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Evaluation of Drip Fertigation in Aerobic Rice-Onion Cropping System

S. Ramadass[1]* and S.P. Ramanathan[2]

[1]Department of Agronomy, TNAU, Coimbatore-03, India
[2]Department of Agronomy, WTC, TNAU, Coimbatore-03, India
**Corresponding author*

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A B S T R A C T

Field experiments were conducted during *kharif* 2016 and *rabi* 2016-17 at Research and Development farm of Jain Irrigation Systems Ltd., Udumalpet with seven treatments comprising of two irrigation (100% and 150% ETc) and three fertigation levels (75%, 100% and 125% RDF) in addition, surface irrigation method as a check for aerobic rice. For onion crop also seven treatments were setup with reducing water levels to 75% and 100% ETc from that of rice water levels by keeping same fertigation levels. The furrow irrigation was maintained as check. In rice crop, surface irrigation method resulted higher growth and yield parameters. Among the aerobic rice treatments, drip fertigation at 150% ETc with 125% RDF was recorded higher growth and yield characters and it was at par with surface irrigation method. But in onion crop, furrow irrigation registered significantly lower growth and yield parameters among the treatments. DF with 100% ETc + 125% RDF registered higher growth and yield parameters.

Introduction

Rice is one of the major food crops of Asia. Food security of Asia mainly depends on irrigation as about 75% of rice is produced from 79 million ha of flooded/wetland paddy production system. In India rice is the staple food of the people of the eastern and southern parts of the country and is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 43.9 m ha. with a production of 106.5 m t. of rice and average productivity of 2.424 t ha^{-1} (MOA, Gov. of India, 2013-14). Rice cultivation has been taken largely on irrigated low land, which produces three quarters of all rice harvested. Water is a looming crisis due to competition among agricultural, industrial, environmental and domestic users. The estimated water availability for agriculture which is 83.3 per cent of total water used today will shrink to 71.6 per cent in 2025 and to 64.6 per cent in 2050 (Yadav, 2002). A growing scarcity of fresh water will pose problems for rice production in future years. Aerobic rice is a production system in which specially developed “aerobic rice” varieties are grown in well-drained, non- puddled and non saturated soils. The concept of aerobic rice holds promise for farmers in water-short irrigated rice environments where water availability at the farm level is too low or where water is too expensive to grow flooded lowland rice. Aerobic rice has been identified as a potential new technology, which can reduce water use in rice production and also recognized as an economically attractive crop. The successful transition from traditional lowland cultivation to aerobic rice production should be invariably under conditions of effective water and fertilizer management, to keep the soil wet with optimum nutrients (Bar-Yosef, 1999). It can be obtained through drip irrigation along with fertilizer application (fertigation). By introducing drip with fertigation, it is possible to increase the yield of crops by three times from the same quantity of water. When fertilizer is applied through drip, it is observed that 30 per cent of the fertilizer could be saved.

However, the aerobic rice crop alone under drip fertigation system would not be much cost effective to the rice growers. So, to increase the farm productivity and over all income for the farmers, a short duration high value crop i.e. onion is included in the system as follow up crop and it looks as a viable cropping system to the water scarce and non traditional rice areas too. It is extensively cultivated throughout India for its high nutrition and medicinal properties. Onion bulbs are rich in minerals like calcium, phosphorus and vitamin C (Singh *et al.*, 2004). Drip fertigation in rice-onion cropping sequence offers scope to increase the productivity of crops per unit land, time and all inputs in crop production strategies.

Materials and Methods

Field experiments were laid out in the R&D Farm of Jain Irrigation Systems Ltd., situated in the Udumalpet Taluk of Tirupur District (TN). The farm is situated in the western Agro climatic zone of Tamil Nadu at 10° 34’ 48’’ N latitude and 77° 14’ 24’’ E longitude and at an altitude of 340.46 m above MSL. The soil of the experimental field is sandy clay with good drainage. The available soil nitrogen, phosphorous and potassium were 196, 6.5 and 350 kg ha^{-1}, respectively with soil pH and EC of 7.66 and 0.21 dS m^{-1}. The experiment was conducted during *kharif* 2015 and summer 2016 with seven treatments of DF @ 100% ETc + 75% RDF (T1), DF @ 100% ETc + 100% RDF (T2), DF @ 100% ETc + 125% RDF (T3), DF @ 150% ETc + 75% RDF (T4), DF @ 150% ETc + 100% RDF (T5), DF @ 150% ETc + 125% RDF (T6) and surface irrigation method were arranged in randomized block design and replicated thrice. Surface irrigation was given one day after disappearance of ponded water to depth of 2.5 cm with manual application of fertilizer. For onion crop also seven treatments were setup with reducing water levels to 75% and 100% ETc from that of rice water levels by keeping same fertigation levels. Here furrow irrigation was used as check. Raised beds were formed with a top bed width of 100 cm and furrows with width of 30 cm and the crop spacing adopted for rice and onion is 20cm x 10cm and 20 x 12cm. Two laterals were laid out per bed with spacing of 50cm x 80cm x 50cm. Proper weed management and plant protection measures were carried out at the appropriate time as per the recommendation.

