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RESPONSE OF WATER CHESTNUT (*Trapa natans* VAR. *Bispinosa* ROXB.) TO DIFFERENT NUTRITIONAL REGIMES IN HAIDERPUR WETLAND, WETLAND, UTTAR PRADESH, INDIA

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ABSTRACT

Water chestnut (*Trapa natans* var. *bispinosa* Roxb.) is an important aquatic crop with significant nutritional value, yet it remains underutilized and traditionally cultivated with indiscriminate fertilizer applications. This study aimed to evaluate the influence of six nutritional regimes on vegetative growth, physico-chemical parameters and biochemical composition of water chestnut in Haiderpur Wetland, Uttar Pradesh, during 2022–2023. The experiment was conducted in a Randomized Block Design with three replications. Results revealed that Jivamrut @ 10% significantly enhanced the number of leaves per plant (35.00), leaf length at 45 DAT (55.06 mm), fruit length (55.47 mm), kernel length (43.02 mm) and kernel thickness (21.62 mm). Treatment with RDF recorded maximum leaf width (68.49 mm at 30 DAT and 70.57 mm at 45 DAT), number of flowers per rosette (5.00 at 60 DAT), plant spread (75.65 cm E-W and 79.75 cm N-S at 45 DAT), fruit width (60.12 mm) and kernel width (40.17 mm). Biochemical analysis showed maximum moisture content with treatment of ½ RDF (19.11%), highest total soluble solids in ½ RDF and Nano-Urea @ 4.0% (3.90). The study elucidates that organic formulations like Jivamrut can significantly improve vegetative growth and fruit physico-chemical parameters, offering a sustainable alternative to excessive synthetic fertilizer application in wetland ecosystems.

***Key words*:** Water chestnut; Jivamrut; Nano-Urea; vegetative growth; biochemical parameters

Introduction

Chestnut (*Trapa natans* var. *bispinosa* Roxb.) belongs to Trapaceae family is a warm-season, aquatic, herbaceous angiospermic nut crop vernacularly known as Singhara, Paniphal or Jalphal (Adkar *et al.*, 2014). The genus *Trapa* comprises three distinct species *viz.*, *T. bispinosa*, *T. natans* and *T. quadrispinosa* are believed to be originated in Europe, Asia and Africa (Hummel and Kiviat, 2004; Hummel and Findlay, 2006). Water chestnut is widely cultivated in tropical, subtropical and temperate regions of world including India, China, Japan, Pakistan, Sri Lanka and Southeast Asian countries (Kumar *et al.*, 1985; Mazumdar, 1985). In India, it is extensively grown in Uttar Pradesh, Madhya Pradesh, Bihar, Tamil Nadu, West Bengal, Assam, Orissa and Jammu and Kashmir (Mazumdar, 1985).

Water chestnut thrives in marshes, ponds and shallow water bodies with pH 6.8–8.2 and calcium carbonate alkalinity of 12–128 mg/L (Anonymous, 2003; Bhatiwal *et al.*, 2012). The crop is becoming a viable alternative to fruit crops due to its enormous potential for cultivation in waterlogged areas though its still underutilized (Babu and Dwivedi, 2012). However, poor yield, lack of adequate growing methods and knowledge have relegated it to minor crop status (Arima *et al.*, 1999). Traditional cultivation practices in Haiderpur Wetland involve

indiscriminate applications of chemical fertilizers like urea and diammonium phosphate at three times more than the recommended doses, leading to various fruit disorders and rapid environmental degradation (Srivastava, 2022; Mishra, 2022).

Nano fertilizers are novel approach in nutrient management, rendering increased nutrient use efficiency, lowering dependence on chemical fertilizer thereby increasing crop production (Shukla *et al*., 2019; Kumar *et al*., 2022). Jivamrut, an eco-friendly organic liquid fertilizer derived from by-products of cow proven to promote crop growth, production and quality (Palekar, 2006; Natarajan, 2007; Sreenivasa *et al*., 2010). Given the ecological sensitivity of Haiderpur Wetland a Ramsar site, there is an urgent need to evaluate sustainable nutritional regimes that maintain crop productivity while minimizing environmental impact. This study was therefore undertaken to assess the influence of different nutritional regimes on the performance of water chestnut in Haiderpur Wetland.

