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Review Article

INFLUENCE OF DRIP FERTIGATION IN AEROBIC RICE PRODUCTION

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Abstract: Rice is a semi aquatic plant being an important staple food crop in Asia and it occupies the enviable prime place among the food crops after wheat. Human consumption accounts 85 percent of total production for rice and it deserves a special status among cereals as world's most important wetland crop. In India, rice is grown in an area of 43.97 million hectare with a production and productivity of 104.32 million tonnes and 2372 kg ha^{-1}, respectively. The increasing shortage of water resources accelerates the development and adoption of aerobic rice system. Aerobic rice is a production system where in rice is grown in well-drained, non- puddled and non saturated soils. The yields that can be obtained here range from 4.5 to 6.5 t ha^{-1}. Adoption of micro irrigation might help in increasing the irrigated area, productivity of crops and water use efficiency. Drip fertigation can be given at various intervals like once a day or once in every two days or even once a week, depending on type of soil and crop. Fertigation interval significantly influenced the growth and yield attributes in aerobic rice due to maintenance of adequate soil moisture by frequent irrigation and nutrient supply match with crop growth demand along with good soil aeration throughout crop growth period. In drip fertigation system the yield increment was up to 61.84 percent as that of surface irrigation with soil application of fertilizers. Scheduling of drip fertigation in right time is optimum for getting maximum yield in direct seeded drip irrigated aerobic hybrid rice.

Keywords: *Aerobic rice, Drip fertigation, Fertigation interval, Water saving, Yield*

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Introduction

Rice (*Oryza sativa* L.) is the most important staple food crop in Asia and it occupies the enviable prime place among the food crops after wheat. Human consumption accounts 85 percent of total production for rice and it deserves a special status among cereals as world's most important wetland crop. Worldwide, rice is being cultivated on an approximate area of 147 million hectare with a total production of 525 million tonnes and average productivity of 3571 kg ha^{-1}. Asia contributes 59 percent of world population and accounts for 92 percent of global rice production. Among many food grains cultivated in India, rice has the pride of being cultivated over an area of 43.97 million hectare with a production of 104.32 million tonnes which contributes to 41.5 percent of total food grain production of our country with the productivity of 2372 kg ha^{-1}.

The estimated water availability for agriculture which is 83.3 percent of total water used today and it will shrink to 71.6 percent in 2025 and to 64.6 percent in 2050 [1]. The shrinking water resources and competition from other sectors, the share of water allocated to irrigation is likely to decrease by 10 to 15 percent in the next two decades. Hence, the expansion of irrigation may depend upon the adoption of new systems such as pressurized irrigation methods with the limited water resources. Among those pressurized irrigation methods, drip irrigation has proved its superiority over other methods of irrigation due to the direct application of water and nutrients in the vicinity of root zone [2]. Fertigation is the judicious application of fertilizers through irrigation water. Fertigation can supply nutrients directly to root zone in available forms, control of nutrient concentration in soil solution and saving in application cost. Thus, fertigation becomes prerogative for increasing the yield of most of the crops under drip irrigation [3]. Aerobic rice is a production system where in rice is grown in well-drained, non-puddled and non-saturated soils [4].

Characteristics and Constraints of Aerobic Rice

More than 75% of the rice production comes from 79 million ha of irrigated lowland. However, the sustainability of the irrigated rice systems is increasingly threatened by scarcity of fresh water resources. It was estimated that 17 million ha of Asia's irrigated rice may experience "physical water scarcity" and 22 million ha may experience "economic water scarcity" by 2025 [5]. The increasing shortage of water resources accelerates the development and adoption of aerobic rice system. Aerobic rice is a new term coined by the International Rice Research Institute (IRRI), for high-yielding rice grown under non flooded conditions in non-puddled and unsaturated (aerobic) soil, which is responsive to nutrient supply, can be rainfed or irrigated, and tolerates (occasional) flooding [6]. This system has been developed and adopted by farmers in Brazil, China, and other Asian countries [7,8]. In broad sense, upland rice can be considered as aerobic rice because of the availability of oxygen in the soil. Aerobic rice is defined in the context of a water-limited irrigated lowland system without puddling. In aerobic rice production system, soils are kept aerobic throughout the growing season. Supplemental irrigation is applied as necessary. The cultivars used are adapted to aerobic soils and have higher yield potential than traditional upland cultivars [9]. In Asia, upland rice is aerobically grown with minimal inputs and it is usually planted as a low-yielding subsistence crop in the adverse upland conditions [10]. Upland rice cultivars are drought tolerant, but have a low-yield potential and tend to lodge with high levels of external inputs such as fertilizer and supplementary irrigation. Aerobic rice is adopted in upland areas where supplementary irrigation is available and soil problem is minimum [11]. In 2001, IRRI started a breeding program to develop tropical aerobic rice cultivars for the Asian tropics [12] and some improved tropical upland rice cultivars (such as Apo) that performed well under aerobic conditions were identified [13].

