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Influence of fertilizer levels applied through conventional and fertigation on yield components and yield of aerobic rice

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Abstract
Field experiments were conducted on sandy loam soils in the field unit of Agronomy division, College of Agriculture, Shivamogga, Karnataka, India during *Kharif* season of 2015 and 2016. In this field trial, the effect of levels and methods of fertilizer application (surface and fertigation) with combination of water soluble fertilizers and normal fertilizers or alone on growth and yield of aerobic rice was studies. The experiment was laid out in a Randomized Complete Block Design (RCBD) comprising of 3 replications and 12 treatments. Results showed that aerobic rice yields differed significantly among the treatments. Conjunctive application of 25% RDF through soil application + 100% RDF through fertigation recorded higher growth and yield parameters *viz*., productive tillers (22 plant^{-1}), panicle length (23.77 cm), total grains (117), filled grains (110.6) total dry matter accumulation (109.19 g plant^{-1}), grain (68.92 q ha^{-1}) and straw yield (79.45 q ha^{-1}); but it was statically on par with plots of 125 or 100% RDF through fertigation alone and conjunctive application of 25% RDF through soil application + 75% or 100% RDF through fertigation compared to soil applied 100% RDF through surface irrigation treatment (43.12 and 50.15 q ha^{-1} respectively for grain and straw). The yield increment was found 41-60 per cent over surface irrigation with soil application of 100 per cent RDF.

Keywords: Aerobic rice, drip, fertilizers, fertigation, water soluble fertilizers

Introduction
Rice (*Oryza sativa* L.) is the most important staple food for more than half the planet's population and is a water intensive enterprise. It is cultivated in different ecosystems in many ways. India being the second largest producer of world (106.57 mt), covers an area of 43.97 m ha with the productivity level of 2424 kg ha^{-1} (Anon., 2016) [1]. As the water use efficiency of rice is very low and loss of applied fertilizers in the field is more, it creates challenges for rice cultivation. So, adoption of aerobic rice system holds well in the present condition.

Aerobic rice production is a revolutionary way of growing rice in well-drained, non-puddled, and non-saturated soils without ponded water Bouman (2001) [2]. This system uses input-responsive specialized rice cultivars and complementary management practices to achieve at least 4-6 t/ha using only 50-70% of the water required for irrigated rice production. This is recommended in areas where water is too scarce or expensive to allow traditional irrigated rice cultivation. Yield of aerobic rice is low due to faulty practice of fertilizer use.In the light of water saving, it is imperative to match fertilizer application for exploring growth potentialities of any crop. Chemical fertilizers are a real asset if they are applied whenever needed by the crop (time of application) in the appropriate method and amount.

Simultaneous use of drip irrigation and fertilizer application (fertigation) opens up new possibilities for controlling water and timely nutrient supply to crops besides maintaining the desired concentration and distribution of nutrients and water into the soil. Fertigation gives advantages such as higher use efficiency of water and fertilizer, minimum losses of N due to leaching, supplying nutrients directly to root zone in available forms, control of nutrient concentration in soil solution and saving in application cost. Thus, fertigation becomes prerogative for increasing the yield of most of the crops under drip irrigation (Jata *et al.*, 2013) [3]. Water soluble fertilizers having high content of nutrients with low salt index can be used for fertigation (Obreza and Vavrina, 1995) [4]. As water soluble fertilizers are very costly inputs, efforts should be made toreduce the quantity of water soluble fertilizers in conjunction with normal fertilizers (Yanglem and Tumbare, 2014) [5]. Keeping the above facts in mind, the present study was conducted with the objective to determine the combined fertilizer rates for getting highest growth and yield aerobic rice production through drip fertigation.

