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Performance of drip fertigation in paddy (*Oryza sativa*, L.): A review

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Abstract
Water becomes a scarce resource due to increased demand for industrial, agricultural and domestic purposes, besides increased cost on fertilizer necessitated for development and adoption of alternative agro techniques which help in effective and efficient utilization of these inputs. In this context alternate wetting and drying (AWD) irrigation practice which is emphasized these days as it helps to bring down water requirement and the input cost, besides, increasing the production. Further, the use of micro irrigation techniques and fertigation is the only way to manage water and nutrient resources efficiently. Drip irrigation, is an irrigation method that applies water slowly to the root zone of plants, through a network of valves, pipes, tubes and emitters. The goal is to optimize water and input usage. Adoption of micro irrigation might help in increasing the irrigated area, productivity of crops and water use efficiency. Direct seeded rice with drip irrigation can address the multifaceted problems of water scarcity, weed competition and environmental pollution. When the rice cultivation is shifted from TPR to DSR, weeds pose major threat to rice production. Under such scenario micro-irrigation /drip irrigation plays important role in restricting weed flora apart from regular supply of required amount of moisture for rice growth.

Keywords: AWD, fertigation, rice, crops and water use efficiency

Introduction

Rice (*Oryza sativa* L.) is the world's most important crop and is a staple food for more than half of the world's population. South East Asia, which is considered as the heartland of rice cultivation is the centre of origin of cultivated rice. Asia accounts for 60 per cent of the global population and stands first in world's rice production and as well as consumption (92 and 90%, respectively) (FAO, 2018) [8]. Rice plays a vital role related with the diet and human health and is rich in various nutrient components like carbohydrates, proteins, certain fatty acids and micronutrients. Rice provides 30 to 75 per cent of the total calories to more than 3 billion Asians (Khush, 2014) [13]. In India, rice is grown in an area of 46.2 m ha and production of 117.32 m t with an average productivity of 2585 kg ha^{-1} (Anon., 2019) [4]. India is the second largest country in terms of rice production and continues to hold the key to sustain food production by contributing 20 to 25 per cent of agriculture and assures food security for more than half of the total population (Anon., 2012) [3]. Rice accounts for 55 per cent of total cereal production in the country. The per capita food intake in India is 2234 calories per day of which 30 per cent comes from rice. The demand for rice is exceeding every year with the increase in the population. The production is expected to reach 140 m t by 2025 and 528 m t by the year 2050 (Paroda, 1998) [14].

Drip irrigation, also known as trickle irrigation is an irrigation method that applies water slowly to the root zone of plants, through a network of valves, pipes, tubes and emitters. The goal is to optimize water and input usage. Adoption of micro irrigation might help in increasing the irrigated area, productivity of crops and water use efficiency (Sivanappan, 2004) [18]. Direct seeded rice with drip irrigation can address the multifaceted problems of water scarcity, weed competition and environmental pollution. When the rice cultivation is shifted from TPR to DSR, weeds pose major threat to rice production. Under such scenario micro-irrigation /drip irrigation plays important role in restricting weed flora apart from regular supply of required amount of moisture for rice growth. Fertilizer application in wetland rice farming is currently done manually through the soil application in split doses. It is labour intensive and makes use of expensive fertilizers. This leads to various losses of nutrients under submerged cultivation. Besides loss of water and fertilizers through seepage and percolation, impounding water in paddy fields has an important environmental impact by contributing to global warming through considerable emission of methane.

During the year 1990, the estimated methane production from paddy fields as 110 m.t, later reduced to 60 m.t in 1992 and to 37 m.t in 1994 (Bouman and Tuong, 2001) [6]. Addressing these issues requires an integrated approach to soil water-plant-nutrient management at the plant rooting zone. One of these technologies is fertigation, which is the direct application of water and nutrients to plants through a drip irrigation system. The introduction of simultaneous micro irrigation and fertilizer application (fertigation) opens new possibilities for controlling water and nutrient supplies to crops besides maintaining the desired concentration and distribution of nutrients and water into the soil.

Brief review on drip fertigation in rice

Vijaykumar (2009) [22] reported that drip fertigation of 100% RDF of recommended P and K- 50% as basal + balance NPK as WSF+ Liquid biofertilizer + humic acid in rice has recorded higher grain yield (6538 kg/ha) and WUE (8.6 kg/ha-mm).

Field investigations by taking maize as a test crop revealed that maximum leaves plant^{-1} (15.1), stem girth (6.86 cm), total dry matter (8.90 t ha^{-1}), leaf area index (15.57) and leaf area duration (201 days) were noticed with the application of 140 kg N ha^{-1} through fertigation as compared to broadcast and side dress application (Hassan *et al.*, 2010) [10].

Drip fertigation with 100 per cent recommended dose of fertilizer (50 per cent P and K as water soluble fertilizer) recorded higher plant height (238.1 cm), leaf area index (4.94), dry matter production (14218 kg ha^{-1}) and root biomass (17.72 g plant^{-1}) over surface application with furrow irrigation (204.0 cm, 3.73, 8102 kg ha^{-1} and 13.16 g plant^{-1}, respectively) (Anitta, *et al*., 2011) [2].

