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Role of hydroponics in paddy nursery for water conservation to promote food security and environmental sustainability

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Abstract
Water and food are basic necessities of life with water being the vital key for food production. Paddy is a water-guzzling crop cultivated in more than 100 countries worldwide and consumed by over half of the global population. Paddy cultivation is mostly through traditional irrigation methods which leads to low water use efficiency coupled with many environmental problems. Paddy consumes 34 to 43% of the global irrigation water and with the rising global population, the increase in demand for rice production along with the shortage of water supply has led to a severe water crisis in rice-cultivating countries. By employing various water-wise approaches like drip irrigation, alternate wetting and drying methods, hydroponics technology water usage can be reduced in paddy cultivation. Usage of Hydroponics technology where crops are cultivated in a soil-less nutrient medium is promising and the Pro Green Hydroponic machine developed by ARF has successfully demonstrated the saving of water while raising paddy nurseries. This technology saves on water, land, time and labor to raise paddy seedlings. The article discusses the benefits of adopting hydroponics technology to raise paddy nurseries.

Keywords: Groundwater exploitation**,** water use efficiency**,** pro green hydroponic machine, hydroponics, paddy nursery

1. Introduction
Rice (*Oryza sativa* L.) is an important crop that is consumed by half of the global population daily. It fulfills 50% of calorie needs, source of primary nutrients and income for large populations in Asian and African countries and is, thus, critical for food security [1]. Traditionally it was consumed in Asian countries but it's no longer limited to this geographical region only. Presently this staple crop is cultivated in many parts of Latin America and Africa also. The crop is cultivated in more than 150 million hectares across the world. For the foreseeable future, rice is likely to remain a key player in Asian and African diets due to growing consumer preferences and population increase [2, 3]. Research work on paddy can be helpful in poverty eradication either indirectly through by developing high-yielding varieties with lower consumer prices or directly through producing high productivity that co-benefit farmer's profit. Nutritionally, rice is a good source of Vitamin E, thiamine, pantothenic acid, folate, Vitamin H or B7. Golden rice is a new variety of rice that is produced through genetic engineering and contains beta-carotene, a precursor of vitamin A. It is envisioned to produce a fortified food to be cultivated and consumed by the population in areas with a deficiency of dietary vitamin A [4]. Hence, rice is an important crop in food matrices and however, its cultivation requires a huge amount of water. Rice consumes 34 to 43% of the global irrigation water and to produce 1 kg of rice 800 to 5000 liters with an average of 2500 liters of water is required [5]. The rising global population and increase in demand for rice production coupled with the scarcity of global water supply has led to severe water-related challenges in agriculture in rice-cultivating countries. India's Green Revolution contributed greatly to enhancing food production mainly in cereals through the development of groundwater-based irrigation. The groundwater accessibility in India has been decreasing, and projections suggest that the need for water will surpass the supply by 50% by 2030 [6]. This critical condition of water may threaten food security worldwide.

Employing efficient irrigation methods, switching crop patterns, managing aquifer recharge, engaging smart technologies and water-wise approaches to conserve water will aid in increasing food production and unlock a prosperous tomorrow [7]. The article examines one of the promising water-wise solutions which is based on hydroponics technology developed by ARF to raise paddy nurseries which can help farmers save significant amount of water, time, land and other resources and contribute to a better tomorrow.

2. Challenges in paddy/rice cultivation

Rice, is a submerged crop and in today's scenario due to urbanization, industrialization, and soil degradation soil-based agriculture is facing a plethora of problems. The currently practiced flooded transplanted system for paddy rice cultivation is not only labor and water-intensive but also releases a large number of pollutants and greenhouse gases [4]. The performance and production of a rice crop are strongly affected by its early-stage growth [8]. In Asia, more than 80% of the freshwater resources are utilized for agriculture, out of which around half of the total irrigation water is consumed in rice production [9]. Irregular distribution of water sources, unpredictable weather and inefficient irrigation have worsened rice cultivation in India. Farming of rice in Northern India has led to depletion in groundwater which has become a solemn challenge for food and water security [7]. In India, major rice production is grown by small and marginal farmers. Rice production involves the requirement of high labor and other associated costs. Manual transplantation of rice seedlings is an intensive labor intensity work and around 250-350 man per day in one hectare is required [4]. Puddling in paddy cultivation is done usually to generate a suitable soil environment for seed development and easy transplantation of rice seedlings by enhancing soil water evaporation and breaking down soil aggregates into smaller particles. The availability of adequate number of labors, sufficient water, ever-growing energy costs for pumping water and using tractors for puddling and other operations for efficient transplantation of rice seedlings stress farmers in the cultivation of paddy in India [10]. Industrialization and urbanization of agricultural land due to escalating population growth have reduced the percentage of arable land for agriculture. Moreover, rice farmers are exposed to chemical, physical, and occupational ergonomic risks in manual transplantation of rice seedlings [11, 12]. Flooded paddy fields are identified as one of the chief suppliers of atmospheric methane and nitrous, greenhouse gases that contribute towards global warming [4, 13]. New agriculture technologies and methods can provide solution to mitigate the above stated problems. Various water-saving approaches for paddy cultivation like drip irrigation methods, System of Rice Intensification (SRI), Alternate Wetting and Drying method (AWD), usage of Hydroponics technology have been employed. Hydroponics technique is one such helpful technology that saves on water, land and enables improved crop production in a limited space. Hydroponics is the system of growing plants in a soilless environment where the artificial rich nutrient medium is used to grow plants in a controlled environment [14, 15]. The Greek word hydroponics means 'hydro' which is water and 'ponics' from the word 'ponein' meaning labor or toil [16, 17]. Using this technology nutrition is directly provided to plant or seed through water and hence it is a soil-less. Role of healthy rice nurseries plays a crucial role in performance and yield of rice crop. Yield of rice crop may decrease up to 10% if unhealthy seedlings are used [18]. Since healthy nursery is the basis of healthy crop, ARF had been raising the paddy nursery through hydroponics (Soilless) agriculture and no synthetic pesticides/insecticides/fertilizers are used. Rice exporters are facing the problem of pesticide residue in the recent past, so starting with healthy, chemical-free nursery through hydroponics technology developed by ARF is a promising solution [8, 12, 18, 19].