Material and Methods

Field studies were conducted during the regular *kharif* rice growing season of 2015 and 2016 in the Field Unit of Agronomy Department of College of Agriculture, UAHS, Shivamogga (latitude 13° 58' North, longitude 75° 34' East longitude with an altitude of 650 m MSL), located under Southern Transition Zone of Karnataka. The experimental soil had sandy loam texture with a predominance of illite clay mineral which is taxonomically classified under the major group Typic haplustept. The experiment was laid out in a Randomized Complete Block Design (RCBD) comprising 3 replications and 12 treatments *viz.*,T_1: 75% RDF through fertigation; T_2: 100% RDF through fertigation; T_3: 125% RDF through fertigation; T_4: 50% RDF- soil application + 25% RDF - fertigation; T_5: 50% RDF- soil application + 50% RDF - fertigation; T_6: 50% RDF- soil application + 75% RDF - fertigation; T_7: 25% RDF- soil application + 50% RDF - fertigation; T_8: 25% RDF - soil application + 75% RDF - fertigation; T_9: 25% RDF - soil application + 100% RDF - fertigation; T_{10}: 75% RDF through soil application; T_{11}: 100% RDF through soil application and T_{12}: 125% RDF through soil application11111.Based on 1.0 PE, fertigation is scheduled for 8 equal splits at 10, 20, 30, 40, 50, 60, 70 and 80 DAS. The aerobic rice cultivar used was MAS 946-1 (Sharada).

The land was ploughed once with disc plough followed by two harrowing with the onset of monsoon to bring the seedbed to fine tilth. During layout, small bunds were provided all around each plot and between irrigation channels. The experimental area was laid out as per the plan and the land within each individual plot was levelled manually to maintain uniform irrigation water application and aerobic rice seeds were dibbled at 25 cm X 25 cm apart. Recommended Farm Yard Manure was applied at the rate of 10 t ha^{-1} two weeks before sowing for all the treatments. The recommended dose of fertilizers (100: 50: 50 of NPK kg ha^{-1} and zinc sulphate @ 20 kg ha^{-1}) were applied as per the treatments. The sources of nutrients for water soluble fertilizers used were 19:19:19 and calcium ammonium nitrate (15.5% N and 17% Ca). In standard soil application, the sources of nutrients applied were in the form of urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O). At different fertigation intervals, fertilizer solution was freshly prepared by taking the required quantity of fertilizer and was filled in plastic bucket which was connected with suction device of ventury system. As per the treatment details, NPK was applied through drip-fertigation method by using ventury system to each plot up to 80 days after sowing at ten days interval. For standard soil application treatments, out of the recommended dose of fertilizers, 50 per cent of recommended nitrogen & potassium and entire dose of phosphorous were applied as basal dose. Remaining 50 per cent of recommended nitrogen was applied in two splits once at 30 days after sowing and another at 55-60 days just before panicle emergence along with 50 per cent of recommended potassium. The data pertaining to the experiment were subjected to statistical analysis suggested by Gomez and Gomez (1984) [6] and results were compared.

Result and Discussion

Contribution to grain yield in cereal crops had conventionally been assessed using yield per plant and various yield attributes. Variations accrued in growth and yield parameter due to application of treatments essentially reflects in achieving final harvestable yield. Conjunctive application of 25% RDF through soil application + 100% RDF through fertigation recorded significantly higher grain and straw yield (Combined over two years - 68.92 and 79.45 q ha^{-1} respectively) as compared to surface irrigation with soil application of 100 per cent RDF (combined over two years - 43.12 and 50.51 q ha^{-1}, respectively for grain and straw) (Table 1). Further, this treatment was on par with plots treated either 125 or 100% RDF through fertigation alone and conjunction of 25% RDF through soil application + 75% RDF through fertigation which yielded grain yield of 60.95 to 66.89 q ha^{-1} and becomes top achievers. Compared to 100 per cent RDF through soil application with surface irrigation, the maximum yield treated plot recorded 60 and 57 per cent higher grain and straw yield, whereas on par treatments at higher hierarchy recorded 41-55 and 38-46 per cent enhancement of grain and straw yield (Fig 3). Maintenance of adequate soil moisture by frequent irrigation and nutrient supply matched with crop growth demand along with good soil aeration throughout crop growth period might have favoured faster cell division and elongation which has ultimately resulted in increased plant height, higher tiller production, more number of leaves & leaf area development and in turn the total dry matter production. Similar results were obtained by Vijaykumar (2009) [16], Abdelraouf *et al.* (2013) [1], Anita Fanish and Muthukrishnan (2011). But in surface irrigation with soil application treatments, where nutrients were applied in two splits (N and K), utilization was reduced during dry period as soil moisture was reduced with time (Singandhupe *et al.*, 2003) [14]. Higher yield was also due to higher yield attributes as seen from Fig 1 and 2 respectively. Higher tillers panicle^{-1}(20-22), panicle length (21-24 cm), number of filled grains (80-110) to total (98-117) was found higher in the above said treatments compelling to become best among the tested treatments.

