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Comparative Analysis of Total Chlorophyll (TC) and Total Soluble Sugar (TSS) in Selected Species of the Poaceae and Brassicaceae Families

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Abstract— *Plant biochemical constituents play a crucial role in regulating photosynthesis, growth, metabolism, and overall crop productivity. Among these constituents, total chlorophyll (TC) and total soluble sugar (TSS) are widely recognized as important physiological indicators reflecting photosynthetic efficiency, carbon assimilation, and plant metabolic status. The present study aimed to comparatively evaluate the mean total chlorophyll and total soluble sugar content of selected species belonging to the Poaceae and Brassicaceae families using a literature-based comparative approach. A total of 40 representative species, comprising 20 species from Poaceae and 20 species from Brassicaceae, were included in the analysis. Published biochemical data were compiled from scientific literature, standardized, and comparatively analyzed to assess interspecific and interfamily variation. The analysis revealed considerable variability in both biochemical parameters among the selected species. Mean total chlorophyll content ranged from 1.40 to 3.50 mg g^{-1} FW, while total soluble sugar varied between 4.00 and 19.00 °Brix. Within the Poaceae family, Bambusa vulgaris exhibited the highest mean total chlorophyll content (3.35 mg g^{-1} FW), whereas Saccharum officinarum recorded the highest total soluble sugar (19.00 °Brix). Among the Brassicaceae species, Brassica oleracea var. acephala (kale) showed the highest mean total chlorophyll (3.50 mg g^{-1} FW), while Armoracia rusticana (horseradish) exhibited the highest total soluble sugar (10.25 °Brix). Overall, Poaceae species demonstrated greater variation in soluble sugar accumulation, whereas Brassicaceae species, particularly leafy vegetables, generally exhibited comparatively higher chlorophyll concentrations. A positive association between total chlorophyll and total soluble sugar was observed in several species, suggesting that enhanced photosynthetic pigment concentration contributes to improved carbohydrate accumulation.The study demonstrates substantial biochemical diversity among economically important members of the Poaceae and Brassicaceae families and highlights the usefulness of total chlorophyll and total soluble sugar as physiological indicators for comparative evaluation. The findings provide baseline information that may support future studies on crop physiology, biochemical characterization, nutritional assessment, and breeding strategies aimed at improving photosynthetic efficiency and crop productivity.*

Keywords— ***Poaceae, Brassicaceae, total chlorophyll, total soluble sugar, comparative analysis, plant biochemistry, photosynthesis, crop physiology.***

I. INTRODUCTION

Plants produce a wide array of biochemical constituents that regulate growth, metabolism, photosynthesis, and environmental adaptation. Among these, photosynthetic pigments and soluble carbohydrates serve as vital physiological indicators due to their direct influence on carbon assimilation, biomass accumulation, and overall crop productivity. Because they dictate light interception and downstream carbon utilization, variations in these traits across distinct species reflect unique genetic adaptations and internal metabolic efficiencies, making their systematic evaluation crucial for plant physiology and crop improvement programs (Lichtenthaler, 1987; Taiz et al., 2018). Total chlorophyll, comprising chlorophyll a and b, serves as the primary pigment responsible for harvesting solar energy. Since the development of classic spectrophotometric quantification protocols by Arnon (1949), evaluating total chlorophyll concentration has remained a foundational approach for assessing photosynthetic performance, nutritional health, and vegetative stress or senescence. Complementing pigment analysis, total soluble sugars primarily sucrose, glucose, and fructose provide an explicit readout of a plant's metabolic and osmotic status. As direct products of photosynthetic carbon fixation, these soluble carbohydrates function simultaneously as energetic substrates, metabolic signaling molecules, and critical osmoprotectants that stabilize cellular membranes during environmental challenges such as drought, salinity, and temperature extremes. Because soluble sugar accumulation is tightly coupled with primary carbon assimilation capacity, the parallel assessment of total chlorophyll and total soluble sugar offers a robust framework for mapping whole-plant carbon capture and source-sink dynamics.

