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Compendium for Mechanised Direct Sown Rice Cultivation in Cauvery New Delta Zone

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Shortages of labour, water and the adverse effects of puddled soil health are forcing farmers to switch from puddled transplant to alternate rice production system. The experiment results showed that sowing of seed @ 40kg ha^{-1} by multi crop planter (Happy seeder) under dry condition. Alternate wetting and drying (AWD) method of irrigation along with the fertilizer dose of 120:50:50 NPK kg ha^{-1}, weed management by the application of Pretilachlor @ 0.45 l ha^{-1} on 5 DAS and two machine weeding on 30 and 45 DAS had recorded the highest establishment percentage, optimum number of productive tillers, the highest number of grains per panicle, the highest grain yield (8.16 t ha^{-1}), net income (74,477 Rs ha^{-1}), BCR(3.80) and the highest water use efficiency (0.58 kg ha^{-1} mm^{-1}). Sowing of seed @ 40 kg ha-1 by multi crop planter (Happy seeder) under dry condition and AWD method of irrigation is important to achieve higher establishment percentage, higher production of grain and straw yield, BCR and WUE. Lesser weed density, higher weed control efficiency and higher plant height was achieved under continuous submerged irrigation. Similarly, increase in seed rate reduced the weed density and increased the weed control efficiency.

Key words: Direct sown rice, Mechanised production, WUE

The method of cultivation of rice in a particular region depends largely on factors such as type of land, type of soils, irrigation facilities, and availability of labourer, intensity and distribution of rainfall. The trend over the last 10 years in Tamil Nadu indicates that the rice production is facing many constraints such as untimely release and non availability of water for the first season, increase in labour cost coupled with poor efficiency of labour, increase in cost of inputs and declining of soil fertility, leading to decrease in profitability for the farmers in rice cultivation (Sivagnanam and Murugan, 2015). Recent changes in rice production technology have improved the desirability towards direct-seeding methods and there has been a rapid shift to the direct-seeding method of rice establishment in Southeast Asia (Kumar and Ladha, 2011). Weed control is a major pre-requisite for improved rice productivity and production under direct seeded rice cultivation. Weed competition is less severe under transplanting than under direct-seeding (Singh *et al*., 2005; Rao *et al*., 2007). Uncontrolled weeds reduced the grain yield by 75.8, 70.6 and 62.6% under dry-seeded rice (DSR), Wet Seeded Rice (WSR) and transplanted rice (TPR), respectively (Singh *et al*., 2005).

The use of high seed density within the context of integrated crop management is an alternate approach to control the weed problem. Greater understanding is required about the effect of seed rate on weed pressure, pest damage, grain yield, grain quality, harvest index, and crop lodging at maturity to develop management strategies for direct-sown rice in the tropics (Mazid *et al*., 2001). Results of several studies have indicated that nearly 30% of the total water used (1,400–1,800 mm) in rice cultivation is consumed mainly in puddling and transplanting operations. Precise water management is also a critical factor for high productivity for both dry- and wet-seeded rice (De Datta and Nantasomsaran, 1991). Therefore, a key concern is how the water requirement of rice culture can be reduced and how farmers can avoid puddling and transplanting operations without yield penalty.

Under the above circumstances, the current research was conducted by changing seed rate and water levels to control the weeds under mechanised direct sown rice to enhance the production, profitability and water productivity of rice.

Materials and Methods

Experiments were conducted during 2013-2015 during *Samba* season at Agricultural Engineering College and Research Institute, Kumulur, Trichy District in split plot design with three replication using ADT 49 (medium duration) rice variety. The experiment was conducted with the objectives to find our better water management approach under shortage of water in mechanised dry seeding rice cultivation; to identify yield attributes responsible for the yield gap among different seed rate and water level; to study the effect of irrigation method and seed rate on weed control and to study the water and weed interaction under mechanised direct sown rice cultivation. The main plot treatment consisted of four levels of irrigation *viz.,* Irrigation at critical stages up to 55 DAS (PI) and submergence of 2.5 cm (I_1), AWD

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up to harvest (I_2) continuous submergence of 2.5 cm (I_3) and farmers' practices (I_4) (dry conditions up to 55 days, then converted as wet condition). The sub plot treatment consisted of four levels of seed rate @ 30 kg ha^{-1} (S_1), 40 kg ha^{-1} (S_2), 50 kg ha^{-1} (S_3) and 60 kg ha^{-1} (S_4).