Genetic and environmental potentiality needs to be explored optimally to reap the source fully towards appropriate developed sink. In the present study, application of 100 per cent RDF through soil application with surface irrigation resulted moderate number of productive tillers (15.97) and panicle characteristics (length of around 20 cm and weight of around 2.90 g). Treatment 25 per cent RDF through soil with 100 per cent RDF through fertigation resulted maximum productive tillers (22.00) along with panicle parameters (length of around 24 cm and weight of 3.8 cm), whereas application of pure 100 and 125 per cent RDF through fertigation and interaction of 25 per cent RDF through soil with 100 per cent through fertigation resulted similar performance to that of maximum and excelled best (4.1.17 and 4.2.17). Further maximum numbers of filled and total grains were observed in the plot of 25 per cent RDF through soil and 100 per cent RDF through fertigation (110 and 117 for *kharif*) and treatments such as pure application of 100 and 125 per cent RDF through fertigation recorded statistically on par grains while other treatments performance was only moderate (Fig. 2). The sink size, that is, the spikelet number per unit area may reduced with deficit and excess water availability situations but compensated fairly well with fertigation practice. That can also be linked to timely uptake of water and nutrients due to frequent split application of fertilizers in drip irrigation coincided with the actual needs of crop and favoured better vegetative growth and yield components. Similar results were obtained by Pritee Aswathy *et al.* (2014) [11] and Anusha (2015) [5]. It is because water soluble fertilizer leave higher concentration of available plant nutrient in top layer (Anitta Fanish, 2013) [2]. Sampath kumar and Pandian (2010) [13] also reported that split application of fertilizers in drip irrigation coincided with the actual needs of crop up to eighty days and favoured good growth and produce maximum yield. Sink and its components subjected to correlation and regression studies (Table 2). It is seen from the data that among the chosen parameters of yield components, all the components given significant relationships wherein, test weight remained at lower level because of uniform distribution of available photosynthate i.e. uniformity of grain filling rate (Ukaoma *et al.*, 2013) [15].

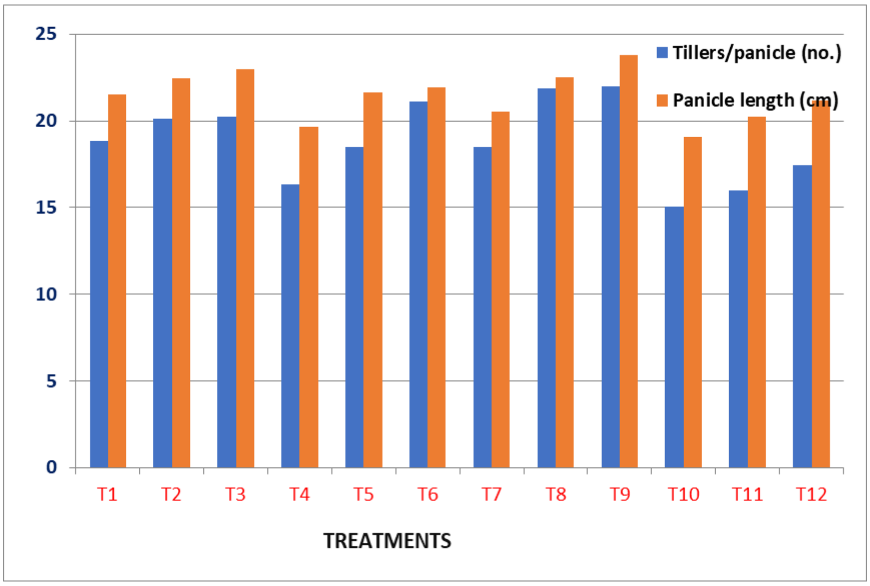

Fig 1: Tillers panicle^{-1} and panicle length of aerobic rice as influenced by fertilizer levels applied through conventional and fertigation methods

