OPTIMIZATION OF WATER AND NUTRIENT REQUIREMENT FOR YIELD MAXIMIZATION IN HYBRID RICE UNDER DRIP FERTIGATION SYSTEM

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ABSTRACT

Field experiments were conducted at central farm, Agricultural College and Research Institute, Madurai, during *Kharif* and *Rabi* 2008 - 2009 to study the effect of drip fertigation on growth and yield of hybrid rice. The experiments were laid out in factorial randomized block design with four replications. The treatments consisted of two irrigation regimes (drip irrigation at 100 % and 150 % PE) and five nutrient levels viz., soil application of 100 % RDF, drip fertigation of 100 % RDF (P as basal, N and K as urea and Kcl), drip fertigation of 50, 75 and 100 % RD of P and K (50 % P and K as basal remaining N, P and K as WSF + LBF). Drip irrigation was scheduled once in two days and fertigation was given once in six days as per the treatment schedule.

Drip irrigation at 150 % PE exhibited better plant height, number of tillers, leaf area index, root characters and dry matter production in hybrid rice. Similarly, it accounted for higher number of productive tillers per hill, panicle length, number of filled grains per panicle, grain and straw yields. The sterility percentage was also lesser in this treatment.

Among the nutrient levels, drip fertigation of 100 per cent RD of P and K (50 % P and K as basal remaining, N, P and K as WSF + LBF) registered better plant height, number of tillers, leaf area index, root characteristics and dry matter production. Yield attributes *viz.,* higher values of number of productive tillers per hill, panicle length, number of filled grains per panicle, grain and straw yields of hybrid rice found to be comparable with drip fertigation of 75 per cent of P and K (50 % P and K as basal remaining, N, P and K as WSF + LBF)

The above treatment also recorded higher N,P and K uptake and lower post harvest soil available N, where as the post harvest soil available P and K were lesser under drip fertigation of 50 per cent of P and K (50 % P and K as basal remaining, N, P and K as WSF + LBF)

Drip irrigation at 100 % PE was found to be better than other irrigation regime (150 % PE) as for as water use is concerned. It has registered an optimum consumptive water use and higher water use efficiency.

Net return and benefit cost ratio were higher with drip irrigation at 150 % PE with drip fertigation of 75 per cent of P and K (50 % P and K as basal remaining, N, P and K as WSF + LBF). It was followed by drip irrigation at 150 % PE with drip fertigation of 100 per cent of P and K (50 % P and K as basal remaining, N, P and K as WSF + LBF)

From the above study, it can be concluded that the rice hybrid Co(R) H3 responded well to the combination of drip irrigation at 150 % PE with drip fertigation of 100 per cent of P and K (50 % P and K as basal remaining, N, P and K as WSF + LBF) maximizing the yield and gross income. However, drip irrigation at 150 % PE with drip fertigation of 75 per cent of P and K (50 % P and K as basal remaining, N, P and K as WSF + LBF) recorded higher net income compared to other treatments. Hence, drip irrigation at 150 % PE with drip fertigation of 75 per cent of P

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and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) was found to be the best treatment combination for hybrid rice.

Objectives

1. To study the performance of raised bed system of rice cultivation under drip fertigation system
2. To find out the effect of drip fertigation on the growth and yield of rice grown under raised bed system of cultivation.
3. To work out the economics of drip fertigation on rice grown under raised bed system of cultivation.

Technical Programme

Treatments

a. Irrigation regimes

I_1 - Irrigation at 100 % PE
I_2 - Irrigation at 150 % PE

b. Nutrient management

N_1 – Soil application of Recommended dose of fertilizer
N_2 – DF of recommended N & K (P as basal)
N_3 – DF of 50 % of Recommended dose of P & K – 50 % as basal + balance NPK as WSF + LBF + Humic acid
N_4 – DF of 75 % of Recommended dose of P & K – 50 % as basal + balance NPK as WSF + LBF + Humic acid
N_5 – DF of 100 % of Recommended dose of P & K – 50 % as basal + balance NPK as WSF + LBF + Humic acid

Design: FRBD **Rep : Four**

Absolute Control: Drum seeding with recommended practices

Note

- PE – Pan Evaporation
- DF – Drip fertigation
- LBF – Liquid bio fertilizer
- WSF – Water soluble fertilizer (13:40:13, and KNO_3)
- The liquid bio fertilizers (Azospi, Phosphofix and Potash activa) were applied in two splits on 15 and 30 DAS @ 500 ml/ha and humic acid was applied @ 2.5 l/ha through the system.
- For the treatment one and two the commercial fertilizers urea, MOP and SSP were used
- Irrigation was given once in two days based on PE
- Fertigation was given once in 6 days as per the treatments
- Seeds were sown in raised beds having a top bed width of 90 cm with a spacing of 20 x 15 cm

Fertigation

The fertilizer used for fertigation were as follows.