The main plot treatment was imposed by using parshal flume, time taken for each treatment was measured and the quantity of water irrigated and total water requirement was calculated for each treatment. The sub plot treatment was imposed by using a multi crop planter (Happy seeder) fitted with an inclined plate seed metering mechanism under dry conditions and the quantum of seed was adjusted by fluted roller metering system. The other agronomic practices of weed management *viz.,* application of Pretilachlor @ 0.45 l ha^{-1} on 5 DAS and two weeding on 30 and 45 DAS were adopted along with fertilizer application of 120: 50: 50 NPK kg ha^{-1} and pest and disease management were adopted. Various parameters such as plant population, establishment percentage, weed density and yield parameters were observed and economics and water use efficiency were calculated.

Results and Discussion

The observation on plant population (numbers/ m^2) at 15 DAS was recorded and establishment percentage was calculated (Table-1). The weed density was recorded on 25 and 40 DAS (Table-2).

Table 1. Influence of seed rate and water regimes on plant population (numbers/ m^2) and establishment percentage under mechanised direct sown rice cultivation

Main plot treatments	Sub plot treatments									
	Plant population (numbers/m^2)					Establishment (%)				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
I1	64	66	76	78	71	73	75	69	73	72
I2	65	65	83	84	74	74	77	74	75	75
I3	69	74	83	86	79	79	83	77	80	80
I4	59	63	74	75	68	67	72	67	68	69
Mean	64	67	79	81		73	77	72	74	
		Main plot treatment	Sub plot treatment	Interaction M x S	Interaction S x M		Main plot treatment	Sub plot treatment	Interaction M x S	Interaction S x M
SED		02	01	02	01		02	01	02	01
CD(p=0.05)		04	03	05	03		04	03	05	03

The yield parameters of rice *viz.,* tiller production (numbers/hill), productive tillers (numbers/hill), number of grains per panicle (Table-3) were observed and grain and straw yields were calculated (Table-4). The cost of cultivation, gross income, net income and BCR were also calculated.

Table 2. Influence of seed rate and water regimes on weed density (Numbers/ m^2) at 25 DAS and 40 DAS under mechanised direct sown rice cultivation

Main plot treatments	Sub plot treatments									
	Weed density at 25 DAS (numbers/m^2)					Weed density at 40 DAS(numbers/ m^2)				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
I1	42	46	32	32	34.5	15	16	10	7	12
I2	27	30	24	23	26.0	17	13	7	7	11
I3	18	19	15	14	16.5	11	6	6	4	7
I4	34	44	34	32	38.8	21	19	13	10	15
Mean	33	32	26	25		16	14	8	7	
		Main plot treatment	Sub plot treatment	Interaction M x S	Interaction S x M		Main plot treatment	Sub plot treatment	Interaction M x S	Interaction S x M
SED		03	01	04	03		02	01	03	02
CD(p=0.05)		05	02	08	05		03	02	05	04

The experimental results showed that irrigation method of AWD up to harvest had recorded the highest number of productive tillers and higher number of grains per panicle, which helped to achieve the highest grain yield (8.16 t ha-^{1}) and net income(74,477 Rs ha^{-1}) with BCR(3.80) (Table-6) and higher water use efficiency (0.58 kg/m^3) (Table-5). Suitable modifications of irrigation infrastructure may not only ensure a high yield of direct-seeded rice, but also improve water-use efficiency (Cantrell and Hettel 2005). The productivity of the direct-seeded crop is on par with transplanting and higher net profit (Singh *et al*., 2005).

Table 3. Influence of seed rate and water regimes on productive tillers (numbers/hill) and grains (numbers/ panicle) under mechanised direct sown rice cultivation

Main plot treatments	Sub plot treatments									
	Productive tillers (numbers/hill)					Grains (numbers/panicle)				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
I1	10.67	11.00	09.33	10.00	10.25	103	104	95	94	99
I2	13.00	12.67	11.33	11.08	12.00	120	121	113	111	116
I3	10.33	11.00	10.33	08.67	10.00	105	107	90	88	96
I4	10.67	10.70	09.70	09.67	10.17	102	101	93	90	107
Mean	11.16	11.33	10.16	09.84		107	108	98	95	
		Main plot treatment	Sub plot treatment	Interaction M x S	Interaction S x M		Main plot treatment	Sub plot treatment	Interaction M x S	Interaction S x M
SED		00.89	00.78	01.63	01.57		04	03	06	07
CD(p=0.05)		01.18	01.22	02.44	02.24		08	07	14	14

Among the treatments, seed rate @ 40 kg ha-^{1} has recorded the highest establishment percentage (77), productive tillers (11.33 numbers per hill), grains (108) per panicle, and the highest yield of (6.39 t ha^{-1}). Lower weed density (25 numbers/m^{2}) at 25 DAS and 40 DAS (7 numbers/m^{2}) was recorded at higher seed rate of 60 kg ha-^{1}.