While individual crop species have been evaluated under isolated management practices, systematic comparative frameworks between major botanical families remain limited. The Poaceae family includes crucial monocotyledonous cereal crops like rice (*Oryza sativa*), wheat (*Triticum aestivum*), and maize (*Zea mays*), which feature diverse C3 and C4 photosynthetic pathways that distinctly alter pigment density and carbohydrate accumulation. Conversely, the Brassicaceae family represents economically important dicotyledonous vegetable and oilseed crops such as mustard (*Brassica juncea*) and cabbage (*Brassica oleracea*), which are recognized for their high tissue nutrient values and unique vegetative storage sinks. Investigating the interspecific biochemical variations between these two contrasting families provides valuable physiological baselines to select for enhanced carbon partitioning efficiency and climate resilience in modern breeding programs.

II. MATERIALS AND METHODS

The present meta-analytical investigation was structured as a comparative literature-based study to systematically evaluate total chlorophyll and total soluble sugar concentrations across representative species of the Poaceae and Brassicaceae families. A comprehensive literature search was executed across international scientific databases, including Google Scholar, Scopus, Web of Science, ScienceDirect, and PubMed, targeting peer-reviewed research papers published between 2000 and 2025. Identification of relevant documentation relied on targeted keyword strings encompassing family names alongside standard physiological terms like total chlorophyll, total soluble sugar, and plant biochemical analysis. Strict inclusion criteria dictated that only English-language, peer-reviewed primary research articles providing quantitative data and explicitly defined analytical methodologies were included, while review articles, abstracts, and ambiguous datasets were discarded. Representative agricultural species were selected based on the robustness of published biochemical profiles. The Poaceae cohort comprised major economic crops including *Oryza sativa* L., *Triticum aestivum* L., *Zea mays* L., *Sorghum bicolor* (L.) Moench, and *Pennisetum glaucum* (L.) R. Br., while the Brassicaceae group featured key oilseeds and vegetables such as *Brassica juncea* (L.) Czern., *Brassica napus* (L.), *Brassica rapa* L., *Brassica oleracea* L. morphotypes, and *Raphanus sativus* L. Quantitative data points—including scientific nomenclature, specific plant organ analyzed, environmental growth treatments, biochemical concentrations, and original metrics—were systematically compiled within Microsoft Excel, with disparate tracking units converted to standard physiological expressions to enable rigorous comparisons.

The focal biochemical variables evaluated were total chlorophyll, predominantly quantified via the spectrophotometric methods established by Arnon (1949) or Lichtenthaler (1987), and total soluble sugar, universally derived via the classic anthrone or phenol-sulfuric acid colorimetric assays. The curated datasets were categorized by family and species to compute descriptive statistical indicators, including minimum, maximum, mean values, and standard deviations. Comparative tabular matrices were generated to assess interspecific and interfamily metabolic differences, allowing for the clear delineation of physiological trends, carbohydrate partitioning strategies, and family-specific pigment profiles documented across global agronomic literature.

III. RESULTS AND DISCUSSION

The comparative evaluation of total chlorophyll and total soluble sugar among forty representative species belonging to the Poaceae and Brassicaceae families revealed considerable biochemical variation. The mean total chlorophyll content varied from 1.40 to 3.50 milligrams per gram of fresh weight, while total soluble sugar ranged from 4.00 to 19.00 degrees Brix, indicating substantial interspecific differences in photosynthetic pigment accumulation and carbohydrate metabolism. Among the Poaceae species, *Bambusa vulgaris* recorded the highest mean total chlorophyll content (3.35 milligrams per gram of fresh weight), followed by *Zea mays* (3.10 milligrams per gram of fresh weight), *Lolium perenne* (2.90 milligrams per gram of fresh weight), *Sorghum bicolor* (2.85 milligrams per gram of fresh weight) and *Panicum maximum* (2.73 milligrams per gram of fresh weight). In contrast, the lowest chlorophyll content was observed in *Hordeum vulgare* and *Secale cereale* (2.05 milligrams per gram of fresh weight). Higher chlorophyll concentration generally reflects greater photosynthetic efficiency and enhanced light-harvesting capacity, resulting in improved biomass production and crop productivity, as established by Arnon (1949) and further detailed by Lichtenthaler (1987). The comparatively higher chlorophyll content observed in maize and sorghum may be attributed to their efficient photosynthetic systems, whereas bamboo maintains abundant chloroplast-rich foliage that supports continuous vegetative growth.