3. A novel method to cultivate rice: Raising of Nursery through Hydroponics

Novel technologies adopted to counteract problems need to be favorable for the environment, have less negative impact on natural resources, reduce cultivation costs and improve farmer's income. Technologies like Pro Green Hydroponics Machine & Technology developed by Agriliv Research Foundation (Formerly known as Ayurvet Research foundation) could be a potential solution (Figure 1). This machine has full-view glass windows to allow the entry of natural light and monitoring of the activities of inner chamber. Since natural light is used in place of artificial light hence "Pro Green" name is given to this technology. With the help of this technology, plantlets grow without soil and saves 95% of the land and water. In the Pro Green Hydroponics Machine & Technology crops are grown in multilayer shelves wherein controlled light is let in through befittingly glazed windows. Specially designed nutrient solutions are supplied to plantlets to fulfill their nutritional requirements. Bare minimum labor inputs and without usage of toxic pesticides/insecticides are the key advantages of using this technology for raising rice nursery seedlings. The seven-day-old hydroponic nursery rice seedlings are successfully transplanted using a mechanical transplanter in the field and approximately 5% water of conventional nursery is utilized (Figure 2).

Fig 1: Pro Green Hydroponics Machine developed by ARF

Fig 2: Paddy nursery grown hydroponically in Pro Green Hydroponics Machine, (A) seven days paddy nursery in hydroponics system, (B, c) hydroponically grown paddy nursery ready for transplantation to field

Fig 3: Hydroponically grown rice seedlings transplanted on field with mechanical transplanter

It is well documented that performance of hydroponically raised rice plants is as much effective as plants raised through conventional method of nursery development [18]. On the contrary since nutrient solution are available directly to root zone of the hydroponically grown rice plantlets, plants flourished and were ready for transplantation to field within 7-8 days of sowing instead of 28 days as in conventional method of paddy cultivation. Till date field trials with nearly 2500 paddy farmers in numerous villages in Western Uttar Pradesh, Sonipat & Panipat in Haryana were carried out along with regular trainings and demonstration sessions of the technology. Using Pro Green Hydroponics Machine & Technology paddy nursery technique a total of 100 hectares have been transplanted with rice seedlings. Research team at ARF is continuously working on hydroponics technology and enabling farmers with hydroponically raised crop nursery of rice, barley, oat, wheat and sugarcane for conservation of water time, labor and other resources. It is well demonstrated that Pro green hydroponics (Soil-less) technology for developing hydroponics crop nurseries uses 95% less water (conserves around 15 lakh liters of water in a year), uses 90% less land, offers higher germination rate, matures in 7-8 days thus saving 18-25 days as compared to conventional nursery. It is reported that the yield was higher by 10-15% as healthy rice seedlings were raised through hydroponic machine. It is also reported that the Pro Green Hydroponic technology apart from saving time, it is also suitable for late sown condition and is independent of the natural monsoon to raise paddy nurseries. The use of mechanical transplanter while transplanting of rice seedlings protects farmers of their occupational ergonomic backaches [8, 12, 18]. The ARF hydroponics machine is also tested for growing wheat, sugarcane, barley nurseries as well that yielded positive results [20, 21].

4. Conclusion

Depletion of ground water is significantly affected by global climate change and increased agricultural activity to meet the increasing food demand of the rapidly growing population. To support millions of smallholder farmers in India, subsidized/free electricity for pumping groundwater for irrigation are offered which subsequently led to extensive groundwater depletion. Critical depletion of ground water is a matter of great concern and efforts are to be made towards sustainable agriculture food production. Hydroponics is one such initiative towards this endeavor to save precious water. Pro Green Hydroponic machine developed by Agriliv Research Foundation (formerly Ayurvet Research Foundation), is a positive water wise strategy to safeguard this valuable natural resource. The use of this technology will help farmers to boost their productivity and also contribute positively towards long term sustainability.

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