



POPULAR ARTICLE

The role of chlorophyll in crop productivity and plant health

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Intricacies of the subject

Chlorophyll is the key green pigment that enables plants to capture solar energy for photosynthesis and, consequently, supports crop growth and yield formation. In crop production, chlorophyll status is closely associated with photosynthetic activity, biomass accumulation, nutritional condition and plant health. Chlorophyll a acts as the principal photosynthetic pigment, while chlorophyll b broadens the range of light absorbed by leaves and transfers energy to chlorophyll a. Leaf chlorophyll is also a useful indicator of nitrogen status and can provide an early signal of drought, heat, salinity, nutrient deficiency and disease stress. The retention of chlorophyll during reproductive growth, commonly expressed as the stay-green trait, can help maintain photosynthesis and assimilate supply during grain filling. With increasing climate variability, maintaining chlorophyll stability through balanced nutrition, efficient irrigation, suitable biostimulants and improved cultivars is important for resilient crop production. Recent advances in SPAD meters drone imaging and artificial intelligence are further improving the ability to monitor chlorophyll and guide precision crop management.

Introduction

Green plants are the foundation of life on Earth. They capture solar energy and convert it into chemical energy through photosynthesis, providing food, oxygen, and energy for almost all living organisms. At the center of this remarkable process is chlorophyll, the green pigment responsible for absorbing sunlight and driving photosynthesis. In agriculture, chlorophyll is much more than a pigment that gives plants their green color. It is directly linked to photosynthetic efficiency, biomass production, crop yield, nutrient status, and plant health. The amount and activity of chlorophyll in leaves often serve as indicators of crop vigor and productivity. Healthy crops with adequate chlorophyll generally exhibit higher photosynthetic rates, better growth, and improved yields. With increasing concerns about climate change, nutrient deficiencies, and declining crop productivity, understanding the role of chlorophyll in crop growth has become increasingly important. This article explores the significance of chlorophyll in plant physiology and its contribution to crop productivity and plant health.

What is chlorophyll?

Chlorophyll is a green pigment found in chloroplasts, specialized organelles present in plant cells.



It absorbs light energy from the sun and initiates the process of photosynthesis. The term chlorophyll originates from the Greek words chloros (green) and phyllon (leaf). There are several forms of chlorophyll, but the most important in higher plants are as Chlorophyll a and Chlorophyll b. Chlorophyll a serves as the primary photosynthetic pigment, while chlorophyll b functions as an accessory pigment that expands the range of light wavelengths absorbed by plants (Taiz *et al.*, 2023). Together, these pigments allow plants to efficiently capture sunlight and convert it into energy-rich compounds.

Chlorophyll and photosynthesis

Photosynthesis is the process by which plants convert sunlight, carbon dioxide, and water into carbohydrates and oxygen. Chlorophyll plays a central role in this process by absorbing light energy and transferring it to the photosynthetic reaction centers.

The photosynthesis process can be simplified as follows:

- Chlorophyll captures solar energy.
- Light energy is converted into chemical energy.
- Carbon dioxide is fixed into carbohydrates.
- Sugars produced are used for growth and development.

Since photosynthesis provides the energy required for crop growth, chlorophyll directly influences crop productivity (Ainsworth and Long, 2022).

Why are plants green?

Chlorophyll absorbs light primarily in the blue and red regions of the visible spectrum. Green light is largely reflected rather than absorbed. As a result, leaves appear green to the human eye. The ability of chlorophyll to selectively

absorb light wavelengths enables plants to efficiently utilize solar energy for photosynthesis.

Types of chlorophyll in plants

Chlorophyll a

Chlorophyll a is the principal photosynthetic pigment found in all green plants. Functions are viz., capturing light energy, driving photochemical reactions, initiating electron transport during photosynthesis. Without chlorophyll a, photosynthesis cannot occur.

Chlorophyll b

Chlorophyll b serves as an accessory pigment. Functions are viz., expanding the range of absorbed light, enhancing photosynthetic efficiency, transferring absorbed energy to chlorophyll a. The balance between chlorophyll a and chlorophyll b influences overall photosynthetic performance (Taiz *et al.*, 2023).