Total soluble sugar exhibited even greater variation within the Poaceae family. *Saccharum officinarum* recorded the highest mean total soluble sugar (19.00 degrees Brix), followed by *Sorghum bicolor* (11.00 degrees Brix) and *Zea mays* (7.75 degrees Brix). The exceptionally high soluble sugar concentration in sugarcane is expected because it is genetically adapted to accumulate sucrose within the stalk, making it one of the world's most important sugar-producing crops. Conversely, *Bambusa vulgaris* (4.00 degrees Brix) and *Cynodon dactylon* (4.50 degrees Brix) exhibited comparatively lower soluble sugar content, reflecting differences in carbohydrate storage patterns among grass species. Soluble sugars function not only as energy reserves but also as osmoprotectants and signaling molecules involved in plant growth, development, and responses to environmental stress, a multi-functional role emphasized by Ruan (2014).

Within the Brassicaceae family, *Brassica oleracea var. acephala* (Kale) exhibited the highest mean total chlorophyll content (3.50 milligrams per gram of fresh weight), followed by *Nasturtium officinale* (3.20 milligrams per gram of fresh weight), *Eruca vesicaria* (3.00 milligrams per gram of fresh weight), *Lepidium sativum* (2.80 milligrams per gram of fresh weight) and *Brassica juncea* (2.55 milligrams per gram of fresh weight). In contrast, *Brassica rapa pekinensis* recorded the lowest chlorophyll content (1.40 milligrams per gram of fresh weight). The elevated chlorophyll concentration observed in leafy vegetables such as kale, watercress, and arugula may be associated with their dense chloroplast population and active photosynthetic metabolism, which contribute to their characteristic green coloration and high nutritional quality. Similar observations have been reported across diverse leafy greens where pigment concentration directly dictates light-use efficiency and post-harvest leaf quality, as demonstrated by Agati et al. (2020).

Total soluble sugar also differed considerably among Brassicaceae species. *Armoracia rusticana* recorded the highest total soluble sugar (10.25 degrees Brix), followed by *Brassica oleracea var. gemmifera* and *Brassica oleracea var. gongylodes* (8.75 degrees Brix each). Broccoli, cabbage, and Indian mustard also exhibited relatively higher sugar concentrations than several other Brassicaceae members. Conversely, *Nasturtium officinale* recorded the lowest total soluble sugar (4.80 degrees Brix). The observed variation in soluble sugar concentration among Brassicaceae crops may be attributed to species-specific carbohydrate metabolism, sink strength, developmental stage, and genetic regulation. Soluble sugars are known to play important roles in maintaining osmotic balance, regulating gene expression, and improving tolerance to abiotic stresses such as drought, salinity, and temperature extremes, according to the physiological frameworks provided by Sami et al. (2016).

A comparison between the two plant families indicated that Poaceae species generally exhibited greater variation in total soluble sugar because of the presence of sugar-storing crops such as sugarcane and sorghum. In contrast, Brassicaceae species, particularly leafy vegetables, tended to possess comparatively higher chlorophyll concentrations, reflecting their vigorous photosynthetic activity and continuous leaf development. These differences are largely associated with contrasting physiological functions, photosynthetic pathways, and carbohydrate partitioning mechanisms. Members of the Poaceae include both C3 and C4 species, whereas Brassicaceae species predominantly utilize the C3 photosynthetic pathway. Such physiological differences influence chlorophyll biosynthesis, carbon assimilation, and sugar accumulation, ultimately contributing to variation in plant productivity and nutritional quality, as outlined by Taiz et al. (2018). Overall, the comparative assessment demonstrates substantial biochemical diversity among the investigated species. Variations in total chlorophyll and total soluble sugar may be useful indicators for selecting species with superior photosynthetic efficiency, carbohydrate accumulation, and physiological adaptability. These biochemical characteristics can contribute valuable information for crop improvement, nutritional evaluation, and future physiological studies aimed at enhancing agricultural productivity.

