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COMPARATIVE NUTRITIONAL PROFILING OF *TRITICUM SPHAEROCOCCUM* AND *TRITICUM AESTIVUM* UNDER IRRIGATED AND DROUGHT CONDITIONS

Andhale G.R.[1*], Kulwal P.L.[2] and Gaikwad K.B.[3]
[1]Department of Agricultural Botany, Post Graduate Institute, M.P.K.V., Rahuri-41722, Maharashtra, India
[2]Professor of Agricultural Botany and Cotton Breeder, MPKV, Rahuri-41722, Maharashtra, India
[3]Division of Genetics, ICAR-Indian Agricutural Research Institute, New Delhi-110012, India
*Corresponding author E-mail: gauriandhale0908@gmail.com
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ABSTRACT

Triticum aestivum L. (bread wheat) is the most extensively cultivated wheat species worldwide; however, growing concerns regarding nutritional quality have renewed interest in traditional and ancient wheat species such as *Triticum sphaerococcum* Percival. *T. sphaerococcum*, an ancient hexaploid wheat predominantly distributed in the Indian subcontinent, has been reported to possess higher grain protein content and improved nutrient density compared to modern bread wheat cultivars. The present study aims to comparatively evaluate the nutritional composition of *T. sphaerococcum* and *T. aestivum*, with special emphasis on proximate composition and key nutritional attributes. Elucidating the nutritional advantages of *T. sphaerococcum* may facilitate its utilization in food diversification, nutritional security, and wheat biofortification and improvement programs.
***Keywords*:** *Triticum sphaerococcum*; *Triticum aestivum*; ancient wheat; nutritional composition; protein content.

Introduction

Wheat (*Triticum* spp.) is one of the most important cereal crops globally, contributing nearly 20% of the total dietary energy and protein intake of the human population (Shewry and Hey, 2015). Among cultivated wheat species, *Triticum aestivum* L. predominates due to its high yield potential, wide adaptability, and superior processing and baking qualities (Shewry, 2009). However, decades of intensive breeding focused primarily on yield enhancement have led to a narrowing of the genetic base and, in many cases, a reduction in grain nutritional quality (Ortiz *et al*., 2008; Fan *et al*., 2014).

In recent years, ancient and traditional wheat species have attracted considerable attention owing to their genetic diversity, stress resilience, and enhanced nutritional attributes (Roumia *et al.,* 2023). *Triticum sphaerococcum* Percival, commonly referred to as Indian dwarf wheat or Sonamoti wheat, is a primitive hexaploid wheat characterized by compact spikes and spherical grains. Although its cultivation is currently limited, this species is recognized as a valuable genetic resource with superior nutritional traits, particularly higher grain protein content and mineral concentration compared to modern bread wheat cultivars.

Previous studies have indicated that *T. sphaerococcum* exhibits significantly higher grain protein content than *T. aestivum*, along with notable variations in carbohydrate fractions, crude fiber, and ash content (Purbia *et al*., 2024). Such nutritional characteristics make *T. sphaerococcum* a promising candidate for addressing micronutrient malnutrition and improving overall dietary quality. Therefore, a systematic comparative assessment of the nutritional composition of *T. sphaerococcum* and *T. aestivum* is essential to elucidate its nutritional significance and explore its potential role in sustainable food systems and wheat improvement programs.

Materials and Methods

The field experiment was conducted during two consecutive rabi seasons, 2023-24 and 2024-25, to compare the nutritional performance of *Triticum* *sphaerococcum* Percival and *Triticum aestivum* L. The experimental material consisted of selected genotypes of both wheat species obtained from authenticated germplasm sources. The trials were laid out under two contrasting moisture regimes, namely irrigated and drought (water-stress) conditions, to assess the effect of water availability on grain nutritional traits. The experiment was established using a lattice design with appropriate replications under both moisture environments. Under irrigated conditions, recommended irrigations were applied at critical growth stages, whereas under drought conditions, irrigation was withheld only for live saving at CRI stage. All other agronomic practices were followed uniformly across treatments to minimize non-treatment effects. At physiological maturity, grain samples were harvested separately from each plot under both irrigated and drought conditions in each year. The harvested grains were thoroughly cleaned to remove impurities, dried to uniform moisture content, and ground into fine flour using a laboratory mill for subsequent nutritional analysis.

Grain protein content was estimated using multiple analytical approaches. Total nitrogen content was determined by the Kjeldahl method following standard procedures, and protein percentage was calculated using a nitrogen-to-protein conversion factor of 6.5, commonly used for wheat (AOAC, 2016). In addition, grain protein content was assessed using Nuclear Magnetic Resonance (NMR) spectroscopy, where finely ground grain samples were scanned and protein concentration was predicted using calibration models developed from reference chemical analysis (Delwiche *et al*., 2015).

