels are distributed in clusters in the xylem, while the Medullary in the middle is composed of a large number of parenchyma cells as an important part of the branches.

Among the anatomical structural characteristics of six peach cultivars, there were significant differences in Epidermis thick, thickness of Sclerenchyma, diameter of conduit, diameter of Medullary and width of lower epidermal cells, while the differences in vascular bundle, diameter of stem, epidermal cells and area of epidermal cells were not obvious. As can be seen from the figure, the maximum thickness of the cortex is Pinggu14(391 μ m), and the minimum thickness is Hongfenghuang (189 μ m). The Epidermis thickness of Hongfenghuang was the thickest (5.6 μ m). Larger cortex and stem tip will increase the proportion of parenchyma, allows plants to store large amounts of water and inclusions, reducing plant in drought environment, plant transpiration channel efficiency has an important influence, and for the xylem cavitation and embolism there is influence, therefore and trees have a bigger relevance of cold resistance, drought resistance. Among the six selected peach varieties, Pinggu 14 has the largest diameter of the vessel, and its shape is approximately round or oval. This structure plays a great role in reducing water loss. Hongfenghuang, however, has the smallest diameter of the tubes, and some of them are quadrilateral or irregular, which has a negative impact on the transport of water and nutrients. There are very few circles or ellipses.

Table 1. Anatomical characteristics of branches of six peach varieties.

Character	Pinggu14	Hongfenghuang	Dajiubao	Qinwang	Jinyumi	Jinhongmi
Epidermis thick	4±0.4	5±0.6	4.5±0.4	4.8±0.4	5.±0.2	2.4±0.2
Cortical thickness	388±3	184±5	248.9±6	215.35±3	194±6	218.24±5
Sclerenchyma	155.2±3	98.94±5	111.55±4	124.16±2	106.7±2	150.35±6
Vascular bundle(number)	5	3	4	3	3	4
Conduit diameter	19.6	13.6	17.2	14.4	14	15.2
Stem diameter	2492	2444	2541	2710	2274	1815
Medullary diameter	1573	1524	1645	1718	1319	1113
Cell length of lower epidermis	9.1±0.9	8.4±0.8	8.6±1.2	9.3±1	10.3±0.6	8.4±1.2
Cell width of lower epidermis	7.6±0.8	4.5±0.6	5.±1	7.2±0.6	6.4±0.5	3.8±1

Remarks: Unit (μm)

Quantitative characteristics of anatomical structure of branches

The analysis of the important index characteristics of the anatomical structure of peach branches showed that (Table 1): the thickness of epidermal cells of peach branches ranged from 2.4 to 5.6 μm , of which the thickness of Jinhong mi was only 2.6 μm , and that of Hongfenghuang was 5.6 μm . Rank from largest to smallest in terms of epidermal thickness: Hongfenghuang>;Jinyumi>Qinwang>Dajiubao>Pinggu 14 > Jinhong mi.

The length of lower epidermal cells ranged from 9.24 μm to 10.95 μm , of which Hongfenghuang was the smallest and Jinyu mi was the largest. The order of epidermal cell length from small to large was: Hongfenghuang<Jinhong mi<Dajiubao< Pinggu 14 <Qinwang<Jinyu mi;The width range was 4.8 μm ~ 8.48 μm , among which Jinhongmi was the smallest and Pinggu 14 was the largest. Jinhong mi <Hongfenghuang<Dajiubao< Jinyu mi<Qinwang<Pinggu 14; The cortical thickness of Pinggu 14 was the thickest and Hongfenghuang was the smallest. The order of cortical thickness from small to large was Hongfenghuang<Jinyumi<Qinwang<Jinhongmi<Dajiubao<Pinggu 14.