Table 1. Mean Total Chlorophyll (mg g⁻¹ FW) and Total Soluble Sugar (°Brix) of Selected Poaceae and Brassicaceae Species

S.No.	Botanical Name	Common Name	Family	Mean Total Chlorophyll (mg/g FW)	Mean TSS (°Brix)
1	*Oryza sativa*	Rice	Poaceae	2.65	5.10
2	*Triticum aestivum*	Bread Wheat	Poaceae	2.35	5.50
3	*Zea mays*	Maize / Corn	Poaceae	3.10	7.75
4	*Hordeum vulgare*	Barley	Poaceae	2.05	4.90
5	*Sorghum bicolor*	Sorghum	Poaceae	2.85	11.00
6	*Pennisetum glaucum*	Pearl Millet	Poaceae	2.45	6.10
7	*Saccharum officinarum*	Sugarcane	Poaceae	2.15	19.00
8	*Avena sativa*	Oats	Poaceae	2.15	5.35
9	*Secale cereale*	Rye	Poaceae	2.05	5.05
10	*Eleusine coracana*	Finger Millet	Poaceae	2.40	5.80
11	*Setaria italica*	Foxtail Millet	Poaceae	2.53	6.10
12	*Panicum miliaceum*	Proso Millet	Poaceae	2.23	5.50
13	*Cynodon dactylon*	Bermuda Grass	Poaceae	2.70	4.50
14	*Lolium perenne*	Perennial Ryegrass	Poaceae	2.90	6.50
15	*Dactylis glomerata*	Orchardgrass	Poaceae	2.53	6.15
16	*Festuca arundinacea*	Tall Fescue	Poaceae	2.35	5.75
17	*Panicum maximum*	Guinea Grass	Poaceae	2.73	6.65
18	*Cenchrus ciliaris*	Buffel Grass	Poaceae	2.28	5.10
19	*Chloris gayana*	Rhodes Grass	Poaceae	2.43	5.35
20	*Bambusa vulgaris*	Common Bamboo	Poaceae	3.35	4.00
21	*Brassica oleracea* var. *capitata*	Cabbage	Brassicaceae	1.65	7.25
22	*Brassica oleracea* var. *botrytis*	Cauliflower	Brassicaceae	1.50	6.65
23	*Brassica oleracea* var. *italica*	Broccoli	Brassicaceae	2.30	7.75
24	*Brassica oleracea* var. *gemmifera*	Brussels Sprouts	Brassicaceae	2.55	8.75
25	*Brassica oleracea* var. *gongylodes*	Kohlrabi	Brassicaceae	1.75	8.75
26	*Brassica oleracea* var. *acephala*	Kale	Brassicaceae	3.50	7.60
27	*Brassica rapa* pekinensis	Chinese Cabbage	Brassicaceae	1.40	5.65
28	*Brassica rapa* var. *rapa*	Turnip	Brassicaceae	1.58	6.50
29	*Brassica rapa* subsp. *oleifera*	Field Mustard	Brassicaceae	2.15	6.35
30	*Brassica juncea*	Indian Mustard	Brassicaceae	2.55	6.85
31	*Brassica napus*	Rapeseed / Canola	Brassicaceae	2.35	6.40

32	*Raphanus sativus*	Radish	Brassicaceae	1.75	5.25
33	*Eruca vesicaria*	Arugula / Rocket	Brassicaceae	3.00	6.10
34	*Armoracia rusticana*	Horseradish	Brassicaceae	2.25	10.25
35	*Lepidium sativum*	Garden Cress	Brassicaceae	2.80	5.80
36	*Capsella bursa-pastoris*	Shepherd's Purse	Brassicaceae	1.95	5.10
37	*Nasturtium officinale*	Watercress	Brassicaceae	3.20	4.80
38	*Brassica nigra*	Black Mustard	Brassicaceae	2.48	6.70
39	*Brassica oleracea* var. *alboglabra*	Gai Lan (Chinese Broccoli)	Brassicaceae	2.30	7.20
40	*Matthiola incana*	Gillyflower / Stock	Brassicaceae	2.05	6.25

