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AGRONOMY

Effect of Drip Fertigation on the Productivity of Hybrid Rice

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ABSTRACT

A field experiment was conducted at Tamil Nadu Rice Research Institute (TRRI), Tamil Nadu Agricultural University, Aduthurai to standardize lateral spacing, plant row spacing, fertilizer levels and source of fertilizers on the productivity of hybrid rice under drip irrigation. The experiment was conducted in strip plot design with replicated thrice. Main plot treatments were two lateral spacing (80 and 100 cm) with two plant row spacing (uniform row spacing and modified row spacing). In 80 cm lateral spacing, uniform row spacing of 20 × 10 cm and modified row spacing of 7.5 × 20 × 25 × 20 × 7.5 cm were adopted. In case of 100 cm lateral spacing, uniform row spacing of 20 × 10 cm and modified row spacing of 7.5 × 15×15×25×15×15×7.5cm were adopted. In sub plots, combination of two fertilizer levels (75 and 100% RDF) and two sources of fertilizers (common fertilizers – urea, single super phosphate and muriate of potash and water soluble fertilizers – urea, mono ammonium phosphate and sulphate of potash) were used for fertigation. Short duration hybrid CORH 3 was used.

Results revealed that lateral spacing at 80 cm with modified row spacing (7.5 × 20 × 25 × 20 × 7.5 cm) produced significantly taller plants (76.1 cm), more number of leaves per hill (74.9/hill) and tillers population (625 per m^2), higher root growth parameters at maximum tillering stage viz., root length (18.5 cm), root volume (13.1cc) and root dry weight (6.2g), higher yield attributes like productive tillers (453/m^2), number of filled grains per panicle(124.9) and higher grain yield of 5055 kg/ha than lateral spacing of 100 cm with modified row spacing. Fertigation with different levels and sources of fertilizers revealed that application of 100 % recommended dose of fertilizers (RDF) as water soluble fertilizer produced significantly higher growth, yield parameters and grain yield of 4230 kg/ha over 75% RDF. However, it was comparable with 100 % RDF as conventional fertilizers.

Highlights

- Growing of rice hybrid CORH 3 under drip irrigation using 80 cm lateral spacing, modified row spacing (7.5 × 20 × 25 × 20 × 7.5 cm) and fertigation of 100 % RDF either as conventional or water soluble fertilizers found to increase the productivity of hybrid rice.

Keywords: Drip fertigation, Lateral spacing, Plant row spacing, , Hybrid rice, Water soluble fertilizers

Rice (*Oryza sativa* L.) is one of the most important food crops in the world. In Asia, more than two billion people are getting 60-70% of their food energy from rice and its derived products. It is the dominant irrigated crop, accounting 30% or more of the total irrigated area and taking up more than two-thirds of the available water supply for agriculture, in many Asian countries (Barker *et al.* 1999). India is the world's second largest producer of rice. It is cultivated over an area of 44.2 million ha, which is about 50 % of the total irrigated agriculture area of the country (Anon, 2016). Rice consumes around 5000 liters of water to produce one kg of grain, which is three times higher than other cereals (Belder *et al.* 2004). Recently, more rice-producing countries are facing water scarcity now than ever before, which threatens the sustainability of irrigated rice ecosystem.

The present and future food security of Asia and India depends upon the irrigated rice production system. Irrigated rice crop uses high amount of water because the crop is grown under low land condition, the soil is puddle and the field is kept flooded with 3 to 5 cm depth of water after transplanting until 10 days before harvest. As the demand for water for domestic, municipal, industrial and environmental purposes rise in the future, less and less water would be available for irrigation. Water availability for agriculture in India which is 83.3% of total water used today, will shrink to 71.6% 2025 and to 64.6% in 2050, indicated by the Ministry of Agriculture, Government of India. To safeguard food security and preserve precious water resources, ways must be explored to grow more rice with less water (Belder *et al.* 2002). In addition, cultivation of paddy using bore well / filter points leads over exploitation of ground water as paddy consumes more water and improper water management practices causes increasing of salt affected soils.

