
**E-ISSN:** 2618-0618
**P-ISSN:** 2618-060X

www.agronomyjournals.com
2024; 7(3): 648-649
Received: 13-12-2023
Accepted: 16-01-2024

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# Flag leaf recorded more photosynthetic rate in rice

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**DOI:** https://doi.org/10.33545/2618060X.2024.v7.i3i.494

**Abstract**
The flag leaf is the last to emerge indicating the transition from crop growth to grain production. Photosynthesis in this leaf provides the majority of the carbohydrates for grain filling. So it is the important leaf for yield potential. Flag leaf size and area can significantly improve the grain yield. A rice field at panicle initiation was chosen to take the observation on physiological efficiency (Photosynthetic rate, transpiration rate and stomatal conductance) using Infra red Gas Analyser in lower, middle and flag leaf. Photosynthetic rate of flag leaf is higher an average of 7.56 µ mol $m^{-2}$ $Sec^{-1}$ for facilitating the translocation of nutrients. Lower leaf has recorded a photosynthetic rate of 2.96. Transpiration rate is in the range of 2.02 to 1.75 stomatal conductance was 0.27 in flag leaf which is lesser than middle leaf (0.29).

**Keywords:** Flag leaf, photosynthetic rate, transpiration rate, stomatal conductance

## Introduction
The flag leaf is the last to emerge indicating the transition from crop growth to grain production. Photosynthesis in this leaf provides the majority of the carbohydrates for grain filling. So it is the important leaf for yield potential. Flag leaf size and area can significantly improve the grain yield. In rice, flag leaves with larger areas are significantly correlated with greater yield and has become a target for breeding programme seeking to achieve an ideal phenotype or ideotype. Quantitative trait loci have been identified for larger flag leaves with the purpose of increasing yield. Rice yield have been increased by regulating NAL 1, a gene that regulate both flag leaf area and photosynthetic rates (Fabre *et al*., 2016) [2]. Early flag leaf senescence significantly reduced the seed setting rate, 100 grain weight and yield. If flag leaf is photosynthetically active with delayed senescence resulting in more photosynthates that can fill grain (Leng *et al*., 2017) [3]. In this experiment, physiology of flag leaf was compared with lower leaves and middle leaves. Besides this photosynthetic rate of flag leaf in two cases was recorded one is on before the emergence of the panicle and after the emergence of the panicle.

## Materials and Methods
A rice field at panicle initiation was chosen to take the observation on physiological efficiency (Photosynthetic rate, transpiration rate and stomatal conductance) using Infra red Gas Analyser in lower, middle and flag leaf. At the time of record, the atmospheric carbondioxide is recorded as 388 ppm during December' 2020. Besides that all the three parameters namely Photosynthetic rate, transpiration rate and stomatal conductance is recorded in panicle and as well as in flag leaf before and after emergence of the panicle.

## Results and Discussion

**Table 1:** Photosynthesis in rice spikelet/panicle

| Photosynthetic rate µ mol $m^{-2}$ $Sec^{-1}$ | Transpiration rate m mol $m^{-2}$ $Sec^{-1}$ | Stomatal conductance mol $sec^{-1}$ |
|---|---|---|
| 1.11 | 0.68 | 0.03 |

Based on our observation using Infra red gas analyzer (IRGA) it was found that Panicle is doing photosynthesis like leaf but in minimum (1.11 µ mol $m^{-2}$ $Sec^{-1}$) and also stomatal conductance

and transpiration. Panicle photosynthesis is crucial for grain yield in cereal crops (Zhang *et al*., 2021) [7].

