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Impact of foliar application on different varieties under drip fertigated aerobic rice

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Abstract
The application of nutrient solution to the foliage of plants acts as an alternative way to fertilize crops. The study was conducted at Agricultural College and research institute, Madurai (semi-arid region of Tamil Nadu) 2022 to find out the effect of supplemental foliar application of macro and micro nutrients of two different rice varieties under drip fertigation (an aerobic soil condition). The experiment was laid out in split plot design with three replications. In main plot, two rice varieties *viz*., CO-54 and ADT-53; and in subplot five foliar application treatments along with no spray treatments were taken for experimentation. The result of the study indicated that 100% RDF of NP and K through fertigation combined with foliar application of 1% urea+2% DAP+1% KCl at panicle initiation and 10 days later produced higher plant height and grain yield when compared to other foliar application treatments. Among different varieties tested, Co-54 performed well and produced higher grain yield (5509 kg ha^{-1}) than ADT-53.

Keywords: CO-54, ADT-53, drip fertigation, foliar application, growth and yield

Introduction
Agriculture is the largest water-consuming sector (about 80% of total water consumption), with rice holding the major share. Rice is one of the most important food crop in World and India plays a crucial role in rice production. At present, rice is growing under conventional methods *viz*., flood irrigation. Many water-saving technologies, such as aerobic cultivation (Parent *et al*. 2010; Sudhir-Yadav *et al*. 2012) [19] and alternate wetting and drying (AWD) irrigation (Bouman and Carracelas *et al*. 2019) have also been implemented to reduce water use and the irrigation costs. However, many experiments have reported the impact of results on grain yields, due to the significant variations of water management (Yadav *et al*. 2012). Aerobic rice system is an innovative way of rice cultivation without puddling and flooding the field (Arefin *et al*., 2018) [2]. Raising rice crop under drip irrigation is one of the aerobic method of cultivation which resulted in higher water productivity (Ramesh *et al*., 2020) [17]. Water and nutrients are important inputs for rice production and may interact with each other to produce a coupling effect. Water and nutrient have positive interactions on rice growth and yield determined through coordination of the source-sink relationship have been widely reported, especially during the developmental and grain filling stage (Wang *et al*.,2016; Aziz *et al*. 2018) [3]. It is possible to expand rice production in order to fulfill the rising population food needs, which are increasing at a pace of 1.32 per cent annually (Aysha Siddika *et al*., 2016). Aerobic rice with micro irrigation practices leads to sustainable rice production for immediate future to address water scarcity with more benefits and environmental safety in the scenario of global warming by reduced methane emission is an added advantage (Parthasarathi *et al*., 2012) [14].

Influence of drip fertigation on growth and yield of rice was studied by Govindan and Grace (2012) [8]. Water use efficiency (WUE) and performance of rice under drip irrigation was studied by Haibing *et al*., (2013) [9] and reported that the highest WUE was found in drip irrigation treatment, which was 1.52–2.12 times higher than conventional flood irrigation treatment. Fertigation is the precise application of water soluble fertilizer through sprinkler and drip irrigation. It is an efficient and agronomically sound method of providing soluble plant nutrients directly to the active plant root zone. Fertigation is a new agricultural technique, which supplies water and fertilizer simultaneously (Castellanos *et al*. 2012) [6]. It can supply fertilizer and water at right time and right place thus, improve water-use efficiency and uptake of nutrients. Foliar application has numerous benefits of foliar nutrition which contribute yield increments in crops (Sathishkumar and Sakthivel, 2019).

Agarwal *et al.* (2004) [1] have demonstrated crop response to drip irrigation cum foliar nutrition with higher nutrient use efficiency. Application of recommended INM practice (100% RDF with vermicompost 5t ha^{-1}) + 2% urea phosphate spray at panicle initiation and 10 days later holds promise in enhancing the rice productivity (Jagathjothi *et al*., 2012) [12]. Soil application of RDF + MMS @ 12.5 kg ha^{-1} at sowing + foliar application of MMF @ 1% at 20 and 40 DAS was recorded significantly higher yield of aerobic rice and micronutrients content in post-harvest soil compared to other treatments (Meghana *et al*., 2020) [10]. Keeping the above information in view, the present study was carried out to study the effect of drip fertigation and supplemental nutrition through foliar application on rice crop.

