**~~Assessment of~~ Genetic Diversity ~~Through~~ for Morphometric and Biochemical Traits in Trapa natans var. spinosa Roxb. from Southwestern Uttar Pradesh (Etawah and Auraiya districts).**

**Abstract**

This study evaluated genetic diversity in *Trapa natans* var. *bispinosa* Roxb. from southwestern Uttar Pradesh using morphometric and biochemical traits. During this study, twenty genotypes collected from Etawah and Auraiya districts showed significant variation in fruit length, breadth, weight, volume, specific gravity, pH, TSS, ascorbic acid, sugars, and protein. The samples had green peel with rudimentary spines (e.g., S18, S20) exhibited superior yield traits, making them ideal for production-oriented breeding, whereas the red peel with rudimentary spines (e.g., S11, S12) had the highest ascorbic acid (up to 6.76 mg/100g) and sugar content, indicating their potential for nutraceutical and processing applications. Moreover, the samples had green peel with the both perfect and rudimentary spine dominated over the red peel once with respect of protein content and fruit breadth. The sample 6 (S6) recorded the highest protein (1.83%) and fruit breadth (58.19 mm), favoring fresh consumption. Genotypic differentiation based on spine and peel color provided a practical framework for targeted cultivar development. The study supports conservation, germplasm enhancement, and future breeding strategies for improving yield, nutritional value, and consumer appeal in water chestnut.

**Key words:-**Rudimentary, genotypes, nutraceutical, germplasm etc.

**Introduction**

*Trapa natans* var. *bispinosa* Roxb. is commonly known as water chestnut, singhara nut, or bull nut, is an annual, aquatic, floating herbaceous plant belonging to the family *Trapaceae*. The genus *Trapa* includes three primary species: *T. natans*, *T. bicornis*, and *T. rossica*. Within *T. natans*, two botanical varieties are distinguished—*T. natans* var. *natans* L., which produces four-horned fruits, and *T. natans* var. *bispinosa* Roxb. bearing two stout, curved horns and cultivated widely for its edible fruits (Crow &Helliquist, 2000).Originally native to the warm temperate zones of Eurasia and Africa, *T. natans* var. *bispinosa* was introduced to the United States in the 1870s as an ornamental plant.Based on color of the peel, water chestnut is categorized into three groups (1) completely green, (2) completely red, (3) green blended with red (Ahmad and Singh, 1998). Though its natural dispersal is restricted due to the heavy, sinking fruits, it has successfully established in northeastern U.S. regions. Now a day, it is cultivated across tropical and subtropical areas including India, Pakistan, Sri Lanka, Indonesia, and several Southeast Asian countries. In India, major production occurs in states such as Uttar Pradesh, Bihar, Tamil Nadu, West Bengal, Assam, Odisha, and Jammu & Kashmir, particularly among communities like the Kashyap, Majwar, and Nishad (Chakor, 1974). Moreover, this aquatic species flourishes in freshwater ecosystems like lakes, ponds, wetlands, and slow-flowing rivers. Fruit development occurs primarily during the winter season (November to January), with nut ripening and natural fruit drop by late January. The fruit is a top-shaped, single-seeded drupe with a fleshy, edible pericarp surrounding a hard, horned endocarp (pyxidium).Furthermore, Adkar *et*. *al*, (2014) reported that *Trapa bispinosa* is rich in essential minerals and bioactive compounds, making it a valuable plant both nutritionally and medicinally. It contains high levels of calcium (Ca), potassium (K), sodium (Na), zinc (Zn), and various vitamins. Phytochemical studies have identified the presence of saponins, phenols, alkaloids, flavonoids, and compounds with strong hydrogen-donating (antioxidant) capacity.

Given its agronomic importance and nutritional potential, detailed characterization of *T. natans* var. *bispinosa* is crucial. The present study aims to investigate the genetic diversity among populations from Etawah, Uttar Pradesh, through the analysis of morphometric traits and biochemical properties, thereby contributing to germplasm evaluation, conservation, and crop improvement strategies.

