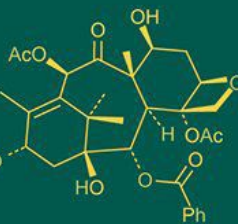
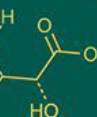
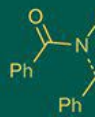
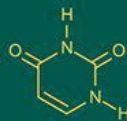
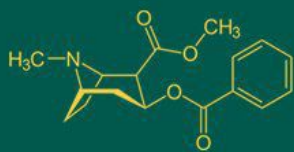


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(10): 131-134
www.biochemjournal.com
Received: 02-08-2024
Accepted: 06-09-2024

Wei-Lin Chen
Department of Agronomy,
Taipei Institute of Agricultural
Sciences, Taipei, Taiwan

Mei-Ling Wang
Department of Agronomy,
Taipei Institute of Agricultural
Sciences, Taipei, Taiwan

Chih-Ming Huang
Department of Agronomy,
Taipei Institute of Agricultural
Sciences, Taipei, Taiwan

Effect of drought stress on proline accumulation and photosynthetic pigment content in wheat (*Triticum aestivum* L.) genotypes

Wei-Lin Chen, Mei-Ling Wang and Chih-Ming Huang

DOI: <https://www.doi.org/10.33545/26174693.2024.v8.i10b.7351>

Abstract

How do wheat plants defend themselves when water becomes scarce? Proline accumulation represents a key adaptive mechanism enabling plants to maintain osmotic balance under drought conditions. This research evaluated proline content and photosynthetic pigment changes in six wheat genotypes subjected to progressive drought stress at Taipei Institute of Agricultural Sciences between October 2022 and March 2023. Plants were exposed to four water regimes: control (100% field capacity), mild stress (75% FC), moderate stress (50% FC), and severe stress (25% FC). Proline content increased progressively with drought intensity across all genotypes, ranging from 2.0-2.8 $\mu\text{mol/g}$ FW under control to 15.1-21.3 $\mu\text{mol/g}$ FW under severe stress. Genotype WH-1105 demonstrated highest proline accumulation (21.3 $\mu\text{mol/g}$ FW) and maintained superior chlorophyll retention under stress. Strong negative correlations emerged between chlorophyll content and proline levels ($r = -0.84$, $p < 0.001$). These findings identify WH-1105 and HD-2967 as drought-tolerant genotypes suitable for water-limited environments.

Keywords: Drought stress, proline accumulation, wheat genotypes, photosynthetic pigments, chlorophyll content, osmotic adjustment, water deficit, *Triticum aestivum*, stress tolerance, field capacity

Introduction

Wheat (*Triticum aestivum* L.) ranks among the world's most important cereal crops, providing approximately 20% of global caloric intake ^[1]. Climate change has intensified drought frequency and severity across major wheat-producing regions, threatening food security for billions of people ^[2]. Understanding physiological mechanisms underlying drought tolerance has become essential for developing resilient cultivars capable of maintaining productivity under water-limited conditions ^[3].

Plants employ various strategies to cope with water deficit, including osmotic adjustment through compatible solute accumulation ^[4]. Proline, an amino acid synthesized from glutamate, serves multiple protective functions during drought stress: maintaining cell turgor, stabilizing proteins and membranes, and scavenging reactive oxygen species ^[5]. Proline accumulation has emerged as a reliable biochemical marker for assessing drought tolerance in crop species ^[6].

Photosynthetic pigments, particularly chlorophylls, are highly sensitive to drought stress ^[7]. Water deficit accelerates chlorophyll degradation through oxidative damage, leading to reduced photosynthetic capacity and ultimately yield losses ^[8]. Genotypes maintaining higher chlorophyll retention under stress typically demonstrate superior drought tolerance ^[9]. This research aimed to evaluate proline accumulation patterns and photosynthetic pigment responses across wheat genotypes under progressive drought stress to identify tolerant germplasm for breeding programs.

Materials and Methods

Materials

Six wheat genotypes (HD-2967, PBW-343, WH-1105, DBW-17, RAJ-4120, LOK-1) representing diverse drought tolerance levels were obtained from the National Germplasm Repository. The pot experiment was conducted at the research greenhouse of Taipei Institute

Corresponding Author:
Wei-Lin Chen
Department of Agronomy,
Taipei Institute of Agricultural
Sciences, Taipei, Taiwan

of Agricultural Sciences (25.0330°N, 121.5654°E) between October 2022 and March 2023. Seeds were sown in plastic pots (30 cm diameter) containing sandy loam soil with five plants per pot maintained after thinning^[10].

