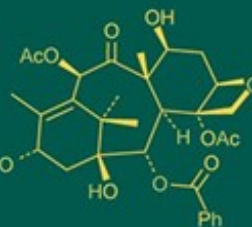
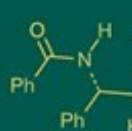
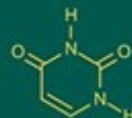


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Developmental and tissue-specific variation in total soluble protein content in onion (*Allium Cepa* L.)

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ABSTRACT

Total soluble protein (TSP) content reflects important biochemical changes associated with plant growth and tissue development. The present study evaluated developmental variation in TSP in leaf and bulb tissues of onion (*Allium cepa* L.) cv. 'Bhima Shweta' at 45, 60, 90 and 120 days after transplanting (DAT) with three biological replicates. TSP was quantified using the Bradford assay and data were analyzed using one and two-way ANOVA. Leaf TSP decreased from 1.7773 mg g⁻¹ FW at 45 DAT to 1.3423 mg g⁻¹ FW at 120 DAT, a reduction of 24.5%. In contrast, bulb TSP increased from 0.6572 to 1.2917 mg g⁻¹ FW during the same period, representing a 96.5% increase. These contrasting trends indicate tissue specific changes in protein accumulation during leaf maturation and bulb development.

Keywords: *Allium cepa*, 'Bhima Shweta', Bulb, Developmental stage, Leaf, Total soluble protein

1. Introduction

Onion (*Allium cepa* L.) is an important vegetable crop valued for its widespread consumption, nutritional properties and economic significance (Gupta *et al.*, 2025) [1]. Its bulbs contain essential nutrients and bioactive compounds, including flavonoids, phenolics and organosulfur compounds which contribute to its nutritional and biological value (Sagar *et al.*, 2022; Yan *et al.*, 2023) [2, 3]. Its high domestic demand and importance in international trade make onion a major commercial horticultural crop and an important source of farm income. India is the world's largest producer of onions and shallots, contributing about 22.42% of global production with 30.79 million tonnes produced in 2024–2025 (DA&FW, 2024-2025) [4].

Onion growth and development involve a transition from vegetative leaf growth to bulb formation and maturation. Leaves serve as the major photosynthetic source, producing assimilates that support plant growth, while the developing bulb functions primarily as a storage sink. Bulb formation is accompanied by enlargement of the leaf bases and progressive accumulation and redistribution of carbohydrates and other metabolites in storage tissues. Consequently, the transition from vegetative growth to bulb development involves changes in assimilate production, translocation and utilization among plant tissues (Rashid *et al.*, 2019; Cheng *et al.*, 2021) [6, 5]. Leaf development is also associated with changes in photosynthetic activity and soluble protein distribution. Steer and Darbyshire (1979) [7] reported spatial and developmental variation in soluble protein content in onion leaves, indicating changes in protein metabolism during leaf growth. Developmental changes in onion are also associated with progressive maturation and senescence of leaves which can alter the physiological and biochemical status of the plant ((Kulinski and Pappelis, 1973; Bhattacharya and Pappelis) [9, 8].

Proteins are essential for cellular structure, metabolic processes and enzymatic activity and their abundance can vary with tissue type and developmental stage. Metabolic and source-sink changes associated with bulb formation can influence biochemical processes in both leaves and developing bulbs (Rashid *et al.*, 2019; Cheng *et al.*, 2021) [6, 5]. Bulb development is also accompanied by changes in carbohydrate metabolism and other related biochemical processes (Zhang *et al.*, 2016) [10]. Therefore, determining TSP content in leaf and bulb tissues at successive developmental stages can help characterize tissue-specific changes in protein accumulation during onion growth and bulb development.

Therefore, the present study assessed changes in TSP content in leaf and bulb tissues of onion cv. 'Bhima Shweta' at 45, 60, 90 and 120 days after transplanting (DAT), focusing on tissue- and developmental stage-related variation during plant growth and bulb development.

2. Materials and Methods

2.1 Plant materials and sampling

Onion genotype cv. 'Bhima Shweta' was obtained from ICAR–Directorate of Onion and Garlic Research, Pune, Maharashtra during the rabi season, December 2025 to April, 2026. Healthy leaf and bulb tissues were collected at 45, 60, 90 and 120 DAT with three biological replicates for each tissue and stage combination.