**Material and method:**

The evaluation study of the collected samples was performed at the Horticulture Research Laboratory, Department of Horticulture, School of Agriculture Science and Technology, Babasaheb Bhimrao Ambedkar University, Lucknow, where physico- chemical parameters of the fruit were analyzed.

The samples of water chestnut (*Trapa natans* var. *bispinosaRoxb*.) were collected from two villages of district Etawah *viz*., Nagla Moti and Narenia, Ekdil and one village of district Auraiya*viz.,* Paliya, Bidhuna.Twenty samples of both green and red colour fruits from different twenty ponds were collected and utilized for exploring the Morphometric and Biochemical variability present in the collectedgermplasm. The individual sample also considered as Treatment.The laboratory experiments were laid out in Completely Randomized Design (CRD).The data were statistically analyzed by the method given by Panse and Sukhatme (1963).



Fig .1 Samples of water chestnut (Trapa natans var. bispinosaRoxb.)

**Result and Discussion:**

**Morphometeric and Physical attributes in *Trapa* genotypes**

The significant variations among morphometeric attributes namely spine (presence/absent), fruit length, fruit width, fruit volume and specific gravity in *Trapa*genotypes were observed during the study. In the collected genotypes, the red peelcolour fruits were found to have only rudimentary spine whereas the green peel fruit had both perfect spine and rudimentary spine. The results are anticipated by the findings of Verma and Panigrahi (2016). The peel colour and spine condition (perfect/rudimentary) are genetic traits.There was a marked variation recorded in fruit length, fruit weight and fruit volume, among the samples collected from different ponds. The fruit length, fruit weight and fruit volume ranged from 31.54mm to 51.62mm, 15.27g to 29.84g and 17ml ~~respectively~~, with the mean value of 41.78mm, 23.49g and 24.48 ml, respectively (Fig .1). Beside this, the fruit breadthranged 47.48 mm to 58.19 mm with the mean value 52.58mm. The fruit breadth was noted maximum in sample 6(S6)with 58.19 mm which had green colour peel and perfect spine. The specific gravity was recorded maximum in sample 11 (S11)with 1.26 with the mean of 0.96 whereas it ranged from 0.85 to 1.26. These variations in water chestnut due to genetic constitution and may also be affected by cultural practices growing condition and maturity time. Our results are also supported by the findings of Pal *et al.,* (2009) where ~~they~~ the fruit weight ranging from 17.52g to 37.95g and fruit length 3.61cm to 4.83 cm, Singh *et al*., (2010) where they found average fruit weight 22.56gm and Dwivedi*et al.*, (2010) recorded the fruit breadth ranged from3.38-6.38 cm, fruit volume ranged from 11.30 ml to 27.80 ml and specific gravity varied from 1.16 to 1.76.

Fig .1 Samples of water chestnut (Trapa natans var. bispinosaRoxb.