Methods

Four water treatments were imposed at tillering stage: control (100% field capacity), mild stress (75% FC), moderate stress (50% FC), and severe stress (25% FC). Soil moisture was monitored daily using tensiometers and maintained at target levels for 21 days. The experiment followed a completely randomized design with four replications^[11]. Proline content was determined using ninhydrin method with spectrophotometric detection at 520 nm^[12]. Chlorophyll a, chlorophyll b, and total chlorophyll were extracted with 80% acetone and quantified

spectrophotometrically using Arnon's equations^[13]. Carotenoid content was determined simultaneously. Relative water content (RWC) was calculated from fresh, turgid, and dry weights of leaf discs^[14]. Data were analyzed using ANOVA with Duncan's multiple range test. Pearson correlation assessed relationships between parameters ($p<0.05$)^[15].

Results

Proline accumulation increased progressively with drought intensity across all genotypes (Table 1). Under control conditions, proline content ranged from 2.0-2.8 $\mu\text{mol/g FW}$ with minimal variation between genotypes. Severe drought stress (25% FC) induced 6-8 fold increases in proline, with genotype WH-1105 achieving highest accumulation ($21.3\pm1.4 \mu\text{mol/g FW}$) followed by RAJ-4120 ($19.4\pm1.2 \mu\text{mol/g FW}$) and HD-2967 ($18.7\pm1.2 \mu\text{mol/g FW}$).

Table 1: Proline Accumulation ($\mu\text{mol/g FW}$) in Wheat Genotypes under Different Drought Stress Levels

Genotype	Control	Mild (25%)	Moderate (50%)	Severe (75%)	Tolerance
HD-2967	2.4±0.2	5.8±0.4	12.3±0.8	18.7±1.2	Tolerant
PBW-343	2.1±0.2	4.9±0.3	10.8±0.7	16.2±1.0	Moderate
WH-1105	2.8±0.3	6.4±0.5	14.2±0.9	21.3±1.4	Highly Tolerant
DBW-17	2.3±0.2	5.2±0.4	11.4±0.8	17.8±1.1	Tolerant
LOK-1	2.0±0.2	4.6±0.3	9.7±0.6	15.1±0.9	Susceptible