To achieve high yields under aerobic conditions, aerobic rice cultivars should combine the drought-tolerance characteristics of upland cultivars with the high-yielding characteristics of lowland cultivars. In northern China and Brazil, aerobic rice cultivars with high yield potential and moderate tolerance of drought stress have been developed through crosses of traditional upland cultivars with improved irrigated cultivars [14]. Furthermore, aerobic rice cultivation has another merit, which is reducing greenhouse gas emission from rice field [15]. The grain yields of 5-6 t ha^{-1} have been reported in aerobic rice system with high-yielding rice cultivars [16-18]. In Brazil, aerobic rice cultivars with high grain yields of 5-7 t ha^{-1} have been developed [19]. While, in northern China, the grain yields of 8 t ha^{-1} and even higher have been achieved using high-yielding aerobic rice cultivars under appropriate management practices. It is well-known that weeds are the most severe constraints to widespread adoption of aerobic rice [20]. Weed pressure in dry direct-seeded aerobic rice is significantly greater than that recorded in transplanted rice [21]. Weeds in plots with a lower seeding rate have more chances to emerge, grow, and build up a strong population and thus pose a serious crop–weed competition. [22] Higher seeding rate to reduce weed biomass in dry direct-seeded aerobic rice.

Benefits of Drip Irrigation & Fertigation

- Enhanced yield upto 50 %
- Higher and cleaner straw production
- Higher water use efficiency
- Conserving irrigation water up to 66%
- Conserving energy use for pumping up to 52%
- Reduced seed rate
- Higher fertilizer use efficiency
- Absence of pollution from leached and washed Nitrate
- Maintains aerobic condition in the soil
- Prevents Methane emission and protects environment as there is no standing water
- Reduced humidity in micro climate
- Incidence of diseases and insects significantly low
- No need for land levelling (prerequisite for flow irrigation)
- No need for labour use for trimming bunds and plugging breaches to contain water.
- Total Labour requirement less
- Intercropping and rotation cropping is possible. Pulse rotation crop will be beneficial.
- Soil structure is maintained (absence of puddling operation that destroys soil structure).
- Lower mosquito population in the ecosystem as there is no standing water.

Benefits in Adopting Aerobic Rice

Application of aerobic rice in areas of the anticipated 37 million ha of water short irrigated lowlands and 40 million ha of rainfed lowlands and uplands, where seasonal rainfall is 600-800mm in Asia will be rescued from water shortage problems and brought under cultivation.