**Table no 1 Morphometeric and Physical attributes in *Trapa* genotypes**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Samples/Treatment** | **Peel colour** | **Spine** | **Length**  **(mm)** | **Breadth**  **(mm)** | **Weight**  **(g)** | **Volume**  **(ml)** | **Specific**  **Gravity** |
| **S1** | Green | Perfect | 42.36 | 52.517 | 22.257 | 21.667 | 1.027 |
| **S2** | Green | Perfect | 38.73 | 56.05 | 21.577 | 21.333 | 1.01 |
| **S3** | Green | Perfect | 34.66 | 52.04 | 19.007 | 17.583 | 1.063 |
| **S4** | Green | Perfect | 34.17 | 52.63 | 21.503 | 22.333 | 0.96 |
| **S5** | Green | Perfect | 35.05 | 56.74 | 20.810 | 20.917 | 0.993 |
| **S6** | Green | Perfect | 40.67 | 58.197 | 24.980 | 25.75 | 0.967 |
| **S7** | Green | Perfect | 37.15 | 53.823 | 21.293 | 21.5 | 0.99 |
| **S8** | Green | Perfect | 31.54 | 49.797 | 15.277 | 18.583 | 0.857 |
| **S9** | Green | Perfect | 35 | 47.483 | 16.773 | 19.583 | 0.853 |
| **S10** | Green | Perfect | 34.56 | 54.977 | 17.670 | 17 | 1.01 |
| **S11** | Red | Rudimentary | 47.24 | 48.48 | 26.100 | 20.5 | 1.267 |
| **S12** | Red | Rudimentary | 45.80 | 52.12 | 28.773 | 28.917 | 0.987 |
| **S13** | Red | Rudimentary | 43.59 | 48.757 | 22.413 | 24.167 | 0.99 |
| **S14** | Red | Rudimentary | 47.07 | 50.507 | 25.960 | 27.917 | 0.923 |
| **S15** | Red | Rudimentary | 43.92 | 54.683 | 27.867 | 30.5 | 0.91 |
| **S16** | Red | Rudimentary | 45 | 48.21 | 24.713 | 28.917 | 0.853 |
| **S17** | Green | Rudimentary | 49.42 | 52.42 | 27.867 | 29 | 0.91 |
| **S18** | Green | Rudimentary | 51.62 | 54.22 | 29.843 | 34.583 | 0.857 |
| **S19** | Green | Rudimentary | 47.30 | 53.657 | 27.363 | 29.333 | 0.96 |
| **S20** | Green | Rudimentary | 50.82 | 54.473 | 27.893 | 29.667 | 0.937 |
| **Mean** |  |  | **41.78** | **52.58** | **23.49** | **24.48** | **0.96** |
| **C.D.**at 5% |  |  | **0.817** | **1.387** | **0.838** | **1.07** | **0.073** |

**Biochemical attributes in *Trapa* genotypes:**

It is evident that table no. 2 shows significant variation in biochemical attributes except only pH among the samples collected from different ponds of District Etawah and Auraiya (UP).The pH value of *Trapa* fruit juice was ranged from 5.37 to 6.75 with mean value of 6.04. The highest pH value was recorded in sample 3 (**S3**) with 6.75. Our results are anticipated by [Faruk](https://ascidatabase.com/author.php?author=M.%20Omar&mid=&last=Faruk)*et al*., (2012) where they found ~~ph~~ pH content ranged from 5.11 in red peel fruits and 5.88 in green peel fruits. Ascorbic acid content among ~~samples~~ the genotypes was found significantly different which varied from 2.75 mg/100g inS10 to 6.76 mg/100g in S11 with the mean value of 4.21 mg/100g. The results are supported by Rehman*et al.*, (2024) where they found ascorbic acid content 2.1 mg/100g in green colour water chestnut and 1.97 mg/100g in red colour in water chestnut. A considerable variation was also observed in the total soluble solids among the sample collected from different ponds location of districts Etawah and Auraiya. The total soluble solids ranged from 2.03 ºB in S11 to 5.9**º**B in S9 with mean value of 3.89 ºB. Our results are validated with the finding of Ram *et al*. (2010) and Dwivedi *et al*., (2010)