The thickness of Sclerenchyma was 104 μm ~ 158 μm , and the order of Sclerenchyma from small to large was Hongfenghuang<Jinyumi<Dajiubao<

Qinwang<Jinhongmi<Pinggu 14. As one of the dermal tissue systems of the stem, the epidermis and cortex have functions such as transpiration control and support. It can be seen from Table 1 that the cortex of the branches of six varieties of peach trees is well developed, among which, the thinnest Hongfenghuang is 189 μm , and the thickest is 391 μm . This structure which increases the mechanical strength and water transport capacity of the branches has a greater relationship with the normal growth of peach trees in the arid environment. The diameter of the six peach cultivars ranged from 13.6 μm to 19.6 μm , among which Pinggu 14 had the largest diameter and Hongfenghuang had the smallest diameter. The order from smallest to largest was Hongfenghuang<Jinyumi<Qinwang<Jinhongmi<Dajiubao<Pinggu14. Stem diameter from small to large: Jinhongmi<Jinyumi<Hongfenghuang<Pinggu 14<Dajiubao<Qinwang.The order of medullary diameter from small to large was: Jinhongmi<Jinyumi<Hongfenghuang<Pinggu14<Dajiubao<Qinwang. There was no significant difference in the number of vascular bundles among the six peach cultivars, and they were evenly distributed in the range of 3-5. Pinggu 14 was the most; Hongfenghuang, Qinwang and Jinyu mi were the least. The results showed that the number of vascular bundles, stem diameter and medullary diameter had no significant effect on drought resistance among the anatomical structure indexes of six peach varieties. The five indexes of epidermal thickness, cortical thickness, thick horn tissue thickness, catheter diameter, lower epidermal cell width and lower epidermal cell length had higher correlation with drought resistance, which could be used as an important basis for comprehensive evaluation.

Comprehensive evaluation of branch anatomical structure characteristics and drought resistance of peach cultivars

Membership function analysis of fuzzy mathematics is an analysis method that comprehensively evaluates a certain characteristic on the basis of multiple measurement indexes, which can avoid one-sidedness of a single index.

Current reference fuzzy subordinate function analysis data are widely used in plant drought resistance and cold resistance of determination of physiological and biochemical experiments, but the relationship between structure and drought resistance of plant anatomy experiment application is less, so this experiment selects fuzzy subordinate function analysis method in order to improve the peach tree branches anatomical structure and the accuracy of the relationship analysis of drought resistance.