2.2 Total soluble protein extraction

The TSP was extracted according to Dancer *et al.* (1990) [11] with minor modifications. Fresh leaf and bulb tissues of 0.1 g were homogenized in 1 mL chilled extraction buffer containing 50 mM HEPES-KOH (pH 7.5), 1 mM EDTA, 5 mM MgCl₂, 0.5 mM PMSF, 2.5 mM DTT and 0.05% Triton X-100. The homogenate was centrifuged at 15,000×g for 20 min at 4 °C and the supernatant was collected as the soluble protein extract.

2.3 Quantification of TSP

The TSP was estimated using the Bradford dye-binding assay (Bradford, 1976) [12] with bovine serum albumin (BSA) as the standard. A calibration curve was prepared using different concentrations of BSA from a 1 mg mL⁻¹ stock solution. For each sample, 150 µL of crude extract was mixed with 50 µL of extraction buffer and made up to 1 mL with Bradford reagent. An aliquot of 200 µL was transferred to a 96-well microplate and incubated for 5 min at room temperature in the dark. Absorbance was measured at 595 nm using a microplate reader against a reagent blank. Protein concentration was determined from the BSA standard curve and expressed as mg g⁻¹ fresh weight.

2.4 Statistical analysis

The TSP values were expressed as mean ± SE. One-way ANOVA was performed for leaf and bulb tissues separately to assess differences among developmental stages. A two-way ANOVA was performed to evaluate the effects of tissue, developmental stage and their interaction. Mean differences were tested using LSD/CD at $P < 0.05$. Analyses were conducted using GRAPES (Gopinath *et al.*, 2021) [13].

2.5 Heatmap analysis

A heatmap was generated using TBtools (Chen *et al.*, 2023) [14] to visualize the variation in TSP content across tissues and developmental stages using mean TSP values (mg g⁻¹ FW).

3. Results and Discussion

3.1 Developmental variation in TSP content of leaf tissue

The TSP content in 'Bhima Shweta' leaf decreased significantly ($P < 0.05$) from 1.7773 mg g⁻¹ FW at 45 DAT to 1.3423 mg g⁻¹ FW at 120 DAT with values of 1.6884 and 1.4916 mg g⁻¹ FW at 60 and 90 DAT respectively (Fig. 1). The CD (LSD) was 0.057% and the CV was 1.919%, indicating significant differences among all developmental stages with relatively low experimental variation. The overall decline in TSP was 24.5% from 45 to 120 DAT, indicating a developmental reduction in soluble protein accumulation. Steer and Darbyshire (1979) [7] also reported spatial variation in onion leaf soluble protein.

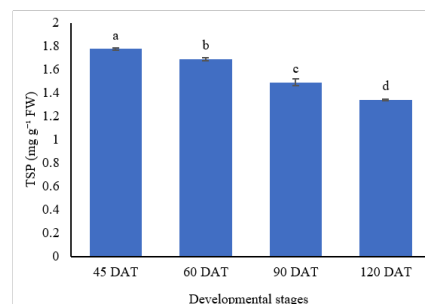


Figure 1. Total soluble protein content in leaf tissue of 'Bhima Shweta'. Different letters indicate significant differences among developmental stages (LSD, $P < 0.05$).

3.2 Developmental variation in TSP content of bulb tissue

In 'Bhima Shweta' bulbs, TSP increased progressively with plant development from 0.6572 mg g⁻¹ FW at 45 DAT to 0.9189, 1.1624 and 1.2917 mg g⁻¹ FW at 60, 90 and 120 DAT respectively (Fig. 2). The differences among developmental stages were significant ($P < 0.05$) with an overall increase of approximately 96.5% from 45 to 120 DAT. This progressive increase indicates enhanced soluble protein accumulation during bulb development. Zhang *et al.* (2016) [10] and Cheng *et al.* (2021) [5] documented substantial biochemical and metabolic changes associated with bulb swelling and maturation. These findings support the observed stage-dependent changes in soluble protein content in 'Bhima Shweta' bulbs.

