

Assessment of the Effect of Photosynthetic Pigment Content on Moisture Level Indicators in Maize Plants

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Annotation: In maize plants, the chlorophyll content in aboveground organs is directly proportional to yield formation. Based on this relationship, varieties with high potential capacity, as well as those characterized by elevated chlorophyll content, can be recommended for cultivation in regions with diverse climatic and soil conditions. Under the influence of unfavorable environmental factors—such as water deficit, salinity, and high air temperatures—the amount and ratio of chlorophyll pigments in plant leaves change, which in turn affects their functional activity. This article presents the results of studies on the effect of moisture availability on the photosynthetic activity of selected maize varieties.

Keywords: Qumqishloq, Kadan 1000, chlorophyll a, chlorophyll b, carotenoids.

Introduction

The efficiency of the photosynthetic process in plants is one of the main factors determining their growth, development, and final productivity. The functional state of the photosynthetic apparatus primarily depends on the content of pigments in the leaves—chlorophyll a, chlorophyll b, and carotenoids—as well as on their quantitative ratios. Any change occurring within the pigment

system directly affects the plant's ability to absorb light energy, synthesize carbohydrates, and maintain overall physiological stability.

Environmental conditions, particularly water availability, represent one of the most important ecological factors influencing the pigment system of plants. Under water deficit conditions, disruptions in leaf cellular structure, chloroplast activity, and photosystem stability lead to intensified pigment degradation. This results in a slowdown of the photosynthetic process and, consequently, a reduction in plant growth rate and yield. Conversely, under adequate moisture conditions, pigment synthesis is enhanced, increasing the photosynthetic potential of plants.

Literature Review and Methods

As a protective response to water deficit, plant varieties tend to increase the content of tightly bound chlorophyll. In seedlings hardened against drought stress, the content of chlorophyll a, chlorophyll b, and carotenoids is significantly higher compared to non-hardened plants. Experiments conducted on different varieties have shown that water deficiency leads to a decrease in chlorophyll content. However, in drought-tolerant varieties, this reduction is less pronounced than in sensitive ones. Under water stress conditions, smaller changes in plastid pigments—especially in the pool of tightly bound plastids—serve as indicators of varietal drought tolerance [1].

The influence of moisture on photosynthetic activity has been widely studied in agronomy and plant physiology. Most researchers report that under water deficit conditions, chlorophyll a and b content in leaf tissues decreases, leading to reduced functional activity of the photosynthetic apparatus. Water deficiency disrupts redox processes in plant cells, suppresses plastid activity, and causes morphological changes in chloroplast structure [2,4].

Studies indicate that C₄-type plants, including maize, are relatively more tolerant to drought compared to other cereal crops. Nevertheless, moisture deficiency induces significant changes in their pigment systems. Alterations in the chlorophyll a/chlorophyll b ratio are associated with impaired photosystem function, while reductions in carotenoid content indicate weakening of antioxidant protection mechanisms [3,5,8]. Chlorophyll content is also influenced by plant developmental stages, varietal biological characteristics, and the combined effects of ecological factors. Literature data confirm that under different irrigation regimes, the composition of maize photosynthetic pigments varies significantly, and pigment degradation intensifies under water deficit conditions [6,7].

Based on this literature analysis, it is evident that changes in moisture availability are closely linked to the quantity and ratio of photosynthetic pigments and to the efficiency of the photosynthetic process, necessitating further detailed investigation.

This study focused on examining the effects of moisture levels on photosynthetic pigments in the maize variety “Kadan 1000” and several other varieties. Field experiments were conducted under different moisture regimes while maintaining uniform agronomic practices across all variants. Moisture levels were defined as natural conditions, moderately limited moisture, and severely dried conditions. Plant samples were collected at identical phenological stages—during the 5–7 leaf stage of vegetation. Chlorophyll a, chlorophyll b, and total carotenoids were determined using spectrophotometric methods. Pigments were extracted using an 80% acetone solution, and absorbance measurements were conducted at wavelengths of 440, 645, and 663 nm. Pigment concentrations were calculated according to Arnon's formula, and chlorophyll a/b ratios and total pigment content were analyzed comparatively. Statistical analysis was performed using analysis of variance (ANOVA), with significance assessed at $P \leq 0.05$. This methodology enabled evaluation of pigment dynamics, the intensity of moisture stress, and plant adaptive responses. The results are valuable for identifying stress-resistant varieties and selecting high-efficiency genotypes.