**Table 2:** Photosynthetic rate, Transpiration rate and stomatal conductance of flag leaf

| | Photosynthetic rate µ mol $m^{-2}$ $Sec^{-1}$ | Transpiration rate m mol $m^{-2}$ $Sec^{-1}$ | Stomatal conductance mol $sec^{-1}$ |
|---|---|---|---|
| Flag leaf | 7.40 | 1.81 | 0.34 |
| | 10.67 | 1.84 | 0.25 |
| | 4.61 | 2.02 | 0.22 |
| Mean | 7.56 | 1.89 | 0.27 |
| Middle leaf | 11.19 | 2.02 | 0.27 |
| | 2.57 | 1.84 | 0.35 |
| | 3.11 | 2.22 | 0.25 |
| Mean | 5.62 | 2.02 | 0.29 |
| Lower leaf | 5.03 | 1.77 | 0.20 |
| | 2.82 | 1.72 | 0.18 |
| | 1.03 | 1.75 | 0.16 |
| Mean | 2.96 | 1.75 | 0.18 |

Photosynthetic rate of flag leaf is higher an average of 7.56 µ mol $m^{-2}$ $Sec^{-1}$ for facilitating the translocation of nutrients. The flag leaf which defined as the last leaf to emerge on maturing flowering stem has a higher photosynthetic rate relative to the lower canopy leaves due to its position at the top of the canopy and more interception of light (Adachi *et al*., 2017) [1]. Lower leaf has recorded lower photosynthetic rate comparing to middle leaf and flag leaf. Lower leaf has recorded a photosynthetic rate (µ mol $m^{-2}$ $Sec^{-1}$) of 2.96. Transpiration rate is in the range of 2.02 to 1.75. stomatal conductance was 0.27 in flag leaf which is lesser than middle leaf (0.29) and in lower leaf (0.18).

The selected wild rice accessions with high leaf photosynthesis per unit area had anatomical features such as larger mesophyll cells with more chloroplasts, fewer mesophyll cells between two adjacent veins, and higher mesophyll cell and chloroplast surface area exposed to intercellular space and the results showed that the existence of desirable variations in Rubisco activity, electron transport rate, and leaf anatomical features that could be targeted for increasing the photosynthetic efficiency of cultivated rice varieties (Mathan *et al*., 2021) [4]. Photosynthetic rate, chlorophyll content, N and P uptake under SRI cultivation were significantly higher compared to those of the conventional rice cultivation, but no differences were found in transpiration rate and leaf temperature. With SRI method, plants in their generative phase (especially in the grain-filling phase) had the highest photosynthetic and the lowest transpiration rates (Nurul Hidyati *et al*., 2021) [5]. Yuvan Zheng *et al*., 2023 [6] reported that an Erect Panicle line, which has the shortest flag leaf, showed a higher yield than Wanlun422(variety) in both years. Erect Panicle (EP) RILs with short flag leaves might show a higher canopy photosynthetic rate in the later ripening stage; therefore, this trait could be a potential phenotypic marker for achieving high yield of Erect Panicle rice.

**Table 3:** Physiological efficiency of flag leaf (before emergence of panicle and after emergence of panicle)

| Parameter | Photosynthetic rate µ mol $m^{-2}$ $Sec^{-1}$ | Transpiration rate m mol $m^{-2}$ $Sec^{-1}$ | Stomatal conductance mol $sec^{-1}$ |
|---|---|---|---|
| Before emergence | 11.73 | 2.86 | 0.57 |
| After emergence | 1.02 | 2.13 | 0.23 |
| | 0.48 | 1.97 | 0.25 |

Before emergence of the panicle the photosynthetic rate of rice flag leaf is higher 11.73 and was recorded a minimum of 0.48 after the emergence of the panicle.

## Conclusion

Photosynthetic rate of flag leaf is higher an average of 7.56 µ mol $m^{-2}$ $Sec^{-1}$ for facilitating the translocation of nutrients. Lower leaf has recorded lower photosynthetic rate comparing to middle leaf and flag leaf. Lower leaf has recorded a photosynthetic rate of 2.96. Transpiration rate is in the range of 2.02 to 1.75 stomatal conductance was 0.27 in flag leaf which is lesser than middle leaf (0.29) and in lower leaf it is 0.18.

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