These situations force to produce more rice with less water to ensure the food security of India where water scarcity for agricultural use is increasing. One of the approaches that lead to a considerable amount of water saving in rice production is drip irrigation. It is fundamentally different approach to reduce water use in rice cultivation where rice is grown as irrigated dry upland crop (Ottis *et al.* 2006). It is considered as an alternative irrigation approach for better water and fertilizer use efficiency (Assouline 2002; Hanson & May 2003; Eid *et al.* 2013). Drip irrigation is a promising system for economizing on the available irrigation water. Preliminary studies in some countries suggested that drip irrigation has the potential for large water savings compared to conventionally flooded rice production. There is growing interest in adopting drip irrigation in rice in several countries with the yield levels ranging of 6-8 t/ha (Medley and Wilson, 2008). Anusha and Nagaraju (2015) compared rice genotypes under drip irrigation with conventional transplanted system and found that across genotypes drip irrigated rice recorded significantly higher yield 7934 kg/ha, 19% higher than that of conventional flood system (6659 kg/ha), resulted in 58% water saving. Water productivity was highest under drip (11.80 kg/ha mm) as compared to transplanted rice (4.17 kg/ha mm). Besides water saving, precise nutrient management through fertigation with drip irrigation can reduce overall fertilizer application rates and minimize adverse environmental impact. Researchers have demonstrated drip-irrigated crop response to N fertilizer with higher water use efficiency (Wang *et al.* 2009). Keeping all this in view, the present study was carried out to study the effect of lateral spacing, plant row spacing, levels and source of fertilizers on the growth, yield parameters and productivity of drip irrigated rice

MATERIALS AND METHODS

A field experiment was conducted at Tamil Nadu Rice Research Institute (TRRI), Tamil Nadu Agricultural University, Aduthurai to study the effect of lateral spacing, plant row spacing, fertilizer levels and source of fertilizers on the productivity of drip irrigated rice. The experimental site TRRI, Aduthurai is present in the middle of the Cauvery Delta Zone, Tamil Nadu, India, geographically located at 11^{o} N latitude 79.3^{o} E longitude with an altitude of 19.4 m above MSL. The soil of the experimental field was alluvial clay with pH of 7.5 and EC of 0.3 dS/m and low, high and medium in available nitrogen, phosphorus and potassium contents respectively. The experiment was conducted in strip plot design with replicated thrice. Main plot treatments consisted of two lateral spacing (80 and 100 cm) with two plant row spacing (uniform row spacing and modified row spacing). In 80 cm lateral spacing uniform row spacing of 20 × 10 cm and modified row spacing of 7.5 × 20 × 25 × 20 × 7.5 cm were adopted. In case of 100 cm lateral spacing, uniform row spacing of 20 × 10 cm and modified row spacing of 7.5 × 15×15×25×15×15×7.5cm were adopted. Number of plant rows irrigated by 80 cm lateral spacing was four rows. Whereas, in 100 cm lateral spacing, it was five rows in uniform spacing and six rows in modified row spacing. In sub plots, combination of two fertilizer levels (75 and 100% RDF) and two sources of feriltizers (common fertilizers - urea and muriate of potash and water soluble fertilizers – mono ammonium phosphate and sulphate of potash) were used for fertigation.

Short duration hybrid CORH 3 was used. Manual sowing of seeds was done in the finely prepared dry soil. Drip system was installed with the lateral spacing of 80 cm and 100 cm and emitter/dripper spacing of 30 cm. Discharge rate of drippers was 1.0 litre per hour. Irrigation was given at 150% Pan Evaporation during throughout the cropping period in every alternate day. Recommended dose of fertilizer (150: 50:50 kg NPK/ha) was adopted. The entire P as SSP was applied as basal during land preparation. The N as urea and K were given in 15 splits starting from 14 DAS to heading stage at 5 days interval along with irrigation water. Observations on growth and yield attributing characters and grain yield of rice, water usage were recorded. Water productivity was worked out by dividing the grain yield with total water used for crop. Data on various characters studied during the course of investigation was statistically analysed with the confidence level set at 5% was used to compare the differences among treatment means (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Growth parameters

Growth parameters of drip irrigated rice significantly varied due to lateral spacing, row spacing and fertigation treatments (Table 1). Lateral spacing at 80 cm with modified row spacing (7.5 × 20 × 25 × 20 × 7.5 cm) produced significantly taller plants (76.1 cm), more number of leaves per hill (74.9/hill) and tillers population (625 per m^2) than lateral spacing of 100 cm with modified row spacing (7.5 × 15 × 15 × 25 × 15 × 15 × 7.5cm). However, this was comparable with uniform row spacing in both 80 and 100 cm lateral spacing. This was mainly due to uniform water availability to all the rows under modified row spacing. Lateral spacing at 80 cm with uniform row spacing (20 ×10 cm) registered higher plant height of 73.9 cm, number of leaves per hill (70.4) and tillers population of 602 per m^2. Uniform row spacing in 80 cm lateral spacing produced more tillers over 100 cm lateral spacing because of higher water available to all the four rows over 100 cm lateral spacing where the fifth row present in the middle received less water. Minimum growth parameters of rice viz., plant height (71.4 cm) and leaves per hill (60.2) were recorded with lateral spacing of 100 cm with modified row spacing.