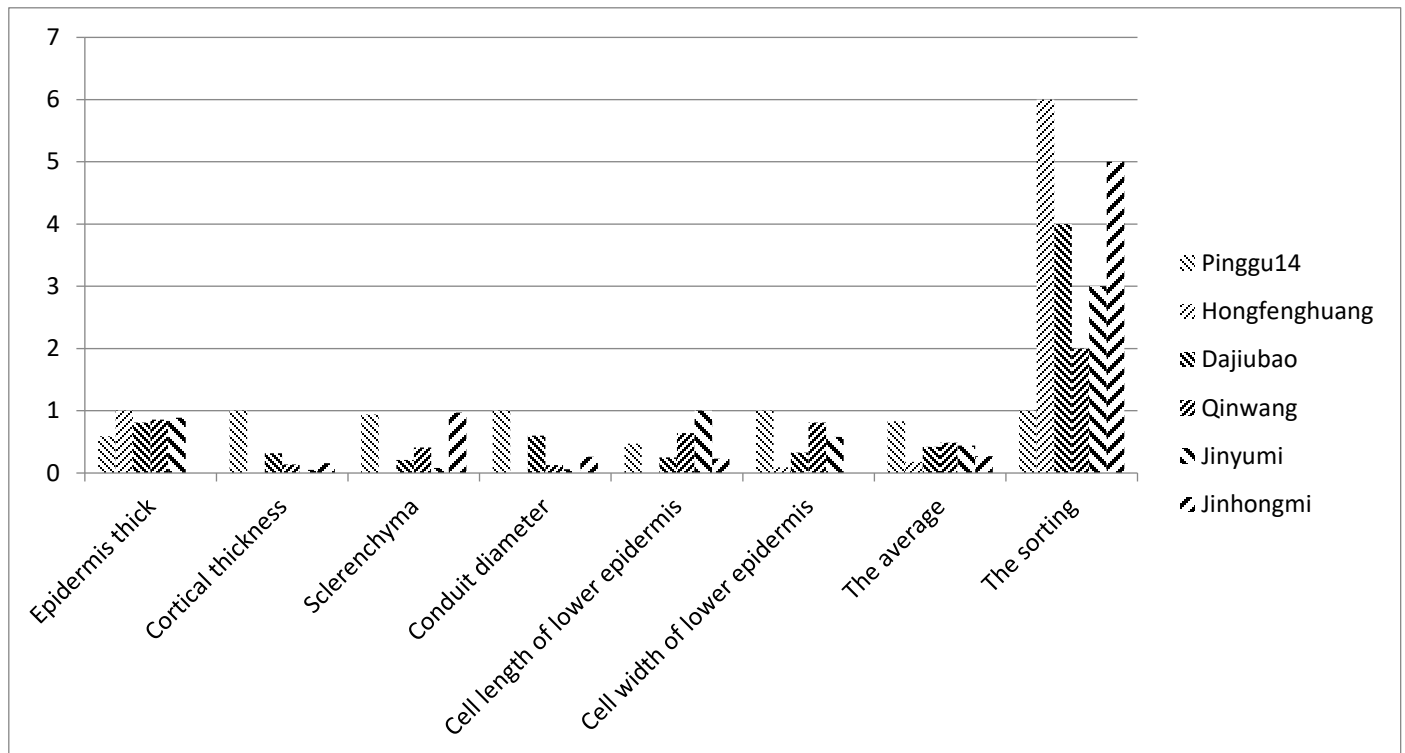


Figure 2. The value of membership function and its comprehensive evaluation results.

The analysis in Figure 2 showed that the number of vascular bundles, stem diameter, medullary diameter and other anatomical characteristics had a certain correlation with drought resistance of peach varieties. Although there was no significant difference in the above indexes among different cultivars, six representative indexes were selected in this paper, namely epidermal thickness, cortex thickness, thick horn tissue thickness, catheter diameter, lower epidermal cell width and lower epidermal cell length, as the basis for comprehensive evaluation of drought resistance. The fuzzy mathematics membership function analysis was used to comprehensively evaluate the anatomical structure indexes of branches of six peach varieties (Figure.2). The results showed that the rank of drought resistance of branches of six peach varieties was: Pinggu 14>Qinwang>Jinyumi>Dajiubao>Jinhongmi>According to the classification of drought resistance of the six peach varieties in this experiment, they can be divided into three categories: those with stronger drought resistance are Pinggu 14, Qin Wang;Drought resistance is generally Jinyumi, Dajiubao;Drought resistance is weak Jinhongmi, Hongfenghuang.

DISCUSSION

Drought-resistance of plants is a complex and comprehensive manifestation of the combination of long-term adaptation to the environment and its own genetic variation characteristics, and is the result of the co-adaptation of the internal physiological and biochemical activities of plants and the morphological and organizational structures of various organs (Rubio-Cabetas et al., 2018). At present, there are many researches on the anatomical structure characteristics and drought resistance of leaves and roots of peach trees, but few researches on the anatomical structure characteristics and drought resistance of peach branches. This is attributed to the high lignin and cellulose content of peach branches, and the difficulty of paraffin section, which affects the analysis of its internal anatomical structure. In this paper, a special plant tissue material softener was selected to treat the peach branches with high hardness to ensure the complete and clear paraffin section.

A researcher (Tuo et al., 2015) and Cheng et al., 2018) pointed out in their study on the characteristics of tissue structure of eight plants in southern Ningxia that the larger the xylem thickness of the plant, the greater the ratio of xylem to branch section area, and the stronger the drought resistance. The greater the ratio of the total area of conduit to the section area of branches, the stronger the drought resistance. (Du et al., 2012) and (Zhang et al., 2023) found peach leaf tissue structure in the vessel diameter, the thickness of the cortex, respectively. Such as indicators for the evaluation of plant drought resistance have larger contribution to these results and based on the fuzzy subordinate function analysis, the six kind of peach tree branches anatomical characteristics and the relationship between drought

resistance and the analysis of the research results are consistent. At the same time, it was found in the experiment that the developed degree of sclerenchyma also had a certain correlation for understanding the drought resistance of peach branches. For example, the sclerenchyma of Pinggu 14 was more developed than that of Jinyumi, and the number of vascular bundles of Pinggu 14 was also more than that of Jinyumi. On the other hand, it shows that the sclerenchyma can be used as one of the indexes to evaluate the drought resistance of peach branches. Due to the few studies on the anatomical characteristics of this kind of plant, further studies on the anatomical characteristics of this kind of plant are needed in the future.