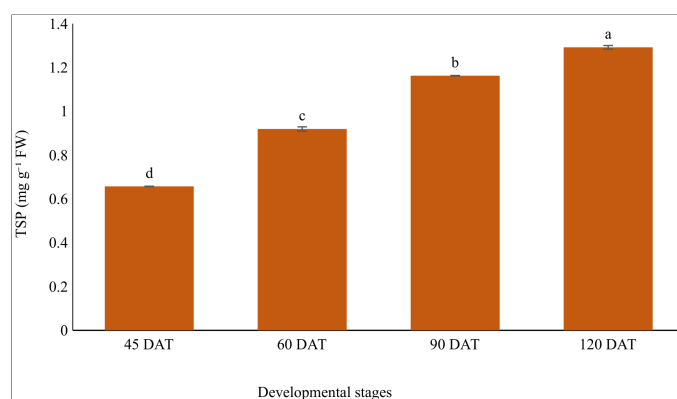


Figure 2. Total soluble protein content in bulb tissue of 'Bhima Shweta'. Different letters indicate significant differences among developmental stages (LSD, $P < 0.05$).

3.3 Developmental variation in TSP content of leaf and bulb tissues

In 'Bhima Shweta', TSP showed contrasting developmental patterns between leaf and bulb tissues (Fig 3 and Fig 4). Leaf TSP decreased from 1.7773 mg g⁻¹ FW at 45 DAT to 1.3423 mg g⁻¹ FW at 120 DAT, whereas bulb TSP increased from 0.6572 to 1.2917 mg g⁻¹ FW. The tissue × developmental stage effect was significant (CD = 0.040%; CV = 1.768%). The decline in leaf TSP may be associated with developmental changes in leaf metabolism, while increased bulb TSP may reflect protein accumulation during bulb development (Cheng *et al.*, 2021) [5]. Steer and Darbyshire (1979) [7] reported higher soluble protein content at the onion leaf tip and declining toward the leaf base. Similarly, Hussein *et al.* (2022) [15] reported higher protein content in shoots (15.93%) than bulbs (9.05%), supporting the tissue dependent variation observed in the present study.

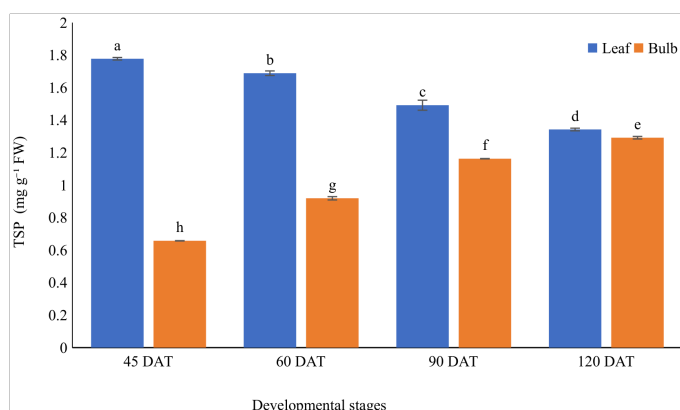


Figure 3. Total soluble protein content in leaf and bulb tissues of 'Bhima Shweta'. Different letters indicate significant differences among tissue × developmental stages (LSD, $P < 0.05$).

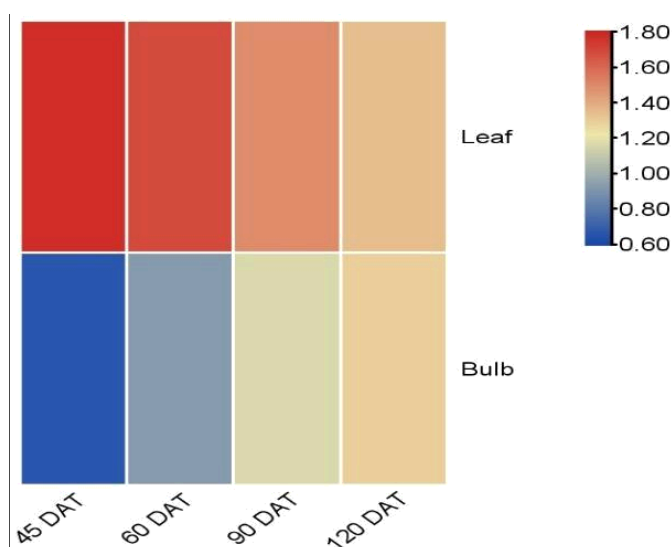


Figure 4. Heatmap of TSP variation in leaf and bulb tissues of 'Bhima Shweta'; colour intensity indicates TSP concentration.