Materials and Methods

Location

The field investigation was conducted at C Block of Central farm, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, India during rabi season 2020. The experimental site is geographically located at 9º 54' N latitude and 78º 80' E longitude at an altitude of 147 m above mean sea level. The mean annual rainfall is 850 mm distributed in 46 rainy days. The experiment was laid out in split plot design consists of two varieties as main plot and six foliar application of macro and micro nutrients with three replications. The soil type of study area is sandy clay loam in texture. In raised beds seeds were dibbled directly at 20 × 10 cm spacing so that four rows were accommodated in each raised beds. Irrigation was given once in three days based on 125% Pan Evaporation (PE) data observed in the meteorological station in AC & RI, Madurai.

Experimental details

Table 1: Crop and variety

S. No.	Particulars	Crop & Enterprises
1.	Crop and Variety	Rice *var* CO-54, ADT-53
2.	Experimental design	Split plot design
3.	Replication	Three

Treatment details

Main plot (Varieties)

V_1 – CO 54

V_2 – ADT 53

Sub plot (Foliar Applications)

F_1 – RDF as (Fertigation) + 1% urea + 2% DAP + 1%KCl at panicle initiation and 10 days later

F_2 – RDF as (Fertigation) + 0.5% $ZnSo_4$ and 1% $FeSo_4$ at tillering and PI stages

F_3 – RDF as (Fertigation) + 2% MAP + 1% KCl at heading and grain filling stages

F_4 – RDF as (Fertigation) + 1.5% fermented egg extract at Tillering, PI & flowering stage

F_5 – RDF as (Fertigation) + 1% $FeSo_4$ at 25- 30 DAS

F_6 – RDF as (Fertigation) + Control (Water spray)

Table 2: Fertigation scheduling

Schedule of fertigation	Urea (Kg/ha)	SSP (Kg/ha)	MOP (Kg/ha)	Fertilizer rate (kg) per day	
				Urea	MOP
Basal application (Soil application)	0	312.5	0	-	-
15-20 DAS (Fertigation - 20%)	65.1	-	20	16 (4 splits)	5 (4 splits)
21-40 DAS (Fertigation - 30%)	97.65	-	30	24 (4 splits)	7.5 4 splits)
41- 70 DAS (Fertigation - 30%)	97.65	-	30	24 (4 splits)	7.5 (4 splits)
71-80 DAS (Fertigation- 20%)	65.1	-	20	16 (4 splits)	5 (4 splits)

Results and Discussion

Influence of foliar application on growth of drip fertigated rice

Plant growth was measured by monitoring plant height (panicle initiation, flowering and harvesting stages) after implementation of treatments and values are presented in Table 3. Among two varieties tested, CO-54 produced higher plants (74.36, 98.47 and 98.72 cm during panicle initiation, flowering and harvesting stages, respectively) than ADT-53 at all the stages of growth. Among the different foliar nutrient application, 1% urea+2%DAP+1%KCl (F_1) recorded significantly higher values (78.0, 101.7 and 102.9 cm during panicle initiation, flowering and harvesting stages, respectively) for plant height when compared to other treatments at all the stages. Among other treatments, the difference between F_3 and F_2 was comparable with each other and the same trend is followed in F_4 and F_5 also. The lowest values for plant height registered under F_6 treatments at all the stages. The percentage increment of plant height due to supplemental nutrition through foliar application ranged from 5.4 to 11.9, 2.77 to 8.78 and 3.18 to 9.11 during panicle initiation, flowering and harvesting stages, respectively. The interaction between varieties and foliar application was found significant and higher values registered under V_1F_1 (78.98, 101.73 and 103.84 cm during panicle initiation, flowering and harvesting stages, respectively). The higher plants under F_1 is mainly due to supply of major nutrients *viz*., N,P and K at critical stages enhance the plat growth by promoting the efficiency of nutrient absorption and reflected in plant height. This result is in line with the findings of (Tejada and Gonzalez, 2004 and Fageria *et al*., 2009) [20, 7] found that rice is well respond to foliar nutrition and increase the quantity of production. Natdanai Juntakad *et al*., 2018 [13] also reported that foliar application of N,P and K increased the uptake of nutrients by the crop and accumulated more in grains under aerobic condition. Next to major nutrients *viz*., NP and K; Zn and Fe play major role in boosting growth of rice crop and recorded higher values next to F_1 and F_3. Under aerobic condition, more Zn and Fe accumulated in rice crop when applied as foliar spray by improved plant growth. This is in agreement with the findings of Natdanai Juntakad *et al*., (2018) [13] and Mohsin and Ahmad, 2014 [11].