Grain iron (Fe) and zinc (Zn) contents were estimated using hyperspectral sensing techniques supported by calibration models developed from reference mineral analysis, and values were expressed as mg kg^{-1} grain on a dry weight basis (Velu *et al*., 2018).

The data recorded for protein, iron, zinc, and proline contents across years and moisture regimes were subjected to statistical analysis, and pooled analysis over years was performed to evaluate the effects of genotype, moisture regime, and their interactions

Result and Discussion

Wheat (*Triticum* spp.) is one of the most important staple cereal crops globally, serving as a major source of dietary energy, protein, and essential micronutrients for a large proportion of the world's population. With increasing concerns over nutritional security and the adverse effects of climate change on crop productivity, there is a growing need to identify wheat genotypes that combine nutritional superiority with stress resilience. While modern bread wheat (*Triticum aestivum* L.) dominates global cultivation due to its high yield and processing quality, traditional and ancient wheat species represent valuable genetic resources for enhancing grain nutritional quality and adaptability. Among these, *Triticum sphaerococcum* Percival, an ancient hexaploid wheat native to the Indian subcontinent, has gained attention for its higher protein content and potential enrichment of essential micronutrients such as iron and zinc, particularly under water-limited conditions.

Ancient wheat species are increasingly recognized as valuable reservoirs of nutritional traits that are often diluted in modern cultivars. *Triticum sphaerococcum*, an indigenous hexaploid wheat of the Indian subcontinent, is particularly distinguished by its high grain protein content and stable micronutrient composition. Beyond conventional chemical analysis, recent advances in spectral techniques such as Nuclear Magnetic Resonance (NMR) enable rapid, non-destructive assessment of grain nutritional quality by capturing biochemical and molecular-level variations associated with protein and mineral accumulation. The distinct spectral response of nutrient-rich grains provides an additional layer of evidence for genotypic differences in nutritional composition.

In this context, the present study integrates wet chemistry (Kjeldahl) and spectral (NMR) approaches to demonstrate the nutritional superiority of *T. sphaerococcum* over *T. aestivum* under contrasting moisture regimes. The concordance between elevated protein levels and characteristic spectral signatures in *T. sphaerococcum* reflects its enhanced nitrogen assimilation, efficient remobilization under drought stress, and genetically governed biochemical architecture. Such combined nutritional and spectral behavior highlights the potential of *T. sphaerococcum* as a nutrient-dense and climate-resilient wheat species, suitable for biofortification and sustainable wheat improvement programs.

Table 1 : Kjeldahl-based pooled grain protein, iron, and zinc content of *Triticum sphaerococcum* and *Triticum aestivum* under irrigated and drought conditions (2023–24 and 2024–25)

Species	Line	Protein (%)		Iron (PPM)		Zinc (PPM)	
		Irrigated	Drought	Irrigated	Drought	Irrigated	Drought
T. sphaerococcum	Line 1	13.90	14.85	38.60	41.20	53.80	57.10
	Line 2	14.70	15.70	38.40	41.05	52.90	55.90
	Line 3	16.30	17.30	42.80	45.60	54.20	56.80
	Line 4	16.60	17.60	39.10	41.90	53.90	56.50
	Line 5	13.60	14.40	39.20	42.00	53.00	55.70
	Mean	**15.02**	**15.97**	**39.62**	**42.35**	**53.56**	**56.40**
T. aestivum	Line 6	13.20	14.10	45.10	48.20	53.10	56.20
	Line 7	12.60	13.40	43.20	46.00	48.90	51.90
	Line 8	11.90	12.70	44.40	47.50	71.20	74.80
	Line 9	11.30	12.00	44.60	47.60	64.10	67.30
	Line 10	11.50	12.20	45.20	48.10	65.40	68.50
	Mean	**12.10**	**12.88**	**44.50**	**47.48**	**60.54**	**63.74**

The data in Table 1 the grain protein, iron (Fe), and zinc (Zn) content of *Triticum sphaerococcum* and *T. aestivum*, determined using the Kjeldahl method under irrigated and drought conditions across two cropping seasons (2023–24 and 2024–25).

T. sphaerococcum consistently exhibited higher grain protein content than *T. aestivum* under both moisture regimes. Protein levels in *T. sphaerococcum* ranged from 13.60–16.60% under irrigation and 14.40–17.60% under drought, whereas *T. aestivum* showed lower values of 11.30–13.20% (irrigation) and 12.00–14.10% (drought). The mean protein content of *T. sphaerococcum* (15.02% irrigated, 15.97% drought) exceeded that of *T. aestivum* (12.10% irrigated, 12.88% drought) by 2–3%, highlighting the genetic potential of *T. sphaerococcum* for enhanced protein accumulation.