Influence of Drip Fertigation on Growth and Yield Parameters of Aerobic Rice

Application of fertilizers through drip irrigation resulted in continuous supply of nutrients besides maintaining optimum water availability which leads to higher uptake of nutrients. As that of growth parameters, drip fertigation at 1.5 PE up to maturity with 100 percent RDF through normal fertilizers resulted in significantly more panicle weight, productive tillers, total grains per panicle and grain yield. Irrespective of fertilizer combinations, fertilizer applied at once in 2 days recorded higher leaf area and leaf area index (LAI). Maintenance of adequate soil moisture by frequent irrigation and nutrient supply match with crop growth demand along with good soil aeration throughout crop growth period might have favoured faster cell division and elongation which has ultimately resulted in higher tiller production, more number of leaves and leaf area development [24]. Singandhupe, *et al*., (2003) [25] reasoned out that the increase in LAI due to increased N supply might also be ascribed to the N-induced enhancement of leaf area. But in surface irrigation with soil application, where nutrients were applied in two splits (N and K), utilization was reduced during dry period as soil moisture was reduced with time [26]. Application of straight fertilizers in combination with water soluble fertilizers is the alternative source for water soluble fertilizers alone [27]. Surface irrigation with soil application of RDF recorded lowest yield attributes. Higher yield attributes under drip fertigation given once in two to four days were because of higher growth parameters like plant height, tillers and leaf area and this favourable influence was due to better and adequate supply of required quantity of water and nutrients at the right time at right form at right place due to drip fertigation. [28] also reported yield improvement in banana under drip fertigation which was mainly due to the maintenance of soil near field capacity throughout the growth period in the active root zone, leading to low soil suction, which thereby facilitated better water utilization, higher nutrients uptake and excellent maintenance of soil-water-air relationship with a higher oxygen concentration in the root zone. This was attributed to complete solubility and availability of the water-soluble fertilizer as compared to normal fertilizer. Water soluble fertilizer had higher concentration of available plant nutrient in top layer [29]. Surface irrigation with soil application recorded lowest grain and straw yield. Parthasarathi, *et al*., (2012) [30] also reported that split application of fertilizers in drip irrigation coincided with the actual needs of crop up to eighty days and favoured good growth and produce maximum yield. Scheduling of drip fertigation once in two to four days with a combination of 50 percent normal and water-soluble fertilizers is optimum for getting maximum yield in direct seeded drip irrigated aerobic hybrid rice. A sound source in terms of plant height, number of tillers to support and the number of leaves is logically able to increase the total drymatter and later lead to higher grain yield. Partitioning of drymatter production and its distribution in different parts is important for determination of total yield of the crop. The increase in yield attributes under drip fertigation might be due to enhanced availability and uptake of nutrients leading to enhanced photosynthesis, expansion of leaves and translocation of nutrients to reproductive parts compared to conventional method of soil application of nutrients. Similar findings were also recorded by Vijaykumar, (2009) [31]. The yield increment is up to 61.84 percent as that of surface irrigation with soil application of fertilizers. Higher leaf area index and crop growth rate which are contributed for assimilation of more photosynthates and resulted in superior yield attributes and yield [32-33]. Higher grain yield may be due to its superiority in producing higher productive tillers $hill^{-1}$, panicle length, thousand seed weight and total number of filled grains $panicle^{-1}$ with lower % chaffyness than the other treatment.

Influence of Fertigation Intervals on Aerobic Rice

Fertigation can be given at various intervals like once a day or once in every two days or even once a week, depending on type of soil and crop. The optimum fertigation interval for drip irrigated crops has not been thoroughly researched. It is often assumed that fertigation at few days interval with drip irrigation is preferable than wide interval fertigation. Water soluble fertilizers having high content of nutrients with low salt index can be used for fertigation. These fertilizers are made of same chemical compounds as those of normal fertilizers but, they are devoid of neutral insoluble materials such as earth, gypsum, dolomite, clay etc. and are almost 100 percent soluble in water without leaving any sediment in fertigation system [34]. As water soluble fertilizers are very costly inputs, efforts should be made to reduce the quantity of water-soluble fertilizers in conjunction with normal fertilizers [35]. Fertigation interval significantly influenced the tiller production in aerobic rice. The maximum number of tillers is recorded with fertigation interval of once in two and four days with 100 percent water soluble fertilizers. It was mainly because of response of hybrid rice to frequent application of water and nutrients through fertigation.

Influence of Drip Fertigation On
Water use and Water productivity

In aerobic rice cultivation, irrigation water use, total water needs of crop and water productivity also shown greater variation.