Among the fertigation treatments, application of 100% RDF as soluble fertilizers recorded significantly taller plants (74.7 cm), more numbers of leaves per hill (71.7/hill) and tillers population (660 per m^2) than 75% RDF irrespective of sources. However, it was on par with 100% RDF as conventional fertilizers which registered plant height of 73.6 cm, number of leaves per hill of 71.4 and tillers population of 634/m^2. Availability of more phosphorus from water soluble fertilizer (MAP) favoured production of more tillers. The enhancement of growth parameters might be due to the uniform wetting area and root zone application of nutrients through drip system coupled with constant and continuous availability

Table 1: Effect of lateral, plant row spacing, fertilizer levels and sources on growth parameters of drip irrigated rice

Treatments	Growth parameters			Leaf chlorophyll (SPAD value)
	Plant height (cm)	No. of leaves per hill	Tillers population m^{-2}	
Main plot: Lateral and plant row spacing				
M_1: LS 80 cm (20 × 10 cm)	73.9	70.4	602	39.2
M_2: LS 80 cm (7.5 × 20 × 25 × 20 × 7.5 cm)	76.1	74.9	625	39.4
M_3: LS 100 cm (20X10 cm)	73.0	65.8	571	37.5
M_4: LS 100 cm (7.5 × 15 × 15 × 25 × 15 × 15 × 7.5cm)	71.4	60.2	606	37.6
CD (P=0.05)	4.3	4.7	48	1.5
Sub plot: Fertilizer levels and sources				
S_1: 75% RDF (CF)	70.9	59.4	544	37.0
S_2: 100% RDF (CF)	73.6	71.4	634	39.1
S_3: 75% RDF (WSF)	72.1	68.8	565	37.6
S_4: 100% RDF (WSF)	74.7	71.7	660	40.0
CD (P=0.05)	3.6	3.4	30	1.9

LS- Lateral spacing ; RDF- Recommended dose of fertilizer ; CF- Conventional fertilizers; WSF- Water Soluble fertilizers.

of optimum soil moisture which permitted the plants to absorb more nutrients. These results are in agreement with the findings of (Reddy and Aruna 2012). Fertigation of 75% RDF as conventional fertilizers recorded significantly shorter plants (70.9 cm), minimum leaves per hill (59.4) and tillers (544 per m^2) than 100 % RDF.

Leaf chlorophyll content was observed by using SPAD meter at flowering stage and revealed that significantly higher SPAD meter reading was recorded in 80 cm lateral spacing irrespective of row spacing over 100 cm lateral spacing. Application of water soluble fertilizers at 100% RDF showed statistically higher SPAD reading over 75% RDF either as conventional or water soluble fertilizers. But, it was comparable with 100% RDF as conventional fertilizers. Higher availability of nitrogen and water under these treatments favoured higher chlorophyll synthesis which led to more SPAD reading.

Root growth characters

Root characters of rice influenced by lateral spacing, row spacing and nutrient management in drip irrigation during maximum tillering stage (Fig. 1). Significantly higher root length (18.5 cm), root volume (13.1cc) and root dry weight (6.2g) were registered under lateral spacing of 80 cm with altered row spacing mainly because of higher availability of water to both the rows. This was comparable with same lateral spacing with uniform row spacing except root dry weight. Drip irrigation creates favourable soil physical, chemical and biological properties that support plant growth under mostly aerobic soil conditions, encouraging better root growth parameters. (Stoop *et al.* 2002). Similarly, Parthasarathi *et al.* (2013) observed that lateral spacing of 80 cm and plants spaced at 20 cm × 10 cm with 1 lph drippers along with sub-surface drip irrigation treatment achieved good root growth of rice. In 100 cm lateral spacing, uniform row spacing produced higher root length and volume over modified row spacing. Presence of closer spacing and more number of rows under 100 cm lateral spacing with modified row spacing caused lesser root length and volume. Lower root growth parameters of rice were noticed with 100 cm lateral spacing in modified row spacing.

