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Strategies to Enhance the Production of Water Chestnut (*Trapa natans* L.) in India

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Abstract

Water chestnut (*Trapa* spp. L) is a very attractive cash crop grown in India during the rainy and autumn season. After transplantation fruiting and harvesting is done within 4-5 months. Adaptation of new high yielding varieties and current management practices could earn almost double income as that of earlier practices. Soil must be well pulverized with a rotavator followed by application of castor and karanj cake [1.0-1.5 t (50:50) ha⁻¹]. Plant spacing is generally 3.0 m × 3.0 m and approximately 1,100 plant population ha⁻¹ during August resulted in more production (10-12.0 t ha⁻¹) in north Bihar condition. The application of inorganic fertilizer N:P:K @ 60:40:40 kg ha⁻¹ is recommended for the maximum benefit. Introduction of Improved Green Spineless and Improved Red Spineless variety and maintenance of water level (0.5 m) up to December were found to be promising for enhanced yield.

Introduction

Water-chestnut is an aquatic annual floated but rooted plant, native to Europe and Asia that has become pride of rural farmers of wetland and semi-wetland ecosystems of India. It belongs to the family *Trapaceae*. Leaf arrangement is alternate (there is one leaf per node) along the stem or opposite there are two leaves per node along them. There are four petals or sepals or petals in the flower. The leaf is not divided, rather the blade is made up of one segment and the leaf blade is triangular with the stalk. The fruit is one seeded dry nut but not nut split open when ripe. The major water chestnut producing states of India are Bihar, M.P., West Bengal, Odisha, U.P. and Chhattisgarh. The major problems are area under cultivation is decreasing, water becoming polluted and interests of the farmer are shifting to fishery and other poly-culture. If we grow water chestnuts in fresh water the plant will be more productive. The objective of this study is to create awareness among people about nutritional importance and find out ways for more production of this crop. Water chestnuts are rich in mineral nutrients, which contribute to various benefits to the human body and mind. Recent research report suggested that water chestnuts are packed with a very high amount of K and Mg. About 100.00 g serving of chestnuts fresh fruits has the following proximate compositions:

- Calories - 45.00 g
- Protein - 3.40 g
- Carbs - 24.00 g
- Fat - 0.20 g

Furthermore, they are packed with fiber, iron, antioxidants, manganese, copper, riboflavin, vitamin B6, and other essential nutrients. So it is a very attractive and delicious food during

autumn and winter in the Indian sub-continent. Fresh nuts are well known for their high water content of about 80.0% (Puste, 2004), starch (52.0%), protein (1.87%) and TSS (7-8%) (Singh *et al.*, 2010). Apart from these quality attributes, it is a good source of fiber, Vitamin B along with Ca, K, Fe and Zn.

Problems in Obtaining High Yield

In the pond the production was very low (4.0 t ha^{-1}). Owing to the maximum production, field cultivation was started at RCM, Darbhanga and production became almost double. After decomposition of water chestnut plants incorporate huge amounts of organic matter to the soil on account of having large plant size and fibrous root system and heavy secondary roots from stem. Fungal diseases like bacterial blight, pests like aphids cause detrimental effects to the growth of plants. Lack of improved genetic materials and maintaining optimum plant populations are also the important problems for obtaining low yield.

Strategies for Higher Yield of Water Chestnut Fruits

There are different technologies for increasing production of water chestnut for improving livelihood security of poor farmers of North Bihar. The water chestnut cultivation is mainly confined among the fisherman community of North Bihar. They provide hard labour to grow water chestnuts and harvest from wetland ecosystems *i.e.*, lakes, pond ditches and low lands. The mainly female members of their family are engaged in the water chestnut production system. There are some improved technologies which were proved to be efficient for more production of water chestnut fresh seeds during harvest season.

1. Transplantation

If a water chestnut plant grows in situ condition the yield of the crop will be very low up to 3.0 t ha^{-1} . Water chestnut is a continuously growing plant during its life span it produces about 20 plantlets or more. And when we go for transplanting in the main field during July then farmers could obtain more yields ($4\text{-}5.0 \text{ t ha}^{-1}$) without giving much more input. During transplantation the primary root system is restructured and influences new growth and better establishment of crops resulting in more production from the unit area of land. In addition, water of the new plots remains fresh for influencing growth and development of water chestnut plants and during harvesting plant population usually remains 45,000-50,000 ha^{-1} .