Table 4. Influence of seed rate and water regimes on grain and straw yield (tha^{-1}) under mechanised direct sown rice cultivation

Main plot treatments	Sub plot treatments									
	Grain yield (tha^{-1})					Straw yield (tha^{-1})				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
I1	5.21	5.62	3.86	3.38	4.52	4.92	5.40	3.66	3.76	4.44
I2	7.11	8.16	5.69	5.04	6.50	6.85	8.14	5.94	5.88	6.70
I3	6.63	7.39	5.16	4.15	5.83	6.74	7.36	5.43	4.47	6.00
I4	4.53	4.38	3.53	3.17	3.90	4.34	4.29	3.53	3.45	3.90
Mean	5.87	6.39	4.56	3.94		5.71	6.30	4.64	4.39	
		Main plot treatment	Sub plot treatment	Interaction M x S	Interaction S x M		Main plot treatment	Sub plot treatment	Interaction M x S	Interaction S x M
SED		0.80	0.90	0.17	0.16		0.65	0.72	0.14	0.16
CD(p=0.05)		0.18	0.19	0.34	0.32		0.14	0.16	0.28	0.32

Higher seeding rate favours rice more than weeds and increases yield under weedy conditions (Phuong *et al*., 2005). Increasing seed rates for direct-seeded rice has little influence on weed suppression, probably because of the intense weed pressure (Moody, 1982). Higher seeding rate develops canopy rapidly and consequently suppresses weeds more effectively, and in contrast, lower seeding rate results in sparse stands and encourage weed growth (Guillermo *et al.*, 2009). Combination of increased crop density and more uniform planting for better weed suppression has been emphasized by many researchers (Weiner *et al*., 2001; Boyd *et al.*, 2009), Crop seeding density can be viewed as a possible strategy to decrease weed pressure and reduce herbicide dependence (Kirkland *et al.*, 2000; Melander *et al.,* 2005; Anwar *et al*., 2011).

Table 5. Influence of water regimes on number of irrigation and water productivity of rice under mechanised direct sown rice cultivation.

Treatment	Number of irrigation	Total water used (m^{3} ha^{-1})	Water Use Efficiency (kg ha^{-1} mm^{-1})
I1: Irrigation at critical stages up to 45 DAS(PI) and submergence of 2.5 cm	21	9188	0.43
I2: AWD up to harvest	29	11386	0.58
I3: Continuous submergence of 2.5 cm	31.5	12678	0.42
I4: Farmers practices (Dry conditions up to 45 days, then converted as wet condition)	21	10095	0.39

Irrigation method of AWD with the combination of seed rate @ 40kg ha-^{1} is important to achieve higher production and economic benefits. Dry seeded rice (DSR) is becoming an attractive option for farmers in the Cauvery Delta Zone (CDZ) due to the elimination of the labour requirement and cost reduction for nursery preparation and maintenance, pulling out and transport of seedlings, and transplanting (Kumar and Ladha,2011).Increase in irrigation intensity by quantity and number of irrigation along with seed rate reduced the weed count (Table-2) and increased the weed control efficiency.

Table 6. Influence of water regimes on number of irrigation on economics (Rs. ha^{-1}) under mechanised semi dry rice cultivation

Treatment combinations	Cost of Cultivation (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	BCR (GI/ COC)
I1S1	25170	62028	39358	2.48
I1S2	25410	67062	44152	2.66
I1S3	25650	46025	22875	1.81
I1S4	25890	40922	17532	1.59
I2S1	25670	84932	61762	3.32
I2S2	25910	97887	74477	3.80
I2S3	26150	68653	45003	2.64
I2S4	26390	61045	37155	2.33
I3S1	25470	79677	56707	3.15
I3S2	25710	88584	65374	3.49
I3S3	25950	62329	38879	2.42
I3S4	26190	50328	26638	1.94
I4S1	24870	54018	31648	2.19
I4S2	25110	52429	29819	2.11
I4S3	25350	42358	19508	1.68
I4S4	25590	38017	14927	1.50

Pandey and Velasco (1999) have shown that direct-seeding methods produce higher income relative to transplanting. A higher net profit arises since savings in labour costs outweigh the value of loss in output.

Conclusion

Sowing of seed by multi crop planter (Happy seeder) under dry condition @ 40 kg ha^{-1}, alternate wetting and drying (AWD) method of irrigation up to harvest of the crop is important to achieve the highest number of productive tillers, the highest number of grains per panicle, the highest grain yield of 8.16 t ha^{-1}, net income of 74,477 Rs ha^{-1} with the BCR of 3.80 and the highest level of water use efficiency (0.58 kg ha^{-1} mm^{-1}).

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