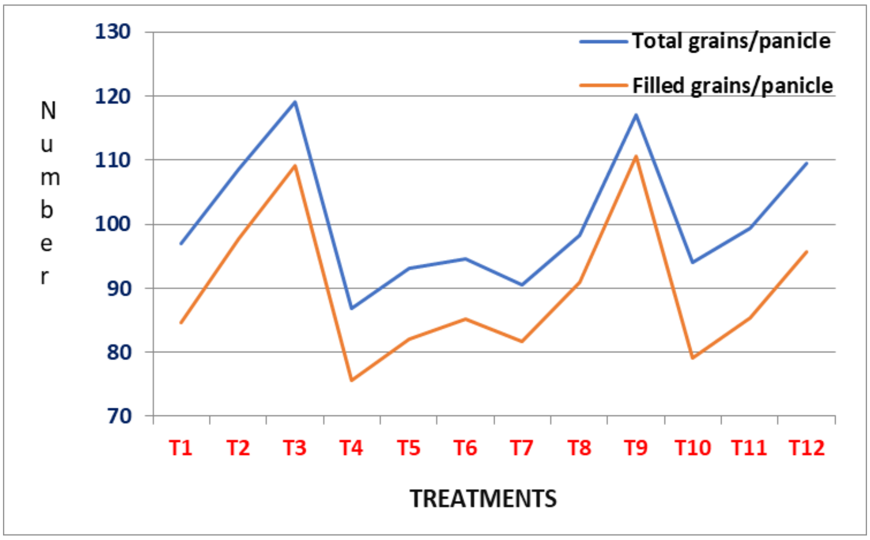

Fig 2: Total and filled grains panicle^{-1} of aerobic rice as influenced by fertilizer levels applied through conventional and fertigation methods

Table 1: Grain and straw yield of aerobic rice as influenced by fertilizer levels applied through conventional and fertigation methods

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled
T_1 - 75% RDF through fertigation	51.62	49.52	50.57	64.47	63.22	63.84
T_2 - 100% RDF through fertigation	61.80	60.11	60.95	70.42	69.17	69.80
T_3 -125% RDF through fertigation	67.58	66.20	66.89	79.08	76.70	77.89
T_4 - 50% RDF - soil application + 25% RDF - fertigation	39.75	38.24	38.99	49.66	48.55	49.10
T_5 -50% RDF - soil application + 50% RDF - fertigation	49.29	47.52	48.41	58.88	57.54	58.21
T_6 - 50% RDF - soil application + 75% RDF - fertigation	58.63	57.09	57.86	69.86	68.28	69.07
T_7 - 25% RDF - soil application + 50% RDF - fertigation	44.00	48.66	47.83	59.64	57.72	58.68
T_8 - 25% RDF - soil application + 75% RDF - fertigation	66.23	64.29	65.26	74.75	73.50	74.13
T_9 - 25% RDF - soil application + 100% RDF - fertigation	69.47	68.37	68.92	80.98	77.92	79.45
T_{10} - 75% RDF through soil application with surface irrigation	37.26	36.45	36.86	43.54	42.29	42.91
T_{11} - 100% RDF through soil application with surface irrigation	43.04	42.19	43.12	51.11	49.91	50.51
T_{12} - 125% RDF through soil application with surface irrigation	50.52	49.63	50.57	61.46	59.53	60.50
S.Em.±	3.20	3.26	3.06	3.77	3.02	3.36
CD (P=0.05)	9.41	9.57	8.98	11.00	8.88	9.86
CV (%)	10.8	11.3	10.5	10.3	8.5	9.3