Drip fertigation at 1.5 PE up to maturity with 100 % RDF recorded higher water productivity of 64.6 kg ha-cm^{-1} besides saving 39 percent of water as compared to surface irrigation. Higher total water use was observed with surface irrigation method (1288 mm) followed by irrigation levels at 1.5 PE up to maturity (844.4 mm) and least total water used with 1.0 PE up to tillering and 1.5 PE up to maturity (766.4 mm). Aerobic rice cultivation the increase in water productivity in all drip irrigated treatments over surface irrigation was mainly due to considerable saving of irrigation water, greater increase in yield of crop and higher nutrient use efficiency. 32-88% higher water productivity was observed under aerobic rice cultivation compared to flooded conditions [36].

Water use efficiency

In aerobic rice situations, higher water use efficiency in drip fertigation is probable as the volume of water applied through drip system roughly corresponds to the consumptive use of plants. Consistent with this, Total water used was highest in surface irrigation method (1073 mm) when compared to different levels and source of fertilizer with drip fertigation (714.5 mm). Aerobic rice fertigated with 100% RDF through drip fertigation with water soluble fertilizer recorded significantly higher water use efficiency (91.01 kg/ha.cm^{-1}), followed by 100 and 75% RDF in which 50% applied as basal with normal fertilizer and 50% top dress through water soluble fertilizer (85.99 and 78.38 kg/ha.cm^{-1}) and 75% RDF through drip fertigation with water soluble fertilizer (79.27 kg/ha.cm^{-1}). In drip irrigation system increase in water use efficiency over furrow irrigation was mainly due to the controlled water release near the crop root zone. Drip fertigation system influence favourable effect of water and nutrients on crop growth and yield probably due to higher water use efficiency [37].

Economics

Drip fertigation system has been found more profitable than surface irrigation due to higher yield. Gross returns were higher when the crop were fertigated with 100% RDF through water soluble fertilizers (Rs. 121222 ha^{-1}) it was followed by treatment with 100 and 75% RDF. This is mainly due to increase in grain and straw yield as compared to rest of the treatments [38].

Conclusion

Lowland rice has been proven over the centuries, to be a remarkably sustainable system for rice production mostly because of its luxurious water availability. Sustainability of lowland rice production threatens present day water crisis and necessitates the adoption of water saving irrigation technologies. The technologies reduce water inputs only at the expense of yield. While, decreased water requirements in rice production and is highly suitable for irrigated lowland rice with insufficient rainfall and favourable uplands with access to supplementary irrigation under aerobic rice production. In aerobic rice production it requires new type of cultivars bred. Fertigation can supply nutrients directly to root zone in available forms, control of nutrient concentration in soil solution and saving in application cost.

Application of review: Maintenance of adequate soil moisture by frequent irrigation and nutrient supply match with crop growth demand along with good soil aeration throughout crop growth period might have favoured faster cell division and elongation which has ultimately resulted in higher tiller production, more number of leaves and leaf area development which increase the yield of aerobic rice under drip fertigation systems.

Review Category: Drip Fertigation

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Cultivar / Variety / Breed name: Rice (*Oryza sativa* L.)