Table 3: Influence of supplemental nutrition on plant height (cm) of drip fertigated rice

Influence of supplemental nutrition on plant height (cm) of drip fertigated rice												
Treatments	**Panicle initiation**				**Flowering**				**Harvesting**			
	V1		V2	Mean	V1		V2	Mean	V1		V2	Mean
F_1	78.98		77.02	78.00	101.73		101.67	101.70	103.84		102.13	102.99
F_2	76.20		73.07	74.64	98.83		94.44	96.64	97.1		100.71	98.91
F_3	74.61		77.80	76.20	101.44		94.76	98.10	102.98		97.63	100.30
F_4	72.36		72.14	72.25	96.18		93.5	94.84	96.35		94.82	95.58
F_5	74.30		72.58	73.44	97.77		94.39	96.08	97.49		97.3	97.40
F_6	69.68		69.66	69.67	94.86		92.11	93.49	94.55		94.24	94.39
Mean	74.36		73.71		98.47		95.14		98.72		97.80	
	V	F	V x F	F x V	V	F	V x F	F x V	V	F	V x F	F x V
S.Ed	0.15	0.92	1.19	1.30	0.76	0.92	1.41	1.30	0.06	1.22	1.58	1.73
CD(p=0.05)	0.64	1.91	2.53	2.70	3.28	1.92	3.86	2.72	0.25	2.55	3.30	3.61

Table 4: Effect of supplemental nutrition on grain yield of drip fertigated rice

Effect of supplemental nutrition on grain yield of drip fertigated rice				
Treatments	**Grain yield (Kg ha^{-1})**			
	V1		**V2**	**Mean**
F_1	5509		5388	5449
F_2	5297		4807	5052
F_3	5447		4983	5215
F_4	4807		4665	4736
F_5	5145		4701	4923
F_6	4570		4451	4511
Mean	5129		4833	
	V	F	V x F	F x V
S.Ed	67	78	121	110
CD(p=0.05)	289	163	336	230

Effect of foliar application on grain yield of rice under drip fertigation

The grain yield of ADT-53 and CO-54 was significantly influenced by the foliar application of macro and micro nutrients. The data pertaining to grain yield (Table 3) indicated that, the higher grain yield was recorded with CO-54 compared to ADT-53 with respect to foliar application treatments. The higher grain yield was noticed under V_1F_1 followed by V_1F_3. Among the different foliar nutrient application, F_1 recorded the higher grain yield (5449 kg ha^{-1}) when compared to other treatments at all the stages. Among other treatments, the difference between F_1, F_2 and F_3 was comparable with each other and the same trend is followed for F_4 and F_5 also. The lowest values for grain yield registered under Control treatment (F_6) (4511 kg ha^{-1}). The percentage increment of grain yield due to supplemental nutrition through foliar application ranged from 5 to 20. The interaction between varieties and foliar application was found significant and highest value registered under V_1F_1 (5509 kg ha^{-1}).

Upland rice varieties could adopt under aerobic soil condition i.e., well drained and this may be due to adoption of root zone, ability of nutrient uptake translocation and accumulation of nutrients (Natdanai Juntakad *et al*., (2018) [13]. In this study also CO-54 is moderately resistant to water stress performed well and yield higher than ADT-53. Foliar application of N,P and K increased the rice grain yield and it may be due to enhancement of ammonium and nitrate and reflected in more accumulation of nutrients in grain. This is in agreement with the findings of Trung and Koji (1982) and Qian *et al*., (2004) [22, 16]. Accumulation of potassium reduces chaffy grains and increases filled grains in plant (Bridgemohan and Bridgemohan, 2014; Thao *et al*., 2015). Supplemental nutrition through foliar spray allows leaves to absorb rapidly into inner cell layers of plant cell and other plant organs. Phattarakul *et al*., (2012) [15] also reported the varietal difference for grain yield coupled with foliar application of nutrients. They also reported that ability of leaf absorption and seed deposition of applied nutrients. The present experiment revealed that there is a need for comprehensive supply of macro nutrients (N,P and K) along with micro nutrients (Zn and Fe) for getting benefit of all supplied nutrients. Natdanai Juntakad *et al*., 2018 [13] also expressed the same view in foliar application of macro and micro nutrients under well drained aerobic soils reported that foliar application of N,P and K increased the uptake of nutrients by the crop and accumulated more in grains under aerobic condition.

Conclusion

From the above study it was concluded that application of 100% RDF of N,P and K through fertigation combined with foliar application of 1% urea+2%DAP+1%KCl at panicle initiation and 10 days later produced higher plants and higher grain yield (5449 kg ha^{-1}) when compared to other foliar application treatments. Among different varieties tested, Co-54 performed well and produced higher grain yield (5129 kg ha^{-1}) than ADT-53. It was also found that Zn and Fe nutrition is essential to achieve more yield under aerobic cultivation of rice.

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