Water soluble fertilizer	Nitrogen(%)	Phosphorus(%)	Potassium(%)
Urea	46	-	-
KNO_3	13	-	45
Poly feed	13	40	13
Liquid bio fertilizer	Azospi	Phosphofix	Potash activa
Humic acid	-	-	-

Results

Total water use (Table 1)

Higher consumptive use of water to the extent of 1027 mm and 822 mm were registered in drip irrigation at 150% PE during 2008 and 2009 respectively. The lowest consumptive use of water was757 mm and 591 mm observed under drip irrigation at 100 % PE during both the years respectively.

Table 1. Total water (mm) used for hybrid rice under drip fertigation system

Planting systems	Irrigation water(mm)		Effective rainfall(mm)		Total water(mm)	
	Kharif 2008	*Rabi 2009*	Kharif *2008*	*Rabi 2009*	Kharif *2008*	*Rabi 2009*
DI at 100% PE	565	479	192	112	757	591
DI at 150% PE	847	718	180	104	1027	822

Statistically not analyzed

Drip irrigation is an efficient method to deliver water and nutrients to the plants because water is directly applied to the effective root zone of crop plants (Balakrishnan, 2006). The loss of water is minimum and that results in the lower water requirement in the drip irrigation system. Drip irrigation at 100 % has resulted in considerable saving in water compared to drip irrigation at 150 % PE.

Plant height and productive tillers (Table 2)

The plant height was significantly influenced by irrigation regimes. Drip irrigation at 150 % PE registered maximum plant height at all the stages of crop growth during both the years, which was followed by drip irrigation at 100 % PE. At maturity it was 104.8 and 101.2 cm respectively.

Nutrient levels also significantly influenced the plant height at all the stages of crop growth. Drip fertigation of 100 per cent RD of P and K (50 per cent P and K as basal, remaining N, P and K as WSF+ LBF) (N_5) recorded higher plant height. At maturity stage the plant height recorded for the above treatment was 114.4 cm and 110.5cm respectively. This was comparable with drip fertigation of 75 per cent RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (N_4).

The interaction effect of irrigation regimes and nutrient levels was significant at all the stages of crop growth. Maximum plant height was recorded under drip irrigation at 150 % PE with DF of 100 per cent RD of P and K (50 per cent P and K as basal, remaining N, P and K as WSF+ LBF) (I_2N_5) which was 119.0 cm and 114.9 cm during both the years respectively. It was comparable with drip irrigation at 150 % PE with

DF of 75 per cent RD of P and K (50 per cent P and K as basal, remaining N, P and K as WSF+ LBF) (I_2N_4).

Table 2. Effect of irrigation regimes and nutrient levels on plant height and productive tillers hybrid rice under drip fertigation system

Plant height at maturity stage (cm) Kharif 2008			**Plant height at maturity stage (cm)**			**No. productive tillers per m^2 Kharif 2008**			**No. productive tillers per m^2 Rabi 2009**		
I_1	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
81.4	84.3	**82.9**	78.6	81.4	**80.0**	460	477	**468**	441	457	**449**
93.9	96.4	**95.2**	90.7	93.1	**91.9**	531	545	**538**	509	522	**516**
98.1	106.5	**102.3**	94.7	102.8	**98.8**	555	602	**578**	531	577	**554**
101.0	117.8	**109.4**	97.5	113.7	**105.6**	571	666	**619**	547	638	**593**
109.8	119.0	**114.4**	106.0	114.9	**110.5**	621	673	**647**	595	645	**620**
96.9	**104.8**		**93.5**	**101.2**		**548**	**593**		**525**	**568**	
I	**N**	**I x N**	**I**	**N**	**I x N**	**I**	**N**	**I x N**	**I**	**N**	**I x N**
0.93	1.47	2.08	0.90	1.42	2.01	7.713	12.19	17.24	7.39	23.98	33.91
1.91	3.03	4.28	1.85	2.92	4.14	15.82	25.02	35.39	15.16	23.98	33.91

Productive tiller production (Table 2)

Drip irrigation at 150 % PE recorded higher productive tillers of 593 m^{-2} and 568 m^{-2} during 2008 and 2009 respectively. Among different nutrient levels, DF of 100 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (N_5) recorded higher productive tillers of 647 m^{-2} and 620 m^{-2} during *2008* and *2009* respectively.

Regarding interaction, drip irrigation at 150 % PE with DF of 100 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (I_2N_5) registered significantly higher number of productive tillers viz., 673 m^{-2} and 645 m^{-2} respectively in hybrid rice during both the years and this was on par with (I_2N_4).