Five plant samples in each replication were drawn for recording various growth and yield parameters. To overcome border effect observations were made on middle plants in the row. The data obtained were subjected to statistical analysis and were tested at five per cent level of significance to interpret the treatment differences as suggested by Gomez and Gomez (1984).

Results and Discussion

Effect of drip fertigation levels on growth and yield of aerobic rice

Plant height

Surface irrigation method registered higher plant height and it was followed by DF at 150% ETc with 125% RDF (Table 1). This was followed by at 150% ETc with 100% RDF. This might be due to increased water level at root zone which led to greater uptake of water and dissolved nutrients. The results are in accordance with the findings of Shekara *et al.*, 2010.

Tiller production

The surface irrigation method favoured significantly higher number of tillers per plant (Table 1). The lowest number of tillers was recorded in the treatment with fertigation scheduled at 100% ETC + 75% RDF. Greater tiller mortality as a result of water deficit and iron deficiency might be the reason for lower tiller number in treatment with irrigation scheduled at 100% ETC and the results were similar to Sudhir *et al.,* (2011).

Leaf area index

Higher the LAI was observed with surface irrigation method (Table 1). Within the drip irrigation treatments DF at 150% ETc with 125% RDF recorded higher LAI. This was on par with 150% ETc with 100% RDF. The reduction in LAI with lower irrigation and fetigation levels (100% ETc with 75% RDF) might be due to reduced turgor pressure under moisture stress conditions which affected the leaf cell expansion. Similar observations were also made by Nguyen *et al.,* (2009) and Bouman *et al.,* (2005). The Increased leaf area index could be attributed to the increased functional leaf area and delayed leaf senescence by production of phytohormones that enhanced cell division and elongation (Elankavi *et al.,* 2009).

Dry matter production

The highest dry matter accumulation (Table 1) with surface irrigation and it was on par with 150% ETc with 125% RDF (T6). This might be attributed to the fact that increased frequency of irrigations in the above schedule has facilitated higher water and nutrient uptake applied to the crop coupled with possible reduction in transpiration rate and CO2 exchange resulted in increased production of photosynthates and their translocation to sink (Shekara and Sharanappa, 2010).

Grain yield

Irrigation and fertigation schedules significantly influenced the grain yield of rice (Table 1). Surface irrigation method registered higher grain yield (5304 kg ha^{-1}) and it was on par with 150% ETc with 125% RDF (T6) with yield of 5110 kg ha^{-1}. The higher grain yield of aerobic rice might be associated with increase in growth and physiological characters were observed under higher moisture regime. These findings were in agreement with results of Gupta *et al.,* (2003). And also, the higher grain yield was might be due to increase in yield attributing characters under high soil moisture regime as a result of frequent irrigation (Shekara *et al.,* 2010).

Effect of drip fertigation levels on growth and yield of onion

Plant height of onion was significantly influenced by irrigation regimes and fertigation levels, during the study (Table 2).

Plant height

There was distinct variation in plant height of onion between furrow irrigation and drip irrigation levels (Table 2). Plant height was significantly higher with drip fertigation at 100 % ETc + 125 % RDF (T_6) with a value of 53.9 cm. The treatment drip fertigation at 100% ETc with 100% RDF (T_5) showed on par yield with $T_{6.}$ This might be due to fact that higher irrigation regimes maintained most of the root zone at adequate soil moisture content that did not fluctuate between wet and dry extremes (Patil and Janawade, 1999). Subsequently, Balasubrahmanyam (2003) noticed that plant height of onion increased with increased amount of irrigation water. Lesser plant height in furrow irrigation might be due to highly fluctuating moisture regimes resulted in stress to the crop and also due to surface irrigation nutrients might have been leached away beyond the root zone as noticed by Paul *et al.,* (1996).