2. Field Cultivation

Field based cultivation provides a uniform platform for taking growth of water chestnut plants as compared to the pond system. The management of plant growth regarding different intercultural operations becomes easy.

About 10-20% more fruits are additionally harvested if the field system of cultivation is adopted. Water chestnut cultivation with the spacing of $3.0 \text{ m} \times 3.0 \text{ m}$ during the first week of August was found to be beneficial for obtaining higher yield during December.

3. Organic Cultivation

To revive the glory of water chestnut food industry particularly in North Bihar and generally in India, shallow and organic cultivation of water chestnut in field level is highly desirable. It has been found that initial soil nutrient status in inceptisols of North Bihar, Darbhanga was like organic carbon content of the initial soils is 0.78%. All the organic parts of the plant decomposed in water after and we harvested water chestnut fruits only ($4.0\text{-}5.0 \text{ t ha}^{-1}$). Soil organic matter (SOC) acts as an important stock for nutrients, propels nutrient cycles, promotes water retention and reduces soil erosion and overall improves productivity. Use of oil cakes like neem cake or karanj cake or castor cake $3.0 \text{ kg katta}^{-1}$ improves soil and water quality of the water chestnut field. The organic cultivation of water chestnut resulted in the maximum plant growth and its complete decomposition leads to organic carbon build up in soil. Use of 4-5 ton FYM ha^{-1} was beneficial for crop growth and fruit production.

4. Water Chestnut Cultivation with Monsoon Water

Water chestnut production using monsoon water in low land, which could enhance additional production in semi-wetlands from freshwater ecosystems and encourage farmers for extending their cultivation time and more income.

Following steps are strictly followed for getting maximum yield and profits from water chestnut cultivation in wasteland or low marshy land where rainwater is accumulated for 4-5 months only. Shallow plots and lands can be converted into shallow depth ponds (0.5-1.0 m) by digging and developing bundh.

- Use 2.0-3.0 three ploughing in the same day with a rotavator.
- Use of more quantity of agricultural lime (0.4 t ha^{-1}) for making the soil calcareous and friable for better root establishment.
- Use of DAP (0.3 t ha^{-1}) as a source of nitrogen and other nutrients.
- Use of FYM ($4.0\text{-}5.0 \text{ t ha}^{-1}$) for source of organic carbon, which facilitates easy availability of nutrients to crop.
- Use of MOP 0.25 t ha^{-1} .
- Use of growth enhancer (multiplex before flowering) for better fruit set.

As the active growing period of the water chestnut is 4-5 months after transplanting, the mature seedlings are better for quick yield within 4.0 months.

5. Manipulation of Water Column

It has been found that more the depth of water accounted for more vigorous growth of plants (leaf area and leaf stalk length). Water chestnut growing in a field system, where growths of plants were significantly reduced which were the positive traits for horticultural practices due to reduction in water column. It has been observed that if we extend the availability of water up to December the additional yield of 10-15% we can obtain (Jana *et al.*, 2019). Weed management was excellent when the field was well pulverized with a rotavator followed by application of castor and karanj cake [1.5-1.6 (50:50) ha⁻¹].

6. Integrated Management of Weeds

After transplanting water chestnut, 2.0 months is the favorable period for weed growth. 2-3 times hand weeding is sufficient to control the weeds. The common weeds at Darbhanga were *Cyperus deformans*, *Oxalis corniculata*, *Nymphaea* spp., *Hydrilla* and *Aeschynomene aspera*. If we use pendimethalin or butachlor before plantation it could effectively reduce weed flora in aquatic environments. Even use of organic oil cakes like neem + castor (50:50) @ 1.5-1.6 t ha⁻¹ and Agriculture lime (0.4 t ha⁻¹) significantly reduces the weed flora and increases the total yield.

7. Integrated Nutrient Management

As it is an aquatic crop it does not require specific soil for its cultivation. However, for commercial cultivation soil should be heavy, muddy and rich in organic matter. Organic manures in the form of oil cakes, poultry manure, compost/FYM are the best for growth and development of water chestnut crops. A significant amount of phosphorus and potassium are needed for optimum growth of the crop. The application of FYM @ 4.5 t ha⁻¹ improves the yield at significant level. The soil rich in Zinc and Boron resulted in increased the number of fruits and their individual weight. The application of inorganic fertilizer N:P:K @ 60:40:30 kg ha⁻¹ is recommended for the maximum benefit. In the new field, however, we can increase K₂O up to 40 kg ha⁻¹ was found to be suitable (Jana, 2020).