Material and Methodology

The field experiment was conducted at Haiderpur Wetland (29°24' N, 78°00' E; altitude 225 m above mean sea level) on the Muzaffarnagar-Bijnor border between the Ganges and Solani Rivers, Uttar Pradesh, India. This region is part of the Hastinapur Wildlife Sanctuary. The climate is moist with mild winters, and the average annual temperature ranges between 49°F and 102°F. The soil is alluvial, rich in organic matter, with alkaline water (pH > 7.4) and electrical conductivity of 222–284 µS/cm

The experiment was conducted during the Kharif season 2022 in a Randomized Block Design (RBD) with six treatments *viz*., T_1 (Control), T_2 (½ RDF), T_3 (¼ RDF), T_4 (Nano-Urea @ 4.0%), T_5 (Jivamrut @ 10%) and T_6 (RDF) replicated thrice. Recommended dose of foliar spray of fertilizer, Nano urea and Jivamrut were as follows, T_1: No fertilizer application, T_2: Urea @ 31.5 kg/ acre and DAP @ 6 kg/acre, T_3: Urea @ 15.75 kg/acre and DAP @ 3 kg/acre, T_4: Nano-Urea @ 7.5 l/ha with 4 % concentration, T_5: Jivamrut @ 7.5 l/ha with 10 % concentration and T_6: Urea @ 63 kg/acre and DAP @ 12 kg/acre. Fertilizers were applied as foliar spray of urea and DAP at an interval 20 days, 40 days, 60 days and 80 days after transplanting respectively. While the dose of foliar spray of Nano-urea @ 7.5 liter/ha and Jivamrut @ 7.5 liter/ha. Conventional dose of fertilizers followed by farmers included application of Urea @ 63 kg/acre and DAP @ 12 kg/acre. The local variety of water chestnut was transplanted on 16 July 2022 at a spacing of 1.5 m × 1.0 m (row-row × plant-plant) and harvested on 27 October 2022. The net plot size was 8 m × 10 m, with a total experimental area of 384 m².

Vegetative parameters like number of leaves per plant (30 DAT), leaf length and width at 3rd node (30 and 45 DAT), number of flowers per rosette (40 and 60 DAT) and plant spread in East-West and North-South directions (30 and 45 DAT) were recorded. Similarly, Physico-chemical parameters like fruit length, fruit width, kernel length, kernel width, kernel thickness and peel thickness were measured using a Vernier calliper at harvest maturity. Biochemical parameters recorded were moisture content (%), total soluble solids (^{0}Brix), and titratable acidity (%) were estimated following standard procedures (Gorakhpurwalla *et al*., 1975; Rangana, 2008; A.O.A.C., 1970).

Data was statistically analyzed using analysis of variance (ANOVA) for RBD as suggested by Fisher (1950). Significance of treatment differences was tested through F-test at 5% level and critical differences (CD) were calculated where results were significant.

Results and Discussion

Vegetative growth parameters

Number of leaves per plant:

The data pertaining to number of leaves per plant at 30 DAT was recorded, statistically analyzed and presented in Table 1. shows that, the differences in number of leaves per plant of water chestnut as influenced by different nutritional regimes were found to be statistically non-significant.

Length of leaves (mm):

Leaf length at 30 DAT ranged from 46.28 mm (T_1) to 53.08 mm (T_6), while at 45 DAT, it ranged from 47.74 mm (T_1) to 55.06 mm (T_5) as presented in Table 1. The maximum leaf length at 45 DAT in T_5 (55.06 mm) was at par with T_6 (53.62 mm). The increase in leaf length with Jivamrut and RDF application reflects enhanced nitrogen availability, which is essential for cell division and elongation. These results corroborate the findings of Singh *et al*., (2023), who reported increased plant height and yield traits with foliar urea application in chickpea and Gond (2020) in water chestnut. Perween and Hasan (2019) also observed maximum cladode length in dragon fruit with NPK application.

Width of leaves (mm):

Leaf width at 30 DAT varied from 53.58 mm (T_1) to 68.49 mm (T_6) and at 45 DAT from 56.44 mm (T_1) to 70.57 mm (T_6) as shown in Table 1. T_6 (RDF) recorded significantly maximum leaf width at both stages, followed by T_5 (70.02 mm at 45 DAT). The superior performance

Table 1: Vegetative growth parameters of water chestnut under different nutritional regimes.