Grain yield (Table 3)

Irrigation regimes and nutrient levels had a profound influence on the grain yield of hybrid rice. Drip irrigation at 150 % PE (I_2) recorded significantly higher grain yield (6206 and 5601 kg ha^{-1}) during both the years. Drip irrigation at 100 % PE (I_1) resulted in producing lesser grain yield (5735 and 5176 kg ha^{-1}) during both the years of study.

Among the nutrient levels, drip fertigation of 100 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (N_5) recorded significantly higher grain yield (6776 and 6115 kg ha^{-1}) during both the years of experimentation followed by drip fertigation of 75 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (N_4). Soil application of 100 % RDF (N_1) recorded lesser grain yield of 4906 and 4428 kg ha^{-1} during both seasons of experimentation.

Table 3. Effect of irrigation regimes and nutrient levels on hybrid rice grain yield under drip fertigation system

Treatments	Kharif *Grain Yield Kg ha -1*			*Rabi Grain Yield Kg ha -1*		
	I_1	I_2	Mean	I_1	I_2	Mean
N_1	4350	4506	**4428**	4120	4206	**4163**
N_2	4420	4624	**4522**	4253	4423	**4338**
N_3	4756	5790	**5273**	4653	5690	**5172**
N_4	5688	6588	**6138**	5830	6524	**6177**
N_5	6183	6892	**6538**	5916	6729	**6323**
Mean	**5079**	**5680**		**4954**	**5514**	
	I	**N**	**I x N**	**I**	**N**	**I x N**
SEd	74.55	117.8	166.7	72.51	114.6	162.1
CD (0.05)	152.9	241.8	342.0	148.7	235.6	332.7

Interaction between the treatments was significant and followed the similar trend as that of number of productive tillers per hill. Among the treatment combinations, drip irrigation at 150 % PE with DF of 100 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (I_2N_5) registered significantly higher grain yield of 7049 and 6361 kg ha^{-1} during 2008 and 2009 respectively and this was on par with (I_2N_4) and (I_1N_5). Significantly lesser grain yield of 4820 and 4350 kg ha^{-1} was registered under drip irrigation at 100 % PE with soil application of 100 % RDF (I_1N_1)) during both the years respectively.

Water use efficiency and water productivity (Table 4)

Drip irrigation had favourable and marked influence on WUE of hybrid rice. Drip irrigation at 100 % PE (I_1) recorded significantly higher WUE efficiency (6.71 and 8.38 kg $ha^{-1}mm^{-1}$). Lower WUE of 5.53 and 6.71 $kgha^{-1}$ mm^{-1}were observed when drip irrigation was given at 150 % PE (I_2).

Table 4. Water Use Efficiency and Water Productivity of hybrid rice under drip fertigation system

Treatments	WUE (kg ha^{-1} mm^{-1})		Water productivity (Rs ha^{-1} mm^{-1})	
	Kharif *2008*	*Rabi 2009*	Kharif *2008*	*Rabi 2009*
Irrigation regime				
I_1	6.71	8.38	64.17	80.02
I_2	5.53	6.71	52.61	63.75
SEd	0.117	0.127	1.096	1.213
CD (0.05)	0.240	0.262	2.250	2.489
Nutrient levels				
N_1	5.07	6.04	48.31	57.85
N_2	5.17	6.29	50.30	61.23
N_3	5.96	7.40	57.25	70.87
N_4	6.96	8.90	65.89	83.63
N_5	7.44	9.10	70.22	85.86
SEd	0.185	0.202	1.733	1.918
CD (0.05)	0.376	0.414	3.557	3.936

Regarding the nutrient levels, drip fertigation of 100 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (N_5) registered higher WUE of 7.44 and 9.10 kg $ha^{-1}mm^{-1}$ followed by drip fertigation of 75 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (N_4). The lowest WUE values were observed when soil application of 100 % RDF (N_1) was done during both the years.

Regarding water productivity, drip irrigation at 100 % (I_1) significantly recorded higher water productivity of (64.17 and 80.02 Rs ha^{-1}). Lowest water productivity of 52.61 and 63.75 Rs ha^{-1} was observed with irrigation at 150 % PE (I_2). Regarding the nutrient levels, drip fertigation of 100 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (N_5) registered higher water productivity of 70.22 and 85.86 Rs ha^{-1} mm^{-1} followed by drip fertigation of 75 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (N_4). The lowest water productivity values were observed with soil application of 100 % RDF (N_1) during both the years.

