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Evaluating the performance of rice varieties (Short and medium duration) under drip irrigation system

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Abstract
Field experiment was conducted during the summer season of 2022 at wetland farms, Tamil Nadu Agricultural University, Coimbatore, to evaluate the performance of various short and medium duration rice varieties under drip irrigation technology. The study was set with randomized block design under drip irrigation scheduled at 100 per cent pan evaporation (PE) and 100 per cent recommended fertilizer dose (RDF) with ten rice varieties *viz.,* five short-duration varieties (CO 54, ADT 53, MDU 6, TPS 5 and CO 51) and five medium-duration varieties (ADT 39, VGD 1, CO 52, TRY 3 and TKM 13). Growth parameters *viz.,* plant height, number of tillers m^{-2}, dry matter production and yield parameters were also recorded. From the study, among the rice varieties CO 54 (short duration) rice variety recorded significantly higher plant height (115.3 cm), tiller production m^{-2} (449 Nos.), dry matter production (12,564 kg ha^{-1}), number of productive tillers m^{-2} (406 Nos.), grain yield (4436 kg ha^{-1}), and straw yield (6633 kg ha^{-1}). It also recorded higher water use efficiency (6.69 kg ha^{-1} mm^{-1}).

Keywords: Drip irrigation system, rice varieties, yield, water use efficiency

Introduction

Rice (*Oryza sativa* L.) is one of the world's most strategic food commodities, strongly linked to food security, economic growth, employment, culture, and regional peace. It is a staple food for more than half of humanity, or more than 3 billion people worldwide (Yadav and Kumar, 2018) [1]. The increased demand for food, as well as water, leads to the shortage of both in the future unless novel technologies are developed. At present, agricultural scientists are aiming to develop rice production systems that can survive under water scarcity. Across the world, the total cultivated area of rice is around 158 million hectares with an annual production of 700 million tonnes. India occupies the second rank in rice area and production worldwide. In India, the area under rice is 45.7 million hectares with a production of 124.3 million tonnes and the average productivity is 2.72 t ha^{-1}. In Tamil Nadu, rice is cultivated on an area of 2.03 million hectares, producing 7.44 million tonnes with average productivity of 3.38 t ha^{-1} (Indiastat, 2020-21) [2].

Aerobic rice is a water-saving rice-growing technique where high-yielding cultivars are sown directly in un puddled situations with no standing water and are irrigated similarly as like that of other upland cereal crops (Bouman *et al*., 2005) [3]. Under low land system, more water is consumed and around 3000- 5000 litres of water is utilized by the crop to produce one kg of grain. Water inputs in aerobic rice systems are less than half of those in standard low land rice systems (470-650 mm), with higher water productivity (64-88 %) and labour use that is 55 per cent lower (Soman *et al*., 2018) [4] than the conventional method. It is essential to create innovative water-saving rice cultivation techniques to combat the water crisis.

Drip irrigation has the potential to save a significant amount of water when compared to the traditionally followed rice cultivation by flooding. With production levels ranging from 6 to 8 t ha^{-1} there is considerable interest in adopting drip irrigation for rice (Medley and Wilson, 2008) (Ramesh *et al*., 2020) [5-6]. When comparing different rice cultures grown under drip irrigation and conventional flood irrigation system it was found that, drip irrigated rice recorded 19 per cent higher yield (7.9 t ha^{-1}) compared to conventional flood system (6.6 t ha^{-1}) and utilized 58 per cent less water than the conventional method. Water productivity was higher in drip irrigation system (11.80 kg ha^{-1} mm^{-1}) as compared to transplanted rice grown under puddled conditions (4.17 kg ha^{-1} mm^{-1}) (Anusha and Nagarajan 2015) [7].

Keeping this in mind, one of the goals was to identify prominent rice varieties for aerobic rice farming using drip irrigation system.