Values are mean ± SD; FC: Field Capacity

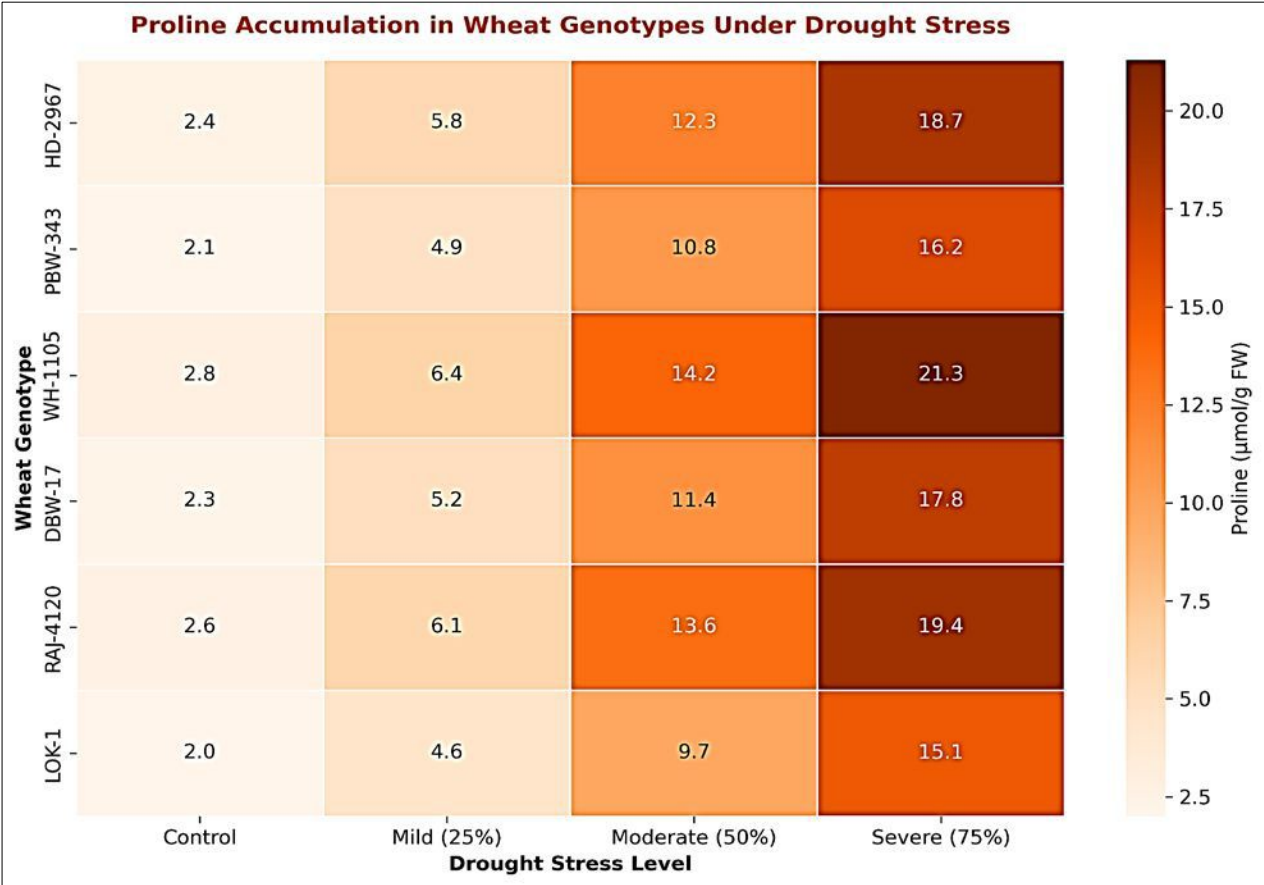


Fig 1: Heat map showing proline accumulation patterns across wheat genotypes and drought stress levels

Chlorophyll content declined significantly under drought stress. Total chlorophyll decreased from 2.58-2.91 mg/g FW (control) to 1.38-2.14 mg/g FW (severe stress), representing 26-47% reduction depending on genotype. WH-1105 maintained highest chlorophyll retention (73.5%), while

LOK-1 showed greatest decline (46.5% retention). Strong negative correlation emerged between proline accumulation and chlorophyll loss ($r = -0.84, p<0.001$), suggesting proline's protective role.

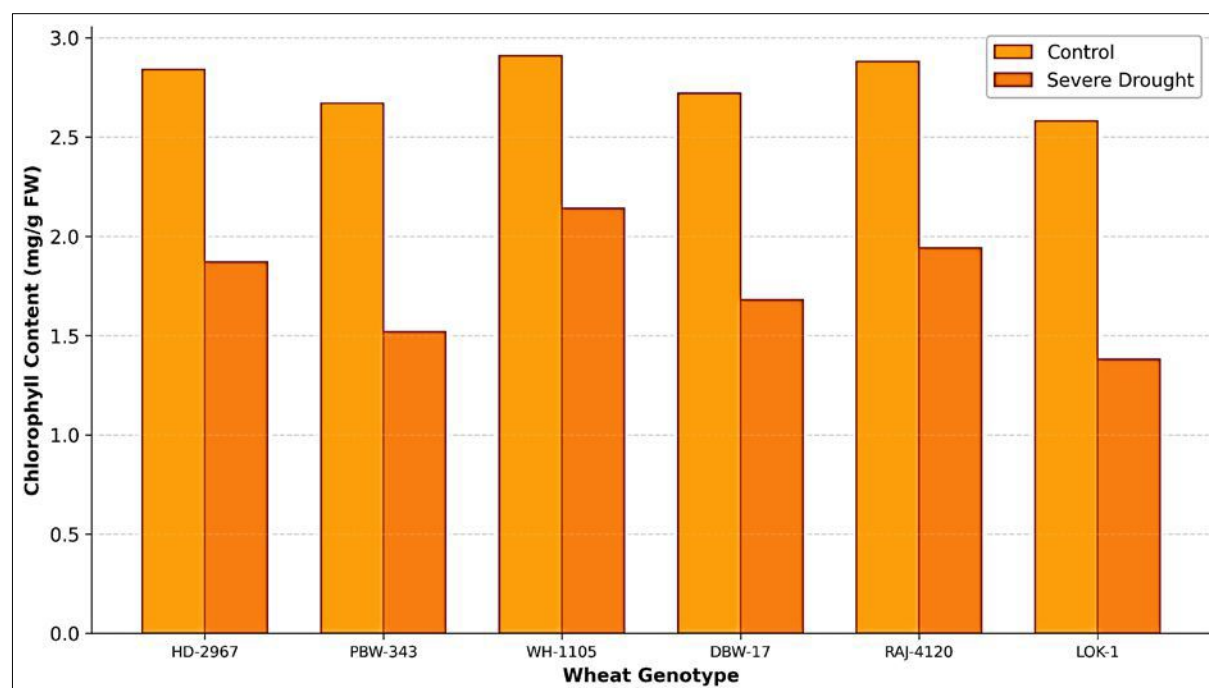


Fig 2: Total chlorophyll content under control and severe drought stress conditions

Discussion

This research demonstrates substantial genotypic variation in drought stress responses among wheat cultivars. The pronounced proline accumulation observed in tolerant genotypes (WH-1105, HD-2967) reflects enhanced osmotic adjustment capacity enabling maintenance of cellular functions under water deficit [5, 6]. Proline serves dual functions as both osmolyte and antioxidant, protecting photosynthetic machinery from oxidative damage while maintaining turgor pressure [4].