Harvest index (Table 5)

Harvest index was numerically high under drip irrigation at 150 % PE (I_1) during both seasons**.**

Table 5. Effect of irrigation regimes and nutrient levels on harvest index of hybrid rice under drip fertigation system

Season	***Kharif***			***Rabi***		
Treatments	**I_1**	**I_2**	**Mean**	**I_1**	**I_2**	**Mean**
N_1	0.45	0.45	**0.45**	0.44	0.46	**0.45**
N_2	0.42	0.42	**0.42**	0.42	0.44	**0.43**
N_3	0.42	0.45	**0.44**	0.43	0.46	**0.45**
N_4	0.46	0.46	**0.46**	0.46	0.47	**0.47**
N_5	0.46	0.47	**0.47**	0.46	0.47	**0.47**
Mean	**0.44**	**0.45**		**0.44**	**0.46**	

Statistically not analysed

With regards to nutrient levels, Drip fertigation of 100 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (N_5) recorded higher harvest index during both the seasons.

Economics (Table 6)

Among the different combinations, drip irrigation at 150 % PE with drip fertigation of 75 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (I_2N_4) resulted in higher net return of Rs.30860 and Rs.29978 ha^{-1} during *2008* and 2009 respectively and it was followed by drip irrigation at 150 % PE with drip fertigation of 100 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (I_2N_5) which registered Rs.30834 and Rs.29209 during 2008 and 2009 respectively. Drip irrigation at 100 % PE with soil application 100 % RDF (I_1N_1) resulted in lesser net returns (Rs.17076 and Rs.14999).

The benefit cost ratio also followed the same trend as that of net returns. Higher B: C ratio of 1.99 and 1.95 was observed in the treatment of drip irrigation at 150 % PE with drip fertigation of 75 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) (I_2N_4) during both the years.

Table 6. Economics of hybrid rice under drip fertigation system

Treatments	Kharif *2008*				*Rabi 2009*			
	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
I_1N_1	24399	41475	17076	1.70	24399	39398	14999	1.61
I_1N_2	23999	43061	19062	1.79	23999	41452	17453	1.73
I_1N_3	28429	46092	17663	1.62	28429	44982	16553	1.58
I_1N_4	31529	53788	22259	1.71	31529	54629	23100	1.73
I_1N_5	34037	58472	24435	1.72	34037	56013	21976	1.65
I_2N_1	24399	42960	18561	1.76	24399	40316	15917	1.65
I_2N_2	23999	44898	20899	1.87	23999	43009	19010	1.79
I_2N_3	28429	55050	26621	1.94	28429	53940	25511	1.90
I_2N_4	31529	62363	30834	1.99	31529	61507	29978	1.95
I_2N_5	34037	64897	30860	1.91	34037	63246	29209	1.86

Statistically not analyzed

Though the cost of installing drip fertigation unit was high (Rs 83,099 ha^{-1}) considering longer life period of drip fertigation system (10 years), the benefit out of drip fertigation will be for longer period.

Kavitha *et al.* (2007) also reported that though the yield was higher with water soluble fertilizer, the benefit cost ratio was less mainly due to high cost of special fertilizer in drip fertigated tomato. However, the yield and gross income was high in the fertigated plots, due to higher uptake and nutrient use efficiencies from the costly fertilizers, which obtained a very meager difference of B: C ratio when compared to drip irrigation with soil application of 100 % RDF. Thus, the additional expenditure towards the water soluble fertilizers was well compensated through greater additional income.

Economic feasibility of adopting drip irrigation has been reported in sugarbeet (Sharmasarkar *et al.,* 2001), chilli (Selvakumar, 2006) and sugarcane (Dhanalakshmi,1999).

Thus, from the forgoing discussion, in addition to higher yield and income, higher quantity of irrigation water saving coupled with higher water and nutrient use efficiencies indicate the practical feasibility of adopting drip fertigation for sustainable rice production. Drip fertigation may also provide opportunity to bring additional area under rice cultivation to meet the domestic and export demands of rice.

Summary and Conclusion

The following conclusion could be drawn in cultivation of hybrid rice CO(R)H3 under drip fertigation system

- ✓ Drip irrigation to hybrid rice at 150 % PE was found to be optimum irrigation regime it recorded higher growth parameters, yield attributes and yield.
- ✓ Drip fertigation of 100 % RD of P and K (50 % P and K as basal, remaining NPK as WSF + LBF) enhanced the growth parameters, yield attributes and yield of hybrid rice.
- ✓ In combination, fertigation of 100 % RD of P and K (50 % P and K as basal, remaining NPK as WSF + LBF with drip irrigation at 150 % PE) excelled the other treatments by recording higher growth and yield.
- ✓ Though the growth, yield attributes and yield of hybrid rice was higher under fertigation of 100 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) with drip irrigation at 150 % P, the cost benefit ratio was comparatively lower than fertigation of 75 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) with drip irrigation at 150 PE due to higher cost of water soluble fertilizer.

Recommendation

Fertigation of 75 % RD of P and K (50 % P and K as basal, remaining N, P and K as WSF + LBF) at six days interval with drip irrigation at 150 % PE once in two days would be an ideal level to achieve higher net income in hybrid rice cultivation under drip fertigation system.