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References

[1] Yadav J. S. P. (2002) *J. Water Manage*, 10(1-2), 1-10.
[2] Pritee Aswathy, Bhanbri M. C., Pandey N., Bajpai R. K. and Dwivedi S. K. (2014) *The Ecoscan.(special issue)*, 473-478.
[3] Jata S. K., Nedunchezhiyan M., Saho T. R. and Sahoo V. (2013) *Odisha Review*, 68-77.
[4] Anonymous (2007) *Tech. bull. University of Agricultural Sciences, GKVK, Bangalore, pp* 13-16.
[5] Tuong T.P. and Bouman B.A.M. (2003) *In, Proc. Water Productivity Workshop*, 12–14. p 50-55.
[6] Bouman B.A.M. (2001) *Int Rice Res Notes*, 16, 17–22.
[7] Pinheiro B.D.S., Castro E.D.M.D. and Guimaraes C.M. (2006) *Field Crops Res*., 97,34–42.
[8] Saito K., Linquist B. and Atlin G.N. (2006) *Field Crops Res*., 96, 216–223.
[9] Atlin G.N., Lafitte H.R., Tao D., Laza A., Amante A. and Courtois B. (2006) *Field Crops Res*., 97, 43–52.
[10] Lafitte R.H., Courtois B., Arraudeau M. (2002) *Field Crops Res*., 75, 171–190.
[11] Bouman B.A.M., Humphreys E., Tuong T.P. and Barker R. (2007) *Adv Agron*., 92, 187–237.
[12] Bouman B.A.M. and Tuong T.P. (2001*) Agric Water Manage*, 49, 11–30.
[13] George T., Magbanua R., Garrity D.P., Tubana B.S. and Quiton J. (2002) *Agron J*., 94, 981–989
[14] Guimaraes E.P. and Stone L.F. (2000) *Int Rice Res Notes, Los Banos, Philippines.*
[15] Mandal D.K., Mandal C., Raja P. and Goswami S.N. (2010) Current Sci., 99,227–231.
[16] Bouman B.A.M., Peng S., Castaneda A. and Visperas R.M. (2005) *Agric Water Manage*, 74, 87–105.
[17] Bouman B.A.M., Yang X.G., Wang H.Q., Wang Z.M., Zhao J.F. and Chen B. (2006) *Field Crops Res*., 97, 53–65.
[18] Peng S., Bouman B.A.M., Visperas R.M., Castaneda A., Nie L. and Park H.K. (2006) *Field Crops Res*., 96,252–259.
[19] Castaneda A.R., Bouman B.A.M., Peng S. and Visperas R.M. (2002) *Int Rice Res Notes*, 165–176.
[20] Rao A.N., Johnson D.E., Sivaprasad B. Ladha J.K. and Mortimer A.M. (2007) *Adv Agron*., 93, 153–255.
[21] Singh S., Ladha JK. Gupta R.K. Bhushan L. and Rao A.N. (2008) *Crop Prot*., 27,660–671.
[22] Mahajan G., Gill M.S. and Singh K. (2010) *J. New Seeds*, 11, 225–238.
[23] Anita Fanish S. and Muthukrishnan P. (2013*) Madras Agric. J*., 98(7-9), 238-242.
[24] Vanitha K. and Mohandass S. (2014) *The Bioscan*, 9(1), 45-50.

[25] Singandhupe R. B., Rao G. G. S. N., Patil N. G. and Brahmanand P. S. (2003) *Europ. J. Agronomy*, 19, 327-340.
[26] Raskar B. S. and Bhoi P. G. (2001) *Madras Agric. J*., 50(11), 801-810.
[27] Pramanik S., Tripathi S. K., Ray R. and Banerjee H. (2014) *Agric. Eco. Res. Rev*., 27(1), 103-109.
[28] Anitta Fanish S. (2013) *Madras Agric. J*., 100(1-3),102-106.
[29] Sampathkumar T. and Pandian B. J. (2010) *Madras Agric. J.* 97(7-9), 245-248.
[30] Parthasarathi T., Mohandass S., Chellamuthu S. and Eli Vered (2012) *Fifth Inter. Ground water Conf. Assess and Manage ground water resources in hard rock systems with special reference to Basaltic terrain*, 410-423.
[31] Vijaykumar P. (2009) *In, Upland Rice Research Consortium Review and Synthesis Meeting and Aerobic Rice Workshop*, 248-252
[32] Soman P. (2012) *In, Proc. Asian Irrig. Forum*, 41.
[33] Gurusamy A., Mahendran P. P., Krishnasamy S. and Babu R. (2013) *Intl. J. Chem. Env and Bio Sci*., 1(2), 387-390.
[34] Yanglem S. D. and Tumbare A. D. (2014) *The Bioscan*, 9(2), 589-594.
[35] Gururaj K. (2013) *M.Sc. (Agri.) Thesis, University of Agricultural Sciences, GKVK, Bangalore.*
[36] Sundrapandiyan R. (2012) *M.Sc. (Agri.) Thesis, Tamil Nadu Agricultural University, Coimbatore,* 410-423.
[37] Rekha B., Jayadeva H. M., Gururaj Kombali, Nagaraju, Mallikarjuna G. B. and Geethakumari A. (2015) *The Ecoscan*, 9(1&2), 435-437.
[38] Veeraputhiran R., Kandasamy O. S. and Sundersingh S.D. (2002) *J. Agric. Res*., 1(20), 88-97.