Table.1 Effect of drip fertigation levels on growth at flowering and yield of aerobic rice during *kharif*, 2015

Treatments	Plant height (cm)	Tiller number m^{-2}	LAI	DMP (kg ha^{-1})	Grain yield (kg ha^{-1})
T_1- DF at 100% ETc with 75% RDF	75.4	266	4.25	5801	3741
T_2- DF at 100% ETc with 100% RDF	80.7	285	4.55	6259	4152
T_3- DF at 100% ETc with 125% RDF	84.2	297	4.73	6560	4448
T_4- DF at 150% ETc with 75% RDF	83.2	294	4.68	6453	4343
T_5- DF at 150% ETc with 100% RDF	89.2	315	5.00	6969	4821
T_6- DF at 150% ETc with 125% RDF	93.5	330	5.22	7353	5110
T_7- SI with soil application of 100% RDF	97.0	342	5.37	7684	5304
S Ed	2.5	10	0.14	207	176
CD (P=0.05)	6.0	23	0.34	504	420

Note: DF– Drip Fertigation ETc – Crop Evapotranspiration
SI – Surface Irrigation RDF – Recommended Dose of Fertilizer

Table.2 Effect of drip Fertigation levels on growth at 60 DAT and yield of onion during *rabi*, 2016-17

Treatments	Plant height (cm)	No. of leaves $plant^{-1}$	DMP (kg ha^{-1})	Bulb yield (kg ha^{-1})
T_1- DF at 75% ETc with 75% RDF	41.0	11.4	2052	15439
T_2- DF at 75% ETc with 100% RDF	44.4	12.3	2218	16690
T_3- DF at 75% ETc with 125% RDF	47.4	13.2	2369	17825
T_4- DF at 100% ETc with 75% RDF	46.6	12.9	2329	17525
T_5- DF at 100% ETc with 100% RDF	50.4	14.0	2522	18979
T_6- DF at 100% ETc with 125% RDF	53.9	15.0	2694	20270
T_7- FI with soil application of 100% RDF	39.4	10.9	1970	14822
S Ed	1.9	0.5	96	719
CD (P=0.05)	4.2	1.2	208	1563

Note: DF– Drip Fertigation ETc – Crop Evapotranspiration
FI – Furrow Irrigation RDF – Recommended Dose of Fertilizer

Leaf production

Different Irrigation and fertigation level was significantly influenced on number of leaves per plant (Table 2). Application of 100% ETc with 125% RDF (T_6) registered more number of leaves per plant. Similarly, Yenus (2013) noticed that highest and few number of leaves per plant of onion from combination of 151 kg N ha^{-1} with 1.2 ETc and 0 kg N ha^{-1} with 0.5 ETc irrigation levels, respectively. Abbey and Joyce (2004) reported that the higher leaf number per plant resulted in irrigation at 100 % ETc is due to the irrigation effect that facilitates nutrient availability and photosynthesis for undisrupted growth of the plant, similarly the reduced number of leaves per plant at 50 % ETc of irrigation level may be attributed to effects of water stress on cell expansion.

Dry matter production

Drip fertigation at 100 % ETc + 125 % RDF obtained higher dry matter production than other drip fertigation regimes and surface irrigation (Table 2). This might be due to the increased plant height and more number of leaves as a result of maintenance of favourable soil moisture in the root zone (Kumar *et al.*, 2007). Abbey and Joyce (2004) noticed that adverse effects of water deficit stress on plant fresh weight and dry matter production became evident six weeks after transplanting and were greatest after ten weeks after transplanting.

Bulb yield

The objective of any applied research is to get increased yield (Table 2). Higher bulb yield was recorded under drip fertigation at 100 % ETc + 125 % RDF. This is in accordance with the findings of Sivanappan (1998) that the yield increases in several crops under drip irrigation over traditional surface irrigation methods. Increased yield might be due to fertigation with higher fertilizer doses which obviously resulted in higher availability of all the three major nutrients in soil solution which led to increased growth and leaf area, higher uptake and better translocation of assimilates from source to sink thus in turn increased the bulb yield (Ansary *et al.,* 2006).

From the study it can be concluded that drip irrigation at 150% ETc combined with 125% RDF Fertigation is the appropriate technology in aerobic rice followed by CO (On) 5 with 100 % ETc + 125 % RDF. The surface irrigation in rice and furrow irrigation in could be replaced with drip fertigation.

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