Material and Methods

The field study was carried out in Wetlands Farm, Tamil Nadu Agricultural University, Coimbatore. The experimental field is located at 11° E latitude and 77° E longitude with an elevation of 426.7 m above the mean sea level (MSL) and is part of Tamil Nadu Western Agro-Climatic zone. The experimental soil was of Noyyal series Typic Haplustalf type. The soil texture is clay loam, with EC and pH of 0.41 dSm^{-1} and 8.2, respectively. The soil's organic carbon content was medium (0.70 %). The soil of the experimental field was low in available nitrogen content (205.0 kg ha^{-1}), medium in available phosphorus content (13.5 kg ha^{-1}) and higher in available potassium content (580.0 kg ha^{-1}). The total quantity of rainfall received throughout the growing season was 130.4 mm in 17 rainy days. The experiment was laid out in randomized block design (RBD) with ten treatments (varieties) and three replications. Ten improved rice varieties were used for the field investigation comprising five short duration varieties (CO 54, ADT 53, MDU 6, TPS 5 and CO 51) and five medium duration varieties (ADT 39, VGD 1, CO 52, TNAU Rice TRY 3 and TKM 13), with seed rate of 40 kg ha^{-1} and spacing of 20 cm x 10 cm. The drip irrigation system consisting of drip laterals with a 16 mm OD PVC (Outside diameter polyvinyl chloride) and lateral spacing of 60 cm was fixed in the sub-main. The emitters were placed at a distance of 30 cm from each other with a discharge rate of 4 litre per hour (lph). A control valve was used to regulate the irrigation and fertigation scheduling from the sub-main to the laterals and the laterals were closed with an end cap. A pre-emergence herbicide of pendimethalin at the rate of 1.25 kg ha^{-1} was applied 3 days after the first irrigation. Irrigation was given daily, based on pan evaporation data. Drip irrigation is scheduled at 100 per cent pan evaporation (PE) with 100 per cent recommended dose of fertilizers at all growth stages. The recommended dose of fertilizer (RDF) *viz.*, 150: 50: 50 kg N: P_2O_5: K_2O ha^{-1} was provided to the crop. Biometric observations like plant height, number of tillers, dry matter production, productive tillers, water use efficiency, grain yield and straw yield observations were recorded as per the standard methodology given below. In each plot, five plants were tagged and biometric observations were recorded in those plants. by using a scale and expressed in centimetres (cm). The plant height was measured from the base of the plant to the tip of the panicle. Dry matter production was calculated by pulling out five plants randomly in each plot and dried in hot air oven at 70 °C for 24 hours till constant weight was obtained and their mean values were converted to kg ha^{-1}. The total number of tillers in each hill of five tagged plants was counted and extrapolated to tillers m^{-2}.

The field data of various growth and yield parameters recorded during the course of the investigation were statistically examined using the methodologies outlined by Gomez and Gomez (1984) [8].

Result and Discussion

Growth parameters

The result revealed (Table 1) that among ten varieties, rice variety CO 54 recorded higher plant height compared to all other varieties. Application of water near to root zone might have stimulated the increased activity of meristematic cells and cell elongation of internodes which resulted in higher growth rate of the stem in turn promoting the plant height of rice. The plant height ranged from 115.3 to 82.5 cm. Among the rice cultivars, CO 54 recorded significantly higher plant height of 115.3 cm which was followed by CO 52 and CO 54 had about 40 per cent increased plant height over VGD 1 (82.5 cm). This result is similar to the finding of Nanditha *et al.*, (2021) [9].

The rice variety CO 54 recorded higher number of tillers m^{-2} and dry matter production compared to all other rice cultivars. The maximum number of 449 tillers m^{-2} were produced by CO 54 than the other rice varieties and was on par with CO 52 (440 tillers m^{-2}). The lower number of tillers m^{-2} was produced under VGD 1 (320 tillers m^{-2}). The dry matter production of rice increased from vegetative to harvest stage. There was a significant difference in dry matter production among the rice varieties. CO 54 variety recorded higher mean DMP at early stages of crop growth and also during later stages. It might be due to more accumulation of photosynthates being found to have occurred in the early stages. CO 54 produced significantly more dry matter (12,564 kg ha^{-1}) compared to other cultivars. The lower dry matter production was recorded by VGD 1 (8,205 kg ha^{-1}).

Yield parameters

Results revealed that CO 54 registered significant higher productive tillers m^{-2} compared to ADT 53, MDU 6, TPS 5, CO 51, ADT 39, VGD 1, CO 52, TNAU Rice TRY 3 and TKM 13 in aerobic rice cultivated under drip irrigation system (Table 1). Higher number of productive tillers m^{-2} were registered by CO 54 (406 productive tillers m^{-2}) and the lower number recorded under VGD 1 variety (263 productive tillers m^{-2}). This result is comparable to the findings of Natarajan *et al.* (2020) [10].