CONCLUSIONS

Based on the above analysis, the ranking of drought resistance of the six varieties tested in this study is as follows: Pinggu 14>Qinwang>Jinyumi>Dajiubao>Jinhongmi>Hongfenghuang. Drought resistance of the peach tree is a complex comprehensive characteristic, cannot use a single character index to describe, so in the future research needs to be further understand peach plant root, stem and leaf anatomical structure, at the same time to its many physiological and biochemical indexes (conductivity, catalase, soluble sugar, etc.) conducted a comprehensive analysis, In this way, we can fully understand and accurately understand the relationship between drought resistance of peach varieties, and provide a more sufficient theoretical basis for the breeding, cultivation and management of drought resistance varieties of peach in the future.

ACKNOWLEDGEMENTS

Not applicable.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this research.

COMPETING OF INTEREST

The authors have declared no conflict of interest.

REFERENCES

- Bhusal, N., Kim, H.S., Hanf, S.G., et al 2020. Photosynthetic traits and plant- water relations of two apple cultivars grown as bi-leader trees under long-term waterlogging conditions. *Environ. Exp. Bot.* 176, 104111.
- Cheng, Z.Y., Sun, L., Wang, X.J. et al 2018. Ferulic acid pretreatment alleviates heat stress in blueberry seedlings by inducing antioxidant enzymes, proline, and soluble sugars. *Biol. Plant.* 62: 534–542.
- Du, K.B., Xu, L., Wu, H. et al 2012. Ecophysiological and morphological adaptation to soil flooding of two poplar clones differing in flood-tolerance. *Flora-Morphol. Distrib. Funct. Ecol. Plants.* 207: 96–106.
- Fetouh, M.I. 2018. Edible landscaping in urban horticulture. pp. 141–173. In: *Urban Horticulture: Sustainability for the Future*.
- Liu, G., Wang, S., Zhao, B. et al 2010. Cold resistance of walnut 1-year-old branches. *Econ. For. Res.* 28: 108–111.
- Li, R., Sun, R., Wang, T. et al 2017. Research progress on plant drought resistance identification and evaluation methods and drought resistance mechanism. *Biotechnol. Bull.* 33: 40.
- Pantelidis, G., Mavromatis, T., Drogoudi, P. 2021. Consecutive wet days may impede fruit quality of peach and nectarine and cause fruit drop. *Sci. Hortic.* 282: 11011.
- Peng, Y.J., Zhou, Z.X., Tong, R.G. et al 2017. Anatomy and ultrastructure adaptation to soil flooding of two full-sib poplar clones differing in flood-tolerance. *Flora-Morphol. Distrib. Funct. Ecol. Plants.* 233: 90–98.
- Rubio-Cabetas, M.J., Clara, P., Beatriz, B. et al 2018. Preformed and induced mechanisms underlie the differential responses of *Prunus* rootstock to hypoxia. *J. Plant Physiol.* 228: 134–149.
- Salah, A., Nwafor, C.C., Han, Y.L. et al 2022. Spermidine and brassinosteroid regulate root anatomical structure, photosynthetic traits, and antioxidant defense systems to alleviate waterlogging stress in maize seedlings. *S. Afr. J. Bot.* 144: 389–402.
- Sun, C., Wang, M., Hu, S. 2018. Effects of different soil water content on growth of *Bambusa emeiensis*. 9–12.
- Tuo, X.Q., Li, S., Wu, Q.S. et al 2015. Alleviation of waterlogged stress in peach seedlings inoculated with *Funnelformis mosseae*: Changes in chlorophyll and proline metabolism. *Sci. Hortic.* 197: 130–134.
- Xu, F., Cai, H., Zhang, X. et al 2022. Comparison of waterlogging tolerance of three peach rootstock seedlings based on physiological, anatomical, and ultra-structural changes. *Horticultrae.* 8: 720.
- Zhang, B., Du, H., Yang, S. et al 2023. Physiological and transcriptomic analyses of the effects of exogenous lauric acid on drought resistance in peach (*Prunus persica* (L.) Batsch). *Plants.* 12: 1492.

- Zhao, T., Pan, X., Ou, Z. et al 2022. Comprehensive evaluation of waterlogging tolerance of eleven *Canna* cultivars at flowering stage. *Sci. Hortic.* 296: 110890.
- Zhou, N.F., Zhang, J.P., Liu, H. et al 2018. Woody plant non-homogenized tissue paraffin slicing method. *Chin. Bull. Bot.* 53: 653–660.