Among the nutrient management practices, 100% RDF as soluble fertilizers produced statistically higher root length (16.4 cm), root volume (11.5 cc) and root dry weight (5.6 g/plant) than 75% RDF irrespective sources at maximum tillering stage. This is mainly because application of fertlizers through drip irrigation resulted in continuous supply of nutrients besides maintaining optimum water availability which leads to higher root growth parameters of rice. Significant difference has not been noticed between water soluble and conventional fertilizers in terms of root growth. Fertigation of 75% RDF produced lesser root growth parameters of rice. Minimum root volume (9.2 cc) and dry weight (4.6 g/plant) were obtained with fertigation of 75% RDF as conventional fertilizers.

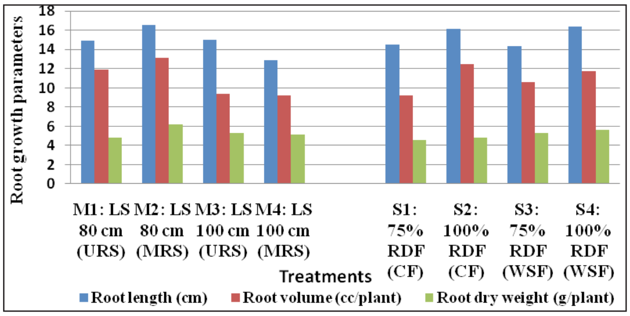

Fig. 1: Effect of lateral, plant row spacing, fertilizer levels and sources on root growth parameters of drip irrigated rice

Yield characters

Yield characters of rice altered favourably by the lateral, row spacing spacing and nutrient management practices (Table 2). Lateral spacing of 80 cm recorded significantly more number of productive tillers (453/m^2) and number of filled grains per panicle (124.9) under modified row spacing (7.5 × 20 × 25 × 20 × 7.5 cm) than lateral spacing of 100 cm irrespective of plant row spacing. However, this treatment was comparable with lateral spacing of 80 cm coupled with uniform row spacing in number of filled grains per panicle. The reasons for higher yield attributes may be due to the continuous supply of required quantity of water and nutrients below the root zone of the crop. This result is in conformity with the findings of Vanitha and Mohandass, (2014). Minimum number of productive tillers was registered in 100 cm lateral spacing with uniform row spacing. In case of filled grains, 100 cm lateral spacing with modified row spacing recorded minimum number of filled grains mainly due to poor lateral movement of irrigation water created water stress at the root zone rows

Table 2: Effect of lateral, plant row spacing, fertilizer levels and sources on yield parameters, grain yield and water productivity of drip irrigated rice

Treatments	Yield parameters			Grain yield (Kg/ha)	Water productivity (kg/ha/mm)
	Productive tillers No./m^2	Filled grains/ panicle	Ill filled grains/ panicle		
Main plot: Lateral and plant row spacing					
M_1: LS 80 cm (20 × 10 cm)	417	116.4	24.0	4721	3.41
M_2: LS 80 cm (7.5 × 20 × 25 × 20 × 7.5 cm)	453	124.9	19.6	5055	3.65
M_3: LS 100 cm (20X10 cm)	380	101.6	23.5	3154	2.28
M_4: LS 100 cm (7.5 × 15 × 15 × 25 × 15 × 15 × 7.5cm)	410	84.6	30.7	2911	2.10
CD (P=0.05)	33	8.6	2.0	305	0.3
Sub plot: Fertilizer levels and sources					
S_1: 75% RDF (CF)	383	102.5	24.9	3656	2.64
S_2: 100% RDF (CF)	445	107.1	23.3	4107	2.96
S_3: 75% RDF (WSF)	382	103.9	24.4	3847	2.78
S_4: 100% RDF (WSF)	450	114.1	25.2	4230	3.05
CD (P=0.05)	29	10.7	1.5	346	0.2

LS- Lateral spacing ; RDF- Recommended dose of fertilizer; CF- Conventional fertilizers; WSF- Water Soluble fertilizers.

away from the lateral during the cropping period. Among the nutrient management practices, water soluble fertilizer at 100 % recommended dose registered more number of productive tillers (450/ m^2) and number of filled grains per panicle (114.1) over lower dose of fertilizer. There was not much variation in yield attributes due to fertilizer sources in both levels.