Treatment	Number of leaves/plants	Length of leaves (mm) at 3rd node		Width of leaves (mm) at 3rd node		Number of flowers/rosettes	
	30 DAT	30 DAT	45 DAT	30 DAT	45 DAT	40 DAT	60 DAT
T_1	30.67	46.28	47.74	53.58	56.44	1.00	2.00
T_2	34.33	52.97	53.11	64.86	67.81	2.00	4.00
T_3	32.67	45.54	48.24	61.37	64.60	1.67	2.33
T_4	34.33	47.90	49.36	62.07	59.26	2.33	4.33
T_5	35.00	47.28	55.06	60.47	70.02	2.00	4.67
T_6	33.67	53.08	53.62	68.49	70.57	2.67	5.00
SE (m) ±	1.93	1.46	1.25	0.94	1.46	0.55	0.98
C.D.(p=0.05)	N/A	4.67	4.00	2.99	4.67	N/A	N/A

of RDF might be due to the readily available macronutrients (N, P, K) that promote vigorous vegetative growth. Similar results were obtained by Bakshi *et al*., (2018) in Kinnow mandarin and Kumar *et al.,* (2022) in cereal and oilseed crops with nano fertilizer application. The comparable performance of T_5 suggests that Jivamrut can effectively substitute partially for chemical fertilizers.

Number of flowers per rosette:

The number of flowers per rosette at 40 DAT was statistically analyzed, with the findings presented in Table 1. No significant variation in number of flowers per rosette at 40 DAT of water chestnut was observed among the different nutritional regimes tested.

Plant spread (cm):

Data pertaining to plant spread in the East–West and North–South directions, recorded at 30 DAT and 45 DAT, were subjected to statistical analysis and are summarized in Table 2. The results revealed that different nutritional regimes had a significant influence on plant spread in the East–West direction at 30 DAT. Among the treatments, the maximum plant spread in the East–West direction (65.68 cm) was recorded under treatment T_6, which was statistically at par with T_2 (64.55 cm) and T_3 (62.43 cm). In contrast, the minimum plant spread in the East–West direction (53.94 cm) was observed under treatment T_1. The remaining treatments, T_5 (58.83 cm) and T_4 (57.52 cm), recorded intermediate values and were statistically comparable to one another. In contrast, the differences among the treatments were found to be statistically non-significant, indicating that the nutritional regimes did not exert a significant influence on plant spread in the North–South direction at 30 DAT, and in both directions at 45 DAT remained unaffected.

Physico-chemical parameters

Fruit length (mm):

Fruit length ranged from 47.18 mm (T_1) to 55.47 mm (T_5) (Table 3). T_5 recorded maximum fruit length (55.47 mm), followed by T_4 (51.88 mm), while minimum was in T_1 (47.18 mm). The enhanced fruit length under Jivamrut application may be due to improved nutrient translocation and assimilation, particularly nitrogen and micronutrients, which are essential for fruit development. These results are in agreement with Babubhai (2022) in moth bean, Daulta *et al*., (1983) in Beauty Seedless grape and Yadav (2019) in Kinnow mandarin. Bakshi *et al*., (2018) also reported maximum fruit length in papaya with integrated nutrient management.

Fruit width (mm):

The data on fruit width were statistically analyzed and are presented in Table 3. The results revealed that the variations in fruit width of water chestnut due to different nutritional regimes were statistically non-significant.

Kernel length and width (mm):

Kernel length ranged from 32.25 mm (T_1) to 43.02 mm (T_5), and kernel width from 35.25 mm (T_1) to 40.17 mm (T_6) as mentioned Table 3. T_5 recorded maximum kernel length (43.02 mm), followed by T_6 (42.87 mm), while T_6 recorded maximum kernel width (40.17 mm), followed by T_5 (38.99 mm). The enhanced kernel dimensions under T_5 and T_6 reflect improved assimilate translocation to the developing kernels (sink). These

Table 2: Plant spread (cm) of water chestnut under different nutritional regimes.

Treatment	30 DAT		45 DAT	
	East-West	North-South	East-West	North-South
T_1	53.94	65.64	65.53	68.00
T_2	64.55	70.07	67.10	74.90
T_3	62.43	69.79	66.67	71.80
T_4	57.52	72.13	67.75	75.50
T_5	58.83	73.69	72.43	78.32
T_6	65.68	70.63	75.65	79.75
SE (m) ±	1.83	4.51	2.43	4.97
C.D.(p=0.05)	5.85	N/A	N/A	N/A

Table 3: Physico-chemical parameters of water chestnut kernels under different nutritional regimes.

Treatment	FL	FW	KL	KW	KT	PT
T_1	47.18	53.32	35.88	35.25	18.30	4.39
T_2	48.64	57.10	41.54	37.80	20.12	2.59
T_3	48.03	54.31	40.41	35.93	17.38	3.36
T_4	51.88	56.19	36.85	36.89	20.26	3.21
T_5	55.47	58.16	43.02	38.99	21.62	5.68
T_6	48.10	60.12	42.87	40.17	19.05	2.82
SE (m) ±	1.33	2.74	0.86	1.08	0.55	0.36
C.D.(p=0.05)	4.24	N/A	2.75	4.82	1.76	1.12

FL: Fruit length; FW: Fruit width; KL: Kernel length; KW: Kernel width; KT: Kernel thickness; PT: Peel thickness

findings are consistent with Alexander *et al.*, (2006) in yellow passion fruit, Kundu and Ghosh (1992) in mango and Sharma (2003) in almond.