Chlorophyll and crop productivity

Enhanced photosynthetic capacity

Photosynthesis is directly dependent on chlorophyll concentration. Leaves with higher chlorophyll content generally exhibit the greater light absorption, higher photosynthetic rates, increased carbohydrate production. These carbohydrates serve as the building blocks for biomass accumulation and yield formation (Long *et al.*, 2022).

Biomass production

The energy generated through photosynthesis supports in leaf growth, stem development, root expansion, flowering, grain filling. Higher chlorophyll content often results in increased biomass production and improved crop performance.



Grain yield

In cereal crops such as rice, wheat, and maize, chlorophyll plays a crucial role during grain filling. Green leaves continue producing assimilates that are transported to developing grains. Premature chlorophyll degradation reduces carbohydrate supply and negatively affects grain weight and yield (Reynolds *et al.*, 2023).

Chlorophyll and plant health

Indicator of nutrient status

Chlorophyll concentration is closely related to nutrient availability, particularly nitrogen. Nitrogen forms an essential component of chlorophyll molecules. Nitrogen deficiency often results in the pale green leaves, yellowing (chlorosis), reduced photosynthesis, lower crop productivity. Therefore, chlorophyll content is widely used as an indicator of crop nutritional status (Hasanuzzaman *et al.*, 2023).

Indicator of stress conditions

Environmental stresses frequently affect chlorophyll synthesis and stability. Examples include the drought stress, heat stress, salinity stress, nutrient deficiencies, disease infections. Declining chlorophyll levels often provide early warning signs of stress before visible symptoms appear.

Monitoring crop health

Modern agricultural technologies use chlorophyll measurements to monitor crop health. Tools are as SPAD meters, chlorophyll meters, remote sensing systems, drone-based imaging.

Factors affecting chlorophyll content

Nitrogen Availability, nitrogen is one of the most important nutrients influencing

chlorophyll formation. Adequate nitrogen promotes: chlorophyll synthesis, leaf expansion. photosynthetic activity. Nitrogen-deficient plants typically show chlorosis and reduced growth.

Light intensity

Light availability influences chlorophyll accumulation. Moderate light generally promotes chlorophyll synthesis, while prolonged shading may reduce chlorophyll concentration and photosynthetic efficiency.

Temperature

Temperature affects chlorophyll biosynthesis and degradation. High temperatures often accelerate chlorophyll breakdown and reduce photosynthetic performance (Dusenge *et al.*, 2023).

Water availability

Drought stress limits chlorophyll synthesis and damages chloroplast structures. Water stress frequently leads to reduced chlorophyll content and impaired photosynthesis.

Disease and pest attack

Pathogens and insect pests can damage leaf tissues and disrupt chlorophyll metabolism. Severe infections often result in chlorosis, necrosis, and reduced crop productivity.

Chlorophyll degradation and leaf senescence

As plants age, chlorophyll gradually degrades during leaf senescence. This process allows nutrients to be remobilized from older leaves to developing grains, fruits, and storage organs. However, premature chlorophyll degradation caused by stress can negatively affect crop yield. Maintaining green leaf area for longer periods is therefore an important objective in crop improvement programs.



The stay-green trait and crop productivity

The "stay-green" trait refers to the ability of plants to retain chlorophyll and photosynthetic activity during reproductive growth stages. Stay-green varieties exhibit for delayed leaf senescence, extended photosynthesis, improved stress tolerance. Higher grain filling efficiency. This trait has gained significant attention in crops such as sorghum, maize, wheat, and rice (Borrell *et al.*, 2024). Under drought and heat stress conditions, stay-green cultivars often outperform conventional varieties.

Chlorophyll and climate change

Climate change presents new challenges to chlorophyll stability and photosynthetic efficiency.

Heat stress

High temperatures damage chloroplast membranes and accelerate chlorophyll degradation. Reduced chlorophyll content lowers photosynthetic efficiency and crop productivity.

Drought stress

Water scarcity limits chlorophyll synthesis and causes oxidative damage to photosynthetic machinery.

Elevated carbon dioxide

Increased atmospheric CO₂ concentrations may stimulate photosynthesis, but the benefits can be limited when chlorophyll content declines due to heat or nutrient stress (Ainsworth and Long, 2022). Maintaining chlorophyll stability under changing environmental conditions is becoming increasingly important for climate-resilient agriculture.