**Table no. 2 Biochemical attributes in *Trapa* genotypes**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Samples** | **pH** | **Ascorbic acid(mg/100g)** | **TSS(̊B)** | **Total sugar %** | **Reducing sugar %** | **Protein %** |
| **S1** | 6.333 | 2.773 | 5.5 | 3.365 | 1.675 | 1.59 |
| **S2** | 6 | 3.26 | 4.233 | 3.02 | 1.185 | 1.55 |
| **S3** | **6.75** | 3.217 | 4.533 | 3.345 | 2.213 | 1.72 |
| **S4** | 6.417 | 2.84 | 4.833 | 4.035 | 2.55 | 1.105 |
| **S5** | 6 | 3.07 | 5.267 | 3.54 | 2.983 | 1.22 |
| **S6** | 5.833 | 5.357 | 4.267 | 3.695 | 1.725 | **1.83** |
| **S7** | 6.167 | 3.123 | 4.933 | 3.73 | 2.825 | 1.675 |
| **S8** | 5.833 | 4.843 | 5.533 | 2.805 | 1.63 | 1.5 |
| **S9** | 6.333 | 2.983 | 4.433 | 3.64 | 2.49 | 1.4 |
| **S10** | 6.333 | 2.753 | **5.9** | 4.03 | 3.013 | 1.58 |
| **S11** | 5.417 | **6.76** | 2.033 | 4.695 | 2.69 | 1.46 |
| **S12** | 5.333 | 6.24 | 2.933 | **5.215** | **3.67** | 1.375 |
| **S13** | 5.867 | 3.827 | 3.2 | 4.905 | 3.62 | 1.1 |
| **S14** | 6.333 | 4.38 | 3.533 | 4.49 | 2.55 | 1.64 |
| **S15** | 5.567 | 6.357 | 3.167 | 4.385 | 2.95 | 1.32 |
| **S16** | 5.667 | 4.42 | 2.867 | 4.8 | 3.145 | 1.78 |
| **S17** | 6.083 | 3.89 | 2.033 | 3.82 | 1.56 | 1.555 |
| **S18** | 6.75 | 4.3 | 2.833 | 3.485 | 2.615 | 1.72 |
| **S19** | 6.583 | 3.8 | 3.1 | 3.24 | 2.815 | 1.56 |
| **S20** | 5.317 | 6.173 | 2.767 | 3.39 | 1.735 | 1.78 |
| **Mean** | **6.0458** | **4.2183** | **3.8949** | **3.8815** | **2.482** | **1.523** |
| **C.D. 5%** | **0.874** | **0.64** | **0.508** | **0.29** | **0.32** | **0.18** |

A considerable variation was also found among the samples with respect to total sugar and reducing sugar content. The total sugar ranged from 2.805 to 5.215 percent with the mean value of 3.8815 percent whereas the sample 12 (S12) which had red peel colour and rudimentary spine was found to have highest (5.215%) total sugar content. The reducing sugar content was also found highest (3.67%) in sample 12 (S12) ~~however,~~ and the range of the reducing sugar among the sample was 1.1 to 3.6 percent. The results are also anticipated by the findings of Mukesh Babu and Dwivedi (2012). However, the quantity of total sugar and reducing sugar found slightly higher than the finding of Mukesh Babu and Dwivedi (2012). The protein content in *Trapa* was also found statistically significant during the study. Since, the highest protein content (1.8%) was recorded in sample 6 (S6) butit ranged from 1.1 to 1.8 percent with mean value of 1.523 percent. Our results are also validated by the findings of Rehman*et al*., (2024) where they recorded the protein content 1.7 percent in green peel and 1.17 percent in red peel genotypes of *Trapa*.

**Conclusion:**

Evaluation of *Trapa* genotypes revealed distinct trends linked to spine type and peel colour. The genotypes with rudimentary spine, especially green peel fruitswere consistently excelled in fruit size, weight, and volume, marking them as ideal for yield enhancement. Red peel types with rudimentary spines also showed large dimensions, confirming that spine rudimentation, regardless of peel colour, is associated with superior morphometric traits. Moreover, the perfect spine, green peel genotypes (S1–S10) generally had moderate size metrics, some (e.g., S6) showed notable breadth and volume. Specific gravity was higher in perfect spine types, with the highest in S11 (rudimentary red), indicating denser fruits.Biochemically, red peel with rudimentary spines (S11–S16) dominated in ascorbic acid (up to 6.76 mg/100g) and sugar content, making them valuable for nutritional and processing purposes. Green peel, perfect spine genotypes showed higher TSS, pH, and protein (up to 1.83% in S6), favoring fresh consumption. The green rudimentary group had a balanced profile, with genotypes like S20 showing both high ascorbic acid and protein, combining physical and nutritional benefits.

Overall, rudimentary spine genotypesparticularly green peel fruits are promising for **yield-focused breeding**, while rudimentary red peel fruitsuit **nutraceutical goals**, and green perfect spine types are apt **for market preferences in taste and protein.**

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