Drip fertigation with water soluble fertilizer (WSF) improved the root system by inducing new secondary roots which were succulent and actively involved in physiological responses. Drip fertigation had pronounced effect on the root architecture especially in the production of highly fibrous root system (Fanish *et al.*, 2013) [7].

Drip fertigation with 125 per cent recommended dose of fertilizer through water soluble fertilizer recorded higher plant height (200 cm), number of leaves (11.67 plant^{-1}), leaf area (3271 cm^2 plant^{-1}), leaf area index (2.73) and total dry matter accumulation (426.26 g plant^{-1}) over soil application (174.63 cm, 10.47 plant^{-1}, 2386 cm^2 plant^{-1}, 1.99 and 334.87 g plant^{-1} respectively) (Richa Khanna, 2013) [16].

Application of 100 per cent recommended dose of fertilizer (150:50:50 NPK kg ha^{-1}) applied with humic acid through drip fertigation recorded maximum root length (58.8 m hill^{-1}), higher chlorophyll content (2.61 mg g^{-1}), leaf area duration (151 days), more filled grain percentage (69.1) in aerobic rice (Vanitha and Dass, 2014) [21].

Anusha *et al.* (2015) [5] reported that fertigation one in two days in aerobic rice recorded significantly higher grain, straw yield and harvest index as compared to fertigation once in four days.

Drip irrigation at 150 per cent pan evaporation + drip fertigation of 100 per cent recommended dose of fertilizer + azophosmet + humic acid recorded 19 per cent increased yield as compared to drip irrigation at 125 per cent pan evaporation + 100 per cent recommended dose of fertilizer through drip (Govindan and Grace, 2012).

Soman (2012) [19] reported that higher grain yield of rice (7.5 to 9.5 t ha^{-1}) under drip fertigation and was found to be significant over conventional irrigation and fertilizer application (3 t ha^{-1}).

The uptake of NPK and FUE was increased by water soluble fertilizer fertigation (226.48 kg kg^{-1} NPK) over fertigation with normal fertilizers (209.34 kg kg^{-1} NPK) in tomato crop (Hebbar *et al.*, 2004) [11].

Drip fertigation of 100 per cent recommended dose of fertilizer at 150 per cent potential evaporation with 2 days interval to aerobic rice resulted in higher water use efficiency, water productivity and also total water saving of 32 per cent over surface irrigation (Sundrapandiyan, 2012) [20].

Significantly higher grain yield was recorded with 100 per cent RDF through drip fertigation with water soluble fertilizer (6503 kg ha^{-1}) and 100 per cent RDF through drip fertigation with water soluble fertilizer recorded significantly higher water use efficiency (91.01 kg ha-cm^{-1}) (Rekha *et al.*, 2014) [15].

Result shows that the yield was found highly significant effect in different nutrient management practices. The yield found to be highest was 5.46 t/ha in NE nutrient management practice than those of farmer practices was 4.430 t/ha. The yield in government practice (4.786 t/ha) and farmer practice had almost similar result. The yield in the Nutrients expert management is 1 t/ha more than the farmer practice. The increased % in Yield over FFP of NE was 23.25% and GR was 8.12%. (Ganesh Gupta *et al*., 2016) [9].

Significant difference in terms of plant height, panicle weight, filled grain/panicle, straw yield, grain yield at 15.5% moisture, biological yield and sterility %. The highest yield (7.362 ton ha-1) was obtained from NE hybrid field which was followed by GR hybrid (6.12 ton ha^{-1}), NE improved (5.20 ton ha^{-1}), FFP (4.76 ton ha^{-1}) and GR improved (4.70 ton ha^{-1}). While comparing Nutrient Expert® (NE) estimation for attainable rice yield with actual rice yield from the farmer field trial; NE-based fertilizer recommendations proved to be successful in reaching the yield targets estimated by the software.

Kavitha (2001) [12] reported that four equal split application of N and K at AT, PI, booting and flowering recorded superior yield parameters which in turn registered higher grain yield of hybrid rice.

Application of 80 kg N/ha in five splits i.e. 20 percent each at basal, 15DAT, tillering initiation, maximum tillering, and panicle initiation stages proved that the best in terms of productivity and net returns of scented rice (Shekhar *et al.*, 2004) [17].

Conclusions

- Under the condition of declining water resources dry direct seeded rice can be successfully grown under drip irrigation with fertigation.
- Irrigation rice water 1.4 ET and fertigation water 75% RDN using conventional fertilizers is an economical practices that can be followed by farmers.
- Water soluble nitrogen fertilizers applied in eight splits enhance nutrient uptake (24.8%) as well as NUE (23.6%) over conventional fertilizer applied to soil surface in three splits.
- According water soluble nitrogen fertilizers in six splits was found optimum for rice.

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