Improving chlorophyll content in crops

Several management practices can help maintain healthy chlorophyll levels.

Balanced nutrient management

Adequate application of nitrogen, magnesium, iron sulphur.

Efficient irrigation

Maintaining optimum soil moisture helps protect chloroplast structures and sustain photosynthesis.

Stress management

Reducing drought, heat, and salinity stress helps preserve chlorophyll content and improve crop performance.

Use of biostimulants

Biostimulants and beneficial microorganisms can enhance chlorophyll synthesis and improve stress tolerance (Rouphael and Colla, 2023).

Improved crop varieties

Breeding programs are developing cultivars with enhanced chlorophyll retention, stay-green characteristics, and improved photosynthetic efficiency.

Modern technologies for chlorophyll assessment

Technological advances have revolutionized chlorophyll monitoring in agriculture.

SPAD Meters

SPAD meters provide rapid and non-destructive estimates of leaf chlorophyll content. They are widely used for nitrogen management and crop monitoring.



Remote sensing and artificial intelligence

Satellite and drone-based technologies allow large-scale assessment of crop chlorophyll status. Vegetation indices such as NDVI and chlorophyll indices provide valuable information for precision agriculture (Zhang *et al.*, 2024). AI-based systems can analyze chlorophyll-related data and support decision-making for nutrient and irrigation management.

Future perspectives

Innovative approaches to improve chlorophyll-related productivity, including, enhancing photosynthetic efficiency, developing stay-green cultivars, improving chloroplast performance. Genetic modification of photosynthetic pathways integrating chlorophyll monitoring into precision agriculture. These advances have the potential to significantly increase crop yields.

References

1. Ainsworth, E.A. and Long, S.P. 2022. Opportunities and challenges in improving photosynthesis under changing climates. *Plant Physiol.*, 190(1): 16–30.
2. Borrell, A.K., Hammer, G.L., van Oosterom, E.J. and Jordan, D.R. 2024. Stay-green traits and crop productivity under climate stress. *Field Crops Res.*, 315.
3. Dusenage, M.E., Duarte, A.G. and Way, D.A. 2023. Plant carbon metabolism under climate warming. *New Phytol.*, 239(2): 421–439.
4. Hasanuzzaman, M., Bhuyan, M.H.M.B., Zulfiqar, F., Raza, A., Mohsin, S.M., Mahmud, J.A. and Fotopoulos, V. 2023. Plant responses and tolerance mechanisms against abiotic stress. *Antioxidants*, 12(4): 843.
5. Long, S.P., Zhu, X.G., Naidu, S.L. and Ort, D.R. 2022. Improving crop photosynthesis

Conclusion

Chlorophyll is far more than a green pigment; it is the engine that drives photosynthesis and supports crop productivity. By capturing sunlight and converting it into chemical energy, chlorophyll enables plants to produce the carbohydrates required for growth, development, and yield formation. Chlorophyll content serves as an important indicator of plant health, nutritional status, and environmental stress. Maintaining healthy chlorophyll levels through proper crop management, balanced nutrition, and stress mitigation can significantly improve agricultural productivity. As climate change and resource limitations continue to challenge global agriculture, enhancing chlorophyll efficiency and protecting photosynthetic capacity will remain central to sustainable crop production and food security.

- and productivity for future agriculture. *Annu. Rev. Plant Biol.*, 73: 601–628.
6. Reynolds, M.P., Braun, H.J. and Cavalieri, A.J. 2023. Improving yield potential through enhanced photosynthesis and crop physiology. *Nat. Rev. Agron.*, 3(2): 88–103.
7. Rouphael, Y. and Colla, G. 2023. Biostimulants for sustainable crop production and stress management. *Sci. Hortic.*, 315: 111012.
8. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A. 2023. *Plant Physiology and Development*. Latest edition. Sinauer Associates/Oxford University Press.
9. Zhang, Y., Wang, H., Li, X. and Chen, S. 2024. Advances in chlorophyll sensing technologies for precision agriculture. *Front. Plant Sci.*, 15: 1378954.