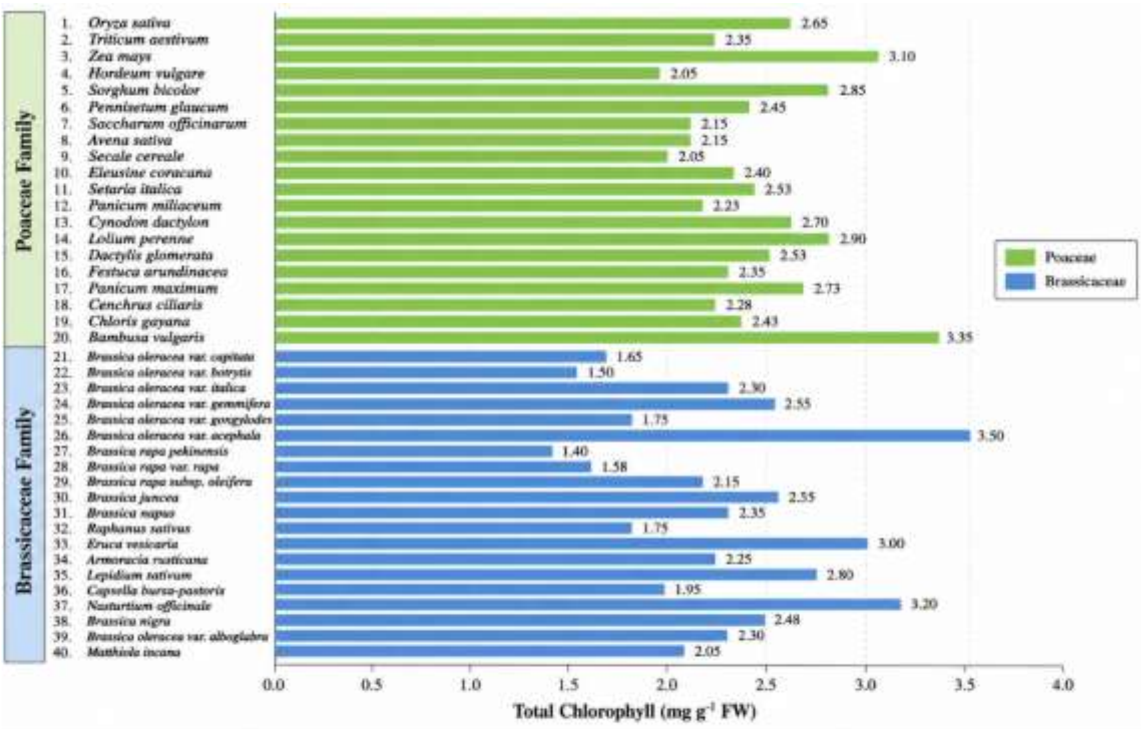

Fig.1. Comparative Mean Total Chlorophyll Content of Selected Poaceae and Brassicaceae Species

IV. CONCLUSION

The present comparative study demonstrated significant variation in total chlorophyll (TC) and total soluble sugar (TSS) among selected species belonging to the Poaceae and Brassicaceae families. The compiled data indicated that chlorophyll concentration and soluble sugar accumulation varied considerably among species, reflecting differences in their physiological characteristics, photosynthetic efficiency, and carbohydrate metabolism. Species of the Poaceae family, particularly *Saccharum officinarum*, *Zea mays*, and *Sorghum bicolor*, exhibited comparatively higher soluble sugar content, whereas leafy Brassicaceae species such as *Brassica oleracea* var. *acephala*, *Nasturtium officinale*, and *Eruca vesicaria* showed relatively higher chlorophyll concentrations. These findings suggest that species-specific biochemical characteristics are closely associated with plant growth habit, photosynthetic capacity, and carbon allocation. the comparative analysis further highlights the importance of total chlorophyll and total soluble sugar as reliable biochemical indicators for evaluating plant physiological performance and metabolic efficiency. Such information can be useful for crop improvement programmes, nutritional quality assessment, physiological research, and the selection of species with desirable biochemical traits. Although the present study was based on comparative literature-derived data, it provides a comprehensive overview of biochemical diversity within two economically important plant families and establishes a foundation for future experimental validation under uniform environmental and management conditions.