8. Integrated Pest Management

Water chestnut aphid, leaf rolling caterpillar and leaf scaring beetles are the main pest of aerial parts of the plant. The aphid and beetles can be effectively controlled by 1-2 times application of monocrotophos or imidacloprid 0.1% or whereas caterpillars by application of Thiodon 50 EC @ 1 ml l⁻¹ at weekly intervals. The occurrences of these pests are not serious. However, timely application of these pesticides improves production of water chestnut at field level by maintaining insect free growth and development.

9. Integrated Disease Management

Bacterial leaf blight is one of the major diseases of water chestnut which causes havoc loss. The causal organism of is *Xanthomonas* spp. which causes leaf spot first after that spots are merged and photosynthetic areas are reduced. In severe cases, leaves become brown and reddish, which causes photosynthetic reduction and subsequently to the yield. Application of copper-oxchloride (0.2%) and Streptomycin (75.0 ppm) at initial stage control this bacterial blight disease. The second most important disease of the water chestnut crop is stem rot/ fruit rot. Both the diseases can effectively be controlled by application of Carbendazim 0.1% at weekly intervals and the fungal population may decimate within 15 days.

10. Use of Improved Genotypes

To obtain better yield of water chestnut local genotypes must be replaced with superior genotypes like Improved Red Spineless (IRS) and Improved Green Spineless (IGS). Yield potential of two spineless cultivars are about 10.0-12.0 t ha⁻¹ (Figure 1-4). For getting better performance spacing should be 3.0 m × 3.0 m and applications of organic oilcakes are necessary to maintain soil organic carbon content.

11. Use of Plant Growth Regulators

After plantation for branch growth and flowering GA₃ @ 200-250 ppm can be used. For high yield and quality yield, applications of growth regulators during 3.0 months crop after transplantation are ideal. For obtaining a quick and desired growth, the applications of biozyme, multiplex, plano-fix were found to be ideal for fruit growth and development.

Water Chestnut: An Attractive Choice of People Today

The demand for water chestnut fruit is always there in India. It is low cost and high nutritive fruits and available in the Indian market for 4-5 months during autumn and winter. It is consumed in large quantities in Bihar, as well as in big cities like Delhi, Kolkata, Hyderabad, Mumbai, Chennai and there is a great demand for this fruit in the whole country as well as abroad. The big traders themselves approached the water chestnut fruit collection and dried them to make water chestnut atta and export them to international markets of USA, Australia and New Zealand. The biggest market of Mithilanchal's water chestnut is Patna. There is always demand from here. From Patna, these water chestnuts are packed and sent abroad also via Mundra sea port. It has been observed that there is a high demand for water chestnut flour even during festivals of Navratri.

Earned Millions from Water Chestnut

The great thing is that after extracting the water chestnut seeds, these were canned and exported. Apart from that water chestnut atta is its high value post harvest product. There is also a huge demand for these two products in national and international markets. How much will be earned from water chestnuts depends on the size of products and the time of harvest. The plants of water chestnut are also used as cattle feed. Farmers make good money by selling it in the markets. In view of the demand for raw fruit, farmers do not have to wander somewhere, but it is easily sold in the market.

a) New Process of Water Chestnut Storage

Water chestnut is a solid crop that needs a clean approach during drying, packaging and making fine flour. Storage in water for 3-4 days for local markets or in refrigerated containers for 5.0-4.0 °C for distant markets is now possible without deteriorating fruit quality after harvest.

b) Fairness in Water Chestnut Marketing

Distant marketing of water chestnut is needed particularly in district towns and capital cities to earn more profit. Cleaning and washing of harvesting fruits and poly packing them, weighing to 2.0 kg and sale in shopping malls may increase profit. Traditional farm gate sale of bulk quantity of the product must be avoided during harvesting season.



Figure 1: Improved Green Spineless (IGS) (Field)



Figure 2: Fruit yield of IGS (12.0 t ha⁻¹)



Figure 3: Improved Red Spineless (IRS) (Field)



Figure 4: Fruit yield of IRS (10.0 t ha⁻¹)

Conclusion

By adopting different agronomical practices like transplantation process, field based organic cultivation, integrated weed, insect and pest management, the agronomic production of fresh fruits can be increased. In addition, with the increasing national and international market demand, fruit size must be increased. Here demand acts as a positive force for more fruit production. New processes for fruit production and post harvest handling could get attractive returns from water chestnut marketing from domestic as well as international markets.

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