In drip irrigated system the performance, in terms of grain yield varied between 3.0 t ha^{-1} and 4.4 t ha^{-1} showing variation in yield, amongst the ten varieties. CO 54 registered higher grain yield of 4463 kg ha^{-1} and it was followed by CO 52 (4200 kg ha^{-1}) (Table 2). The higher grain yield of CO 54 might be associated with higher tillering capacity and it contains more grains per panicle compared to other varieties under aerobic rice cultivation**.** With regards to straw yield, CO 54 recorded higher value of 6633 kg ha^{-1} followed by CO 52 (6066 kg ha^{-1}). The increase in the grain and straw yield of CO 54 is related to higher tiller production and dry matter production which resulted in superior yield attributes and yield. This effect is in similar to the findings of Govind and Grace (2012) [11]. The Harvest Index (HI) was higher in CO 52 and TRY 3 (0.41) and lesser in ADT 53 (0.37) (Table 3). Higher HI values lead to increased contribution for yield increment (Parthasarathi *et al.*, 2013) [12]. VGD 1 recorded lower grain and straw yield of 3046 kg ha^{-1} and 4930 kg ha^{-1} respectively. Production of less productive tillers $plant^{-1}$ subsequently reduces both source and sink capacity which in turn reduced the grain and straw yield of VGD 1.

Water use efficiency

The results revealed that significant higher water use efficiency was recorded in CO 54 variety (6.69 kg ha^{-1} mm^{-1}) followed by CO 52 (5.49 kg ha^{-1} mm^{-1}) and it was on par with TRY 3 (5.28 kg ha^{-1} mm^{-1}) (Table 2). This is in agreement with the findings of Keerthi *et al.*, (2018) [13]. The higher water use efficiency (WUE) and water productivity (WP) can be improved either by increasing yield or by maintaining the yield level with a reduced quantity of water.

Table 1: Effect of drip irrigation system on growth parameters and productive tillers in short and medium duration of rice varieties.

Varieties		Plant height (cm)	Dry matter production (kg ha^{-1})	No. of tillers m^{-2}	Productive tillers m^{-2}
Short	CO 54	115	12564	519	406
	ADT 53	96	9387	501	289
	MDU 6	102	9856	406	309
	TPS 5	98	9547	399	297
	CO 51	105	10501	440	322
Medium	ADT 39	88	8789	434	269
	VGD 1	83	8205	453	263
	CO 52	109	11954	465	383
	TRY 3	107	11759	412	344
	TKM 13	92	9010	442	279
SEd		6	573.25	21	17.53
CD (5 %)		12	1204.34	43	36.83

Table 2: Effect of drip irrigation system on grain yield, straw yield, harvest index and water use efficiency (WUE) in short and medium duration of rice varieties

Varieties		Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index	WUE (kg ha^{-1} mm^{-1})
Short	CO 54	4437	6633	0.40	6.69
	ADT 53	3113	5280	0.37	4.69
	MDU 6	3633	5503	0.40	5.48
	TPS 5	3417	5356	0.39	5.15
	CO 51	3807	5606	0.40	5.74
Medium	ADT 39	3103	5096	0.38	4.06
	VGD 1	3046	4930	0.38	3.98
	CO 52	4200	6066	0.41	5.49
	TRY 3	4036	5726	0.41	5.28
	TKM 13	3190	5170	0.38	4.17
SEd		197.23	343.21	0.02	
CD (5 %)		414.35	721.04	NS	

Conclusion
From the present field investigation on drip irrigation for rice, it could be concluded that growing of CO 54 under drip irrigation using 60 cm lateral spacing, spacing (20 ×10 cm) and fertigation of 100 per cent recommended dose of fertilizers found to increase the productivity of CO 54 rice variety. Rice variety CO 54 recorded (Table 3.) significantly higher plant height, greater number of productive tillers, increased dry matter production and more grain yield than all other rice varieties. As a result, Rice variety CO 54 recorded greater number of productive tillers which is the most important yield contributing parameter which indicates higher yield compared to all other varieties. Hence, it is suitable for aerobic rice under drip irrigation system which can be recommended to farmers.

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