Kernel and peel thickness (mm):

Kernel thickness ranged from 17.38 mm (T_3) to 21.62 mm (T_5) and peel thickness from 2.59 mm (T_2) to 5.68 mm (T_5) as illustrated in Table 3. T_5 recorded maximum kernel thickness (21.62 mm) and peel thickness (5.68 mm), followed by T_4 (20.26 mm kernel thickness). The increased kernel thickness under Jivamrut application indicates improved kernel filling, possibly due to enhanced nutrient availability and uptake. Similar results were obtained by Yadav (2019) in Kinnow mandarin. The maximum peel thickness in T_5 may be attributed to increased structural carbohydrate deposition.

Biochemical parameters

Moisture content (%):

Moisture content ranged from 16.53% (T_5) to 19.11% (T_3) (Table 4). T_3 recorded maximum moisture content (19.11%), followed by T_2 (18.04%), while minimum was in T_5 (16.53%). The higher moisture content under reduced fertilizer doses (T_3 and T_2) may be ascribed to lower solute accumulation and higher water retention in kernels. These results are consistent with Rab *et al.*, (2012) in apple and Namdev (2021) in sweet pepper. The lower moisture content in T_5 suggests higher dry matter accumulation, which is desirable for storage and processing.

Total Soluble Solids (TSS) (^{o}Brix):

TSS ranged from 3.40% (T_5) to 3.90 ^{0}B (T_2 and T_4) as mentioned in Table 4. Maximum TSS was recorded in T_2 and T_4 (3.90 ^{o}B each), followed by T_6 (3.80 ^{o}B), while minimum was in T_5 (3.40 ^{o}B). The higher TSS under T_2 and T_4 may be due to better sugar accumulation and translocation. Similar findings were reported by Namdev (2021) in sweet pepper, Navel *et al.*, (2012) in tomato

Table 4: Biochemical parameters of water chestnut kernels under different nutritional regimes.

Treatment	Moisture (%)	TSS (%)	Titratable acidity (%)
T_1	16.56	3.50	0.08
T_2	18.04	3.90	0.10
T_3	19.11	3.70	0.09
T_4	16.82	3.90	0.13
T_5	16.53	3.40	0.07
T_6	17.13	3.80	0.09
SE (m) ±	0.23	0.02	0.01
C.D.(p=0.05)	0.73	0.08	N/A

and Yadav (2019) in Kinnow mandarin. The relatively lower TSS in T_5 suggests that Jivamrut application may favour vegetative growth over sugar accumulation in kernels.

Titratable acidity (%):

Data regarding titratable acidity of water chestnut were subjected to statistical analysis and are depicted in Table 4. The findings demonstrated that the nutritional regimes tested failed to bring about any significant variation in the titratable acidity of water chestnut.

Conclusion

The present study demonstrates that different nutritional regimes significantly influence the vegetative growth, physico-chemical parameters and biochemical composition of water chestnut in Haiderpur Wetland. Among the treatments evaluated, T_5 (Jivamrut @ 10%) emerged as the most promising organic alternative, recording maximum number of leaves per plant (35.00), leaf length at 45 DAT (55.06 mm), fruit length (55.47 mm), kernel length (43.02 mm) and kernel thickness (21.62 mm). T_6 (RDF) recorded maximum leaf width (70.57 mm at 45 DAT), number of flowers per rosette (5.00 at 60 DAT), plant spread (79.75 cm N-S at 45 DAT), fruit width (60.12 mm) and kernel width (40.17 mm). Biochemical analysis revealed that T_3 (¼ RDF) recorded maximum moisture content (19.11%), T_2 and T_4 recorded maximum TSS (3.90%), and T_4 recorded maximum total acidity (0.13%).

The study concludes that Jivamrut @ 10% can effectively substitute partially for chemical fertilizers, promoting sustainable cultivation of water chestnut in ecologically sensitive wetland ecosystems like Haiderpur. This approach not only maintains crop productivity but also reduces environmental pollution and enhances soil health. The findings have significant implications for farmers in the region, offering a cost-effective and eco-friendly alternative to indiscriminate usage of chemical fertilizer. Future research should focus on long-term

effects of organic formulations on soil health, water quality, improved cultivars and crop sustainability in wetland ecosystems.

Conflict of Interest: Authors declare no conflict of interest.

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