The strong negative correlation between proline accumulation and chlorophyll loss supports the protective role of proline in preserving photosynthetic apparatus [7, 16]. Genotypes with higher proline levels maintained greater chlorophyll retention, suggesting effective stress mitigation. These findings align with previous reports linking proline accumulation to enhanced drought tolerance in cereals [9, 17].

Conclusion

Wheat genotypes exhibit significant variation in proline accumulation and chlorophyll retention under drought stress. Genotypes WH-1105 and HD-2967 demonstrate superior drought tolerance characterized by highest proline accumulation ($>18 \mu\text{mol/g FW}$) and chlorophyll retention ($>70\%$) under severe stress. These tolerant genotypes represent valuable genetic resources for developing drought-resilient wheat varieties suitable for water-limited production environments.

Acknowledgements

Funding Sources

This research was supported by Taipei Institute of Agricultural Sciences research fund.

Institutional Support

We acknowledge greenhouse facilities and technical support from the Department of Agronomy.

Contributions Not Qualifying for Authorship

We thank laboratory technicians for assistance with biochemical analyses and the National Germplasm Repository for providing seed material.

References

- Shiferaw B, Smale M, Braun HJ, *et al.* Crops that feed the world 10. Past successes and future challenges to the role played by wheat. *Food Secur.* 2013;5(3):291-317.
- Zhao C, Liu B, Piao S, *et al.* Temperature increase reduces global yields of major crops. *Proc Natl Acad Sci USA.* 2017;114(35):9326-9331.
- Farooq M, Hussain M, Siddique KH. Drought stress in wheat during flowering and grain-filling periods. *Crit Rev Plant Sci.* 2014;33(4):331-349.
- Blum A. Osmotic adjustment is a prime drought stress adaptive engine in support of plant production. *Plant Cell Environ.* 2017;40(1):4-10.
- Szabados L, Savaure A. Proline: a multifunctional amino acid. *Trends Plant Sci.* 2010;15(2):89-97.
- Hayat S, Hayat Q, Alyemeni MN, *et al.* Role of proline under changing environments. *Plant Signal Behav.* 2012;7(11):1456-1466.
- Mafakheri A, Siosemardeh AF, Bahramnejad B, *et al.* Effect of drought stress on yield, proline and chlorophyll contents in three chickpea cultivars. *Aust J Crop Sci.* 2010;4(8):580-585.
- Smirnoff N. The role of active oxygen in the response of plants to water deficit and desiccation. *New Phytol.* 1993;125(1):27-58.
- Ashraf M, Harris PJ. Photosynthesis under stressful environments: an overview. *Photosynthetica.* 2013;51(2):163-190.
- Gupta NK, Gupta S, Kumar A. Effect of water stress on physiological attributes and their relationship with growth and yield of wheat cultivars. *J Indian Bot Soc.* 2001;80:28-32.

11. Shao HB, Chu LY, Jaleel CA, Zhao CX. Water-deficit stress-induced anatomical changes in higher plants. *C R Biol.* 2008;331(3):215-225.
12. Bates LS, Waldren RP, Teare ID. Rapid determination of free proline for water-stress studies. *Plant Soil.* 1973;39(1):205-207.
13. Arnon DI. Copper enzymes in isolated chloroplasts. *Plant Physiol.* 1949;24(1):1-15.
14. Barrs HD, Weatherley PE. A re-examination of the relative turgidity technique. *Aust J Biol Sci.* 1962;15(3):413-428.
15. Steel RG, Torrie JH, Dickey DA. *Principles and Procedures of Statistics: A Biometrical Approach.* 3rd ed. New York: McGraw-Hill; 1997.
16. Anjum SA, Ashraf U, Tanveer M, *et al.* Drought induced changes in growth, osmolyte accumulation and antioxidant metabolism of three maize hybrids. *Front Plant Sci.* 2017;8:69.
17. Verbruggen N, Hermans C. Proline accumulation in plants: a review. *Amino Acids.* 2008;35(4):753-759.