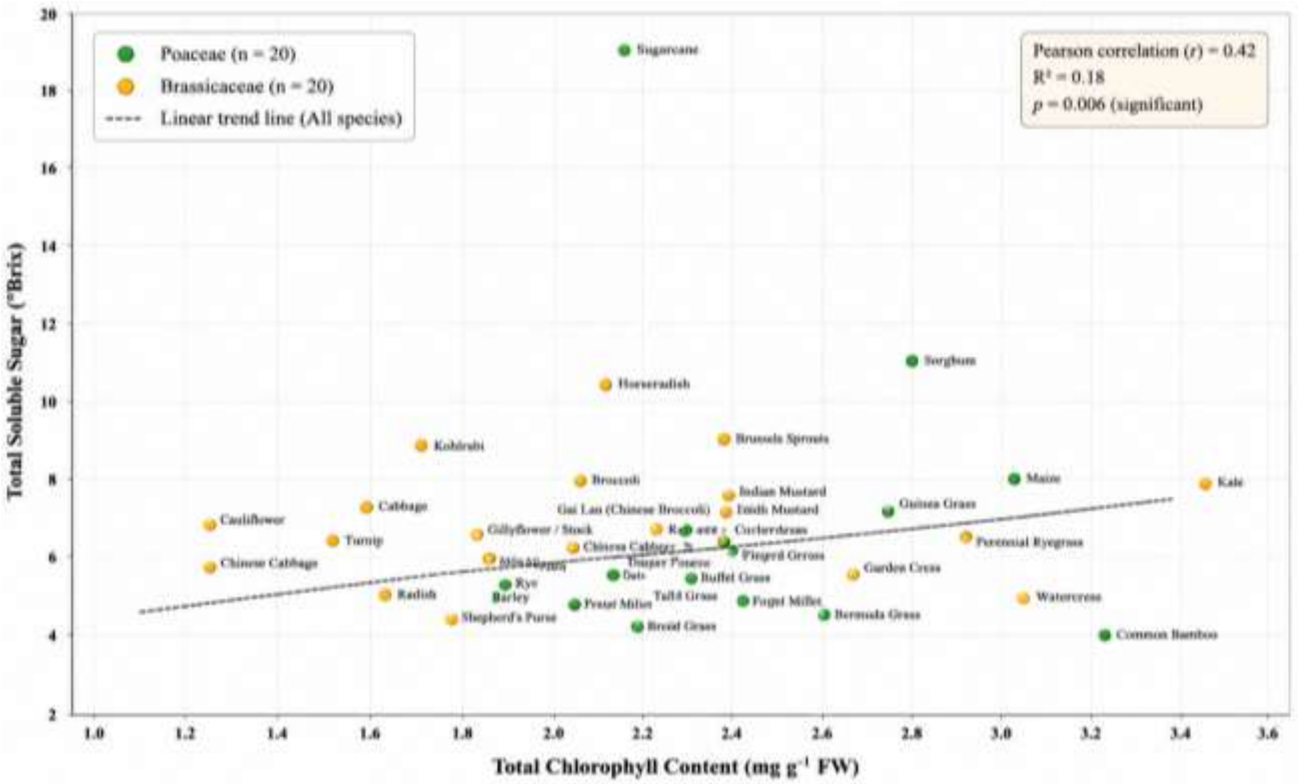

Fig.2. Relationship between total chlorophyll and total soluble sugar

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