Number of ill filled grains was more in 100 cm lateral spacing with modified row spacing(30.7) mainly due to poor soil moisture and more number of rows per lateral (six rows), followed by lateral spacing 80 cm with uniform plant row spacing (24.0). Minimum number of ill filled grains (19.6) was noticed in lateral spacing of 80 cm with modified row spacing over other treatments. Presence of adequate soil moisture in all the rows under modified row spacing favoured better grain filling. Lesser number of ill filled grains per panicle (23.3) was noticed with 100 % RDF as conventional fertilizers than 100 % RDF as water soluble fertilizers. This was followed by application of 75% RDF as water soluble fertilizers (24.4). More number of ill filled grains per panicle (25.2) was obtained with 100 % RDF as soluble fertilizers.

Grain yield

Grain yield of rice was positively influenced by different lateral, row spacing and nutrient management under drip irrigation (Table 2). Significantly higher grain yield of 5055 kg/ha was obtained with lateral spacing of 80 cm and modified row spacing (7.5 × 20 × 25 × 20 × 7.5 cm) than other treatments. Alteration of plant row spacing brought the second row closer to the lateral (30 cm in uniform spacing and 22.5 cm in modified row spacing) caused higher availability of soil moisture in the root zone of all the four rows present in between the laterals at regular interval favoured better crop growth, yield attributes and grain yield in this treatment. The amount of water supplied with drip irrigation which is sufficient to saturate the soil during reproductive stage resulting in better spikelet fertility and finally the yield. Similar trend was observed by Sritharan *et al.* (2010), Soman (2012), and Vanitha (2012) on rice. Lateral spacing of 80 cm with uniform plant row spacing (20 × 10 cm) recorded grain yield of 4721 kg/ha. The lateral spacing at 100 cm in both regular as well as modified row spacing registered significantly lesser grain yield than 80 cm, mainly due to poor lateral movement of water and lesser availability of soil moisture and nutrients at 100 cm lateral spacing. In the case of 100 cm lateral spacing, uniform row spacing registered higher grain yield of 3154 kg/ha than modified row spacing (2911 kg/ha).

Among the levels and sources of fertilizer tested in fertigation, application of 100 % recommended fertilizer as water soluble fertilizer produced significantly higher grain yield of 4230 kg/ha over lesser doses of fertilizers. Drip fertigation with water soluble fertilizers such as MAP and SOP provides the essential nutrients directly to the active root zone, thus minimizing the loss of nutrients which ultimately helps in higher nutrient uptake and improving the productivity of rice. Further, continuous availability of water and nutrients that resulted in higher uptake of nutrients in turn improved grain yield under drip fertigation. Similar findings were reported by Karthika and Ramanathan (2019). This was comparable with application of 100% fertilizer as conventional fertilizer. Reduction in fertilizer dose (25%) recorded lesser yield than 100% recommended dose of fertilizers in both the sources. Between sources of fertilizers, no significant difference in grain yield was observed.

Water productivity

Water productivity is an accurate indicator of agricultural productivity in relationship to crop's consumptive use of water. Water productivity of drip irrigated rice positively influenced by lateral spacing, plant row spacing, fertilizer levels and doses. In this field trial, water productivity results reflected exactly the same trend as grain yield. Total water used for rice cultivation under drip irrigation at 150% pan evaporation was 1386 mm during cropping season. Higher water productivity of 3.65 kg/ha/mm of water was obtained under 80 cm lateral with modified row spacing mainly because of higher grain yield under this treatment due to uniform wetting. Similarly, improved water productivity of aerobic rice was achieved under drip irrigation as compared to flooded rice (Grassi *et al.* 2009). Lateral spacing of 100 cm recorded lesser water productivity over 80 cm spacing. Between fertilizer levels, 100 % RDF produced higher water productivity over 75% RDF. Water soluble fertilizers recorded increased water productivity over conventional fertilizers. Higher water productivity was mainly due to higher grain yield obtained under these treatments.

CONCLUSION

From the present field investigation on drip fertigation for hybrid rice, it could be concluded that growing of hybrid rice CORH 3 under drip irrigation using 80 cm lateral spacing, modified row spacing (7.5 × 20 × 25 × 20 × 7.5 cm) and fertigation of 100 % recommended dose of fertilizers either as conventional or water soluble fertilizers found to increase the productivity of hybrid rice.

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