4. Conclusion

The present study demonstrated clear developmental and tissue-specific variation in total soluble protein (TSP) content in onion cv. 'Bhima Shweta'. Leaf tissue showed higher TSP content than bulb tissue throughout the study period, with the highest leaf TSP recorded at 45 DAT (1.7773 mg g⁻¹ FW). Leaf TSP decreased progressively by 24.5% to 1.3423 mg g⁻¹ FW at 120 DAT. In contrast, bulb TSP increased by 96.5%, from 0.6572 mg g⁻¹ FW at 45 DAT to 1.2917 mg g⁻¹ FW at 120 DAT. Thus, leaf and bulb tissues exhibited opposite developmental patterns, with decreasing TSP in leaves and increasing TSP in bulbs. The significant differences among developmental stages and tissue × stage combinations indicate that both tissue type and developmental stage strongly influence TSP accumulation in 'Bhima Shweta'. These findings provide useful baseline information on protein dynamics during onion growth and bulb development.

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References

- Gupta AJ, Kaldete S, Volaguthala S, Mahajan V. Onion nutritional and nutraceutical composition and therapeutic potential of its phytochemicals assessed through preclinical and clinical studies. *Journal of Functional Foods*. 2025;129:106889.

- Sagar NA, Pareek S, Benkeblia N, Xiao J. Onion (*Allium cepa* L.) bioactives: Chemistry, pharmacotherapeutic functions, and industrial applications. *Food Frontiers*. 2022;3(3):380-412.
- Yan JK, Zhu J, Liu Y, Chen X, Wang W, Zhang H, Li L. Recent advances in research on *Allium* plants: Functional ingredients, physiological activities, and applications in agricultural and food sciences. *Critical Reviews in Food Science and Nutrition*. 2023;63(26):8107-35.
- Department of Agriculture and Farmers Welfare, 2024-2025. *Agricultural statistics at a glance 2024*. Ministry of Agriculture & Farmers Welfare, Government of India. <https://agriwelfare.gov.in/> (accessed on 15 September, 2026).
- Cheng W, Rashid HA, Stark R, Thomas B. The role of organ-and daylength-specific gene expression in bulb development and resource management in onion (*ALLIUM CEPA* L.). *Scientia Horticulturae*. 2021;286:110223.
- Rashid MH, Cheng W, Thomas B. Temporal and spatial expression of *Arabidopsis* gene homologs control daylength adaptation and bulb formation in onion (*Allium cepa* L.). *Scientific Reports*. 2019;9(1):14629.
- Steer BT, Darbyshire B. Some aspects of carbon metabolism and translocation in onions. *New Phytologist*. 1979;82(1):59-68.
- Bhattacharya PK, Pappelis AJ. Nucleic acid, protein, and protein-bound lysine and arginine patterns in epidermal nuclei of the mature and senescing onion bulb. *Mechanisms of Ageing and Development*. 1983;21(1):27-36.
- Kulinski FB, Pappelis AJ. Quantitative interferometry of onion epidermal nuclei in development and in senescence. *New Phytologist*. 1973;72(4):851-4.
- Zhang C, Zhang H, Zhan Z, Liu B, Chen Z, Liang Y. Transcriptome analysis of sucrose metabolism during bulb swelling and development in onion (*Allium cepa* L.). *Frontiers in Plant Science*. 2016;7:1425.
- Dancer J, Hatzfeld WD, Stitt M. Cytosolic cycles regulate the turnover of sucrose in heterotrophic cell-suspension cultures of *Chenopodium rubrum* L. *Planta*. 1990;182(2):223-31.
- Bradford MM. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Analytical Biochemistry*. 1976;72(1-2):248-54.
- Gopinath PP, Parsad R, Joseph B, VS A. grapesAgri!: collection of shiny apps for data analysis in agriculture. *Journal of Open Source Software*. 2021;6(63):3437.
- Chen C, Wu Y, Li J, Wang X, Zeng Z, Xu J, Liu Y, Feng J, Chen H, He Y, Xia R. TBtools-II: A "one for all, all for one" bioinformatics platform for biological big-data mining. *Molecular Plant*. 2023;16(11):1733-42.
- Hussein WI, Faizy HS, Youssef SM. Nutritional values and phytochemical analysis of *Allium calocephalum* Wendelbo, a valuable endemic wild garlic to Zagros mountains. *Revis Bionatura*. 2022;7(4):1-9.

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