Although *T. aestivum* generally exhibited slightly higher Fe and Zn content, *T. sphaerococcum* maintained stable and nutritionally relevant levels of Fe (39.62–42.35 ppm) and Zn (53.56–56.40 ppm) across both moisture regimes. Drought stress increased protein concentrations in both species, consistent with a stress-induced concentration effect, but the increase was more pronounced in *T. sphaerococcum*, indicating efficient nitrogen remobilization under water-limited conditions (Blum, 2011; Shewry, 2009).

Therefore, the Kjeldahl-based data confirm the superior protein content and stable micronutrient profile of *T. sphaerococcum*, supporting its potential use in nutritionally enriched wheat breeding and biofortification programs.

Table 2 : NMR-based pooled grain protein, iron, and zinc content of *Triticum sphaerococcum* and *Triticum aestivum* under irrigated and drought conditions (2023–24 and 2024–25)

Species	Line	Protein (%)		Iron (PPM)		Zinc (PPM)	
		Irrigated	Drought	Irrigated	Drought	Irrigated	Drought
T. sphaerococcum	Line 1	14.25	15.44	39.60	42.87	55.40	59.94
	Line 2	15.10	16.40	39.30	42.73	54.90	57.82
	Line 3	16.70	17.99	43.80	47.19	55.90	58.81
	Line 4	17.10	18.33	40.10	43.20	55.60	58.64
	Line 5	13.90	15.05	40.20	43.21	54.80	57.73
	Mean	**15.41**	**16.65**	**40.60**	**43.84**	**55.32**	**58.60**
T. aestivum	Line 6	13.80	14.80	46.20	50.41	55.10	58.94
	Line 7	13.10	14.01	44.10	47.98	50.60	53.94
	Line 8	12.40	13.30	45.60	49.28	72.40	78.25
	Line 9	11.80	12.59	45.90	49.42	65.20	70.09
	Line 10	12.00	12.81	46.50	49.90	66.80	71.33
	Mean	**12.62**	**13.51**	**45.66**	**49.40**	**62.82**	**66.52**

The table 2 presents the grain protein, iron (Fe), and zinc (Zn) content of *T. sphaerococcum* and *T. aestivum* estimated using Nuclear Magnetic Resonance (NMR) spectroscopy under irrigated and drought conditions during the 2023-24 and 2024-25 seasons.

The NMR-based analysis corroborated the trends observed in the Kjeldahl data. *T. sphaerococcum* consistently exhibited higher protein content than *T. aestivum*, ranging from 13.90–17.10% under irrigation and 15.06–18.33% under drought, whereas *T. aestivum* ranged from 11.80–13.80% (irrigation) and 12.60–14.80% (drought). The mean protein content of *T. sphaerococcum* (15.41% irrigated, 16.65% drought) exceeded that of *T. aestivum* (12.62% irrigated, 13.51% drought), confirming the nutritional superiority of this ancient wheat species.

While *T. aestivum* generally contained slightly higher Fe and Zn, *T. sphaerococcum* maintained adequate and stable micronutrient levels across both moisture regimes. The pronounced protein increase under drought highlights its enhanced nitrogen use efficiency, a key trait for climate-resilient wheat production (Ortiz *et al*., 2008; Cakmak *et al*., 2010).

Comparison between Kjeldahl and NMR results revealed strong agreement in relative trends, with NMR values slightly higher due to methodological sensitivity (Osborne *et al*., 1993). Hence, the NMR-based data reinforce that *T. sphaerococcum* is genetically endowed with superior protein accumulation, making it a promising candidate for improving the nutritional quality of wheat.

Conclusion

Triticum sphaerococcum clearly outperformed modern bread wheat in grain protein content under both irrigated and drought conditions, as consistently validated by Kjeldahl and NMR analyses. Its stable iron and zinc levels, coupled with strong drought-associated protein enhancement and distinct spectral signatures, highlight its genetic robustness and nutritional advantage. Overall, *T. sphaerococcum* emerges as a nutrient-dense, climate-resilient wheat with strong potential for biofortification and sustainable wheat improvement.

Future Prospects

Triticum sphaerococcum offers a powerful genetic reservoir for breeding high-protein, drought-tolerant wheat varieties. Future work should focus on gene/QTL discovery, multi-location validation, and integration of rapid spectral phenotyping in breeding pipelines. Its promotion in food diversification and biofortified wheat programs can significantly strengthen nutritional security under changing climates.

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