RDF: 100:50:50 kg NPK ha^{-1}

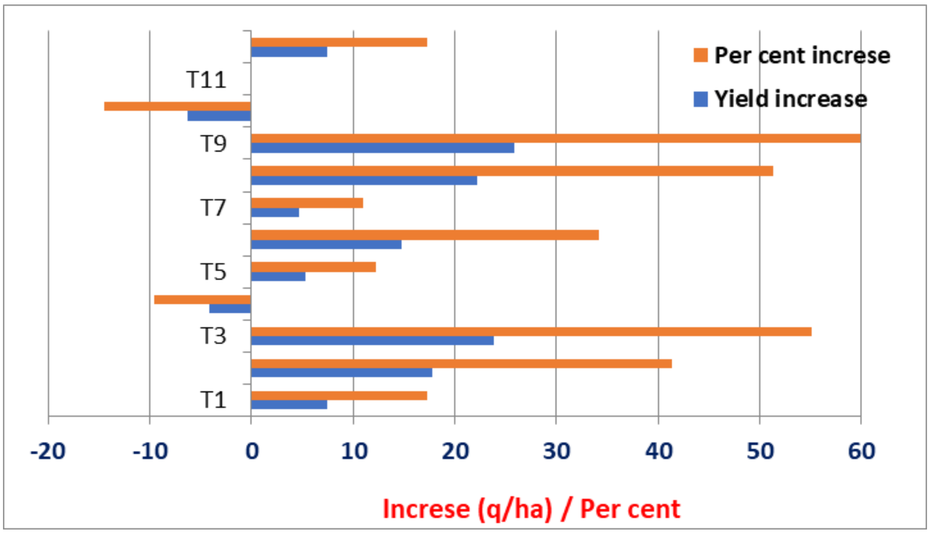

Fig 3: Increase in yield (q ha) and per cent increase by different treatments as compared to surface irrigation with 100% RDF through soil application

Table 2: Regression response for grain yield and yield components

Year	Season	Response curve	R	R^2	
2015	*kharif*	$Y = -14.731 + 3.575\, x_1$	0.783	0.614	Y= Grain yield x_1-Productive tillers x_2-Panicle weight x_3-Panicle length x_4-No. of filled grains x_5-Test weight
		$Y = -43.020 + 29.148\, x_2$	0.824	0.679	
		$Y = -95.366 + 6.824\, x_3$	0.782	0.612	
		$Y = -21.688 + 0.808\, x_4$	0.695	0.484	
		$Y = -16.919 + 1.674\, x_5$	0.193	0.037	
		$Y = -91.329 + 0.937\, x_1 + 12.265\, x_2 + 2.797\, x_3 + 0.116\, x_4 + 0.727\, x_5$	0.885	0.783	
2016	*kharif*	$Y = -11.651 + 3.380\, x_1$	0.757	0.573	
		$Y = -40.438 + 28.63\, x_2$	0.817	0.668	
		$Y = -67.202 + 5.486\, x_3$	0.721	0.520	
		$Y = -16.944 + 0.751\, x_4$	0.675	0.456	
		$Y = -19.803 + 1.473\, x_5$	0.156	0.024	
		$Y = -52.396 + 1.150\, x_1 + 12.969\, x_2 + 1.461\, x_3 + 0.124\, x_4 - 0.089\, x_5$	0.842	0.710	
Combined *kharif*		$Y = -13.228 + 3.48\, x_1$	0.770	0.594	
		$Y = -41.311 + 28.763\, x_2$	0.820	0.673	
		$Y = -79.57 + 6.077\, x_3$	0.749	0.561	
		$Y = -19.290 + 0.780\, x_4$	0.686	0.471	
		$Y = 18.041 + 1.589\, x_5$	0.176	0.031	
		$Y = -67.388 + 1.176\, x_1 + 12.197\, x_2 + 1.913\, x_3 + 0.122\, x_4 + 0.262\, x_5$	0.861	0.742	

Note: The independent variable x refers to the parameters listed in serial number and Y is dependent variable i.e. grain yield
**Correlation is significant at P = 0.01= 0.413
*Correlation is significant at P = 0.05= 0.321

Conclusion

Soil application of 25 per cent RDF (25:12.5:12.5 NPK kg ha^{-1}) as basal with 75 per cent RDF (75: 37.5: 37.5 NPK kg ha^{-1}) through fertigation scheduled for 8 splits from 10 to 80 DAS with 1.0 PE resulted in 55 per cent higher grain yields over 100 per cent RDF through soil application with surface irrigation and found best.

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