Results and Discussion

Field experiments conducted to study the response and adaptive mechanisms of maize varieties to water deficiency revealed the effect of moisture levels on photosynthetic pigment content in leaves. These parameters were determined during the flowering stage of the studied maize varieties. The results obtained at the flowering stage are presented in **Table 1**.

Table 1. Effect of moisture levels on photosynthetic pigment content, mg/g fresh weight (flowering stage)

No.	Varieties	Soil moisture	Chlorophyll a, mg/g	Chlorophyll b, mg/g	Carotenoids, mg/g
1	Qumqishloq	Moderate	3.02 ± 0.05	1.52 ± 0.04	0.86 ± 0.07
		Limited	2.68 ± 0.03	1.33 ± 0.02	0.68 ± 0.04
2	Kadan 1000	Moderate	3.15 ± 0.02	1.78 ± 0.03	1.15 ± 0.05
		Limited	2.95 ± 0.05	1.50 ± 0.05	0.96 ± 0.06

Under conditions of two different soil moisture levels, variations in chlorophyll a content were observed in all maize varieties. A decrease in moisture resulted in a corresponding reduction in chlorophyll a content across all varieties. Chlorophyll b and carotenoid contents also varied depending on moisture availability. In the Qumqishloq variety, under moderate moisture conditions, chlorophyll a content was 3.02 mg/g, chlorophyll b 1.52 mg/g, and carotenoids 0.86 mg/g. Under limited moisture conditions, these values decreased to 2.68 mg/g, 1.33 mg/g, and 0.68 mg/g, respectively.

In the Kadan 1000 variety, moderate moisture conditions resulted in chlorophyll a content of 3.15 mg/g, chlorophyll b 1.78 mg/g, and carotenoids 1.15 mg/g. Under limited moisture conditions, these values decreased to 2.95 mg/g, 1.50 mg/g, and 0.96 mg/g, respectively.

Under moderate soil moisture conditions, pigment synthesis intensified in all varieties, whereas limited moisture led to a reduction in pigment content. As soil moisture decreased, pigment content in maize leaves declined. The values of these indicators varied depending on moisture availability, varietal characteristics, and biological traits. Under limited moisture conditions, the total pigment content was highest in the Kadan 1000 variety. Overall, drought conditions caused a reduction in pigment content in all maize varieties compared to moderate moisture conditions, with clear varietal differences observed.

Effect of Moisture Levels on Photosynthetic Intensity

Data obtained under drought conditions indicate that water deficiency initially enhances CO₂ diffusion in many plants, but prolonged drought leads to a decline in photosynthetic activity. Drought exerts a particularly strong negative effect on photosynthesis intensity in drought-sensitive plant species and varieties.

Adequate water supply is crucial for the photosynthetic process, as sufficient water in leaf tissues enhances plastid activity. Conversely, reduced water availability lowers overall photosynthetic productivity, partly due to increased stomatal resistance.

Field experiments evaluated the effects of different soil moisture levels on photosynthetic intensity in maize varieties. These parameters were measured during the stem elongation, tasseling, and flowering stages (**Table 2**).

Table 2. Effect of moisture levels on photosynthetic intensity

No.	Varieties	Soil moisture	Stem elongation (g/m ² ·h)	Tasseling (g/m ² ·h)	Flowering (g/m ² ·h)
1	Qumqishloq	Moderate	0.93 ± 0.03	1.24 ± 0.06	1.81 ± 0.07
		Limited	0.67 ± 0.02	0.89 ± 0.04	1.53 ± 0.05

2	Kadan 1000	Moderate	2.05 ± 0.03	3.26 ± 0.04	4.95 ± 0.04
		Limited	1.38 ± 0.04	2.89 ± 0.05	4.37 ± 0.06

Under limited moisture conditions, photosynthetic intensity was lower than under moderate moisture conditions. Significant differences were observed between varieties grown under different moisture regimes, reflecting their individual biological characteristics. Moderate soil moisture positively influenced photosynthetic intensity and promoted organic matter accumulation, while limited moisture resulted in the lowest values across all varieties.

Conclusion

Under limited moisture conditions, reductions in photosynthetic intensity varied among maize varieties, likely due to differences in water supply, drought tolerance, and biological characteristics. Varietal differences were identified, with Qumqishloq and Kadan varieties exhibiting relatively higher photosynthetic intensity under water stress conditions compared to other varieties.

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