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Rooting Behaviour of Aerobic Rice under Integrated Package of Agrotechniques

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ABSTRACT

Aerobic rice is a new system of rice cultivation under limited water condition. Rice having a shallow root system is not a desired character for water stress condition. Therefore, a deep root system is needed for acquiring water and nutrition from the relatively wet deep soil layer to obtain a stable yield under aerobic conditions. In this context a pot experiment was conducted during Kharif, 2011 and 2012 at Zonal Agricultural Research Station, GKVK, Bengaluru to investigate the effect of integrated package of agrotechniques on rooting behaviour and yield of aerobic rice. The observations pertaining to root growth were recorded at panicle initiation stage and at maturity. The root growth parameters *viz.* root length, root number, root volume, root dry weight and shoot dry weight were significantly higher with the application of RDF+FYM+Biofertilizers+$FeSO_4$+IWM practices (T_8) as compared to all other treatments. The grain yield per plant and straw yield per plant also followed the similar trend.

Key words: Aerobic rice, intercultivation, root growth, integrated agrotechniques

INTRODUCTION

Rice is a moisture hungry crop and is the single biggest user of fresh water. Rice is a prolific user of water which required 3000-5000 liters of water to produce one kg of grain which is almost 2 to 3 times higher than any other cereal crops such as wheat and maize (IRRI, 2009). Rice is cultivated under four major ecosystems *viz.,* irrigated (57%), rainfed lowland (31%), rainfed upland (9%) and deepwater (3%). In India, out of the total available water for irrigation, 60 per cent is diverted for rice cultivation. The water supply-demand gap in India is projected to be 25 per cent by the year 2020 (Sunder *et al.*, 1996). Thus lack of water rather than land may become the principal constraint to increase food output and to keep the world in peace (Sivanappan, 1997).

With emerging water scarcity in many part of the world, the traditional way of lowland rice cultivation can no longer be sustained. Along with high water requirement, traditional system of rice production in long run leads to destruction of soil aggregates and reduction in macropore volumes (Shashidhar, 2007). Crop growth and yield are the results of metabolic process and as such variation in yield is to be viewed as the product of variation in the metabolic processes. Cultural and nutritional management alter the rate of metabolic processes through modifying the soil plant environment. As root is the absorbing organ, development of root is evidently an index of the vigour of the above ground portion also. It has been suggested that upland and aerobic rice are more sensitive to water stress than other upland crops due to its shallow root system (Angus *et al.*, 1983).

Therefore, a deep root system is needed for acquiring water and nutrition from the relatively wet deep soil layer to obtain a stable yield under aerobic conditions. In this contrast a pot experiment was conducted under poly house condition to study the impact of integrated package of agrotechniques on rooting behaviour of aerobic rice.

MATERIALS AND METHODS

Study area: A pot experiment was conducted during July to December, 2011-12 to 2012-13 at Zonal Agricultural Research Station, GKVK, Bengaluru, Karnataka. The farm is located in the Eastern Dry Zone of Karnataka and is geographically situated between 12°58' North latitude, 77°35' East longitude with an altitude of 930 m above the mean sea level. The soil of the experimental site was red sandy loamy in texture and pH was neutral. The soil was medium in available nitrogen, phosphorus and potassium. The organic carbon content was low in range (Table 1).

Weather and crop growth: Rainfall received during the crop growth period was 487.7 and 406.9 mm in 2011 and 2012, respectively. The rainfall during both the years of study was less than the normal rainfall. During the year 2011, the total rainy days during cropping period were 35 and the highest in the month of August (14). The actual mean sunshine hours were considerably lower during the entire crop growth period. The open pan evaporation was less than normal during entire crop growth period (Fig. 1). During kharif 2012, the rainfall during cropping period was deficit but did not interfere with the normal crop growth and yield of aerobic rice as it was grown under irrigation. The total rainy days during growing season were 23 and the highest was in the month of August (8). The actual mean sunshine hours were considerably lower during the entire crop growth period. The open pan evaporation was less than normal during entire crop growth period (Fig. 2).

Table 1: Physical and chemical properties of the soil in the experimental area during Kharif, 2011 and 2012

Particulars	Values	
Physical properties		
Coarse sand (%)	55.7	
Fine sand (%)	23.5	
Clay (%)	13.5	
Silt (%)	07.3	
Soil texture	Red sandy loam	
Chemical properties	Kharif, 2011	Kharif, 2012
pH	6.58	6.57
EC (dSm^{-1})	0.28	0.25
Organic carbon (%)	0.46	0.45
Available Nitrogen (kg ha^{-1})	292.3	297.1
Available Phosphorus (kg ha^{-1})	20.0	21.2
Available Potassium (kg ha^{-1})	119.9	137.8
DTPA Fe (ppm)	10.7	9.82
DTPA Zn (ppm)	0.45	0.46
Physical constants		
Field capacity (%)	18.72	18.25
Permanent wilting point (%)	6.91	6.62
Bulk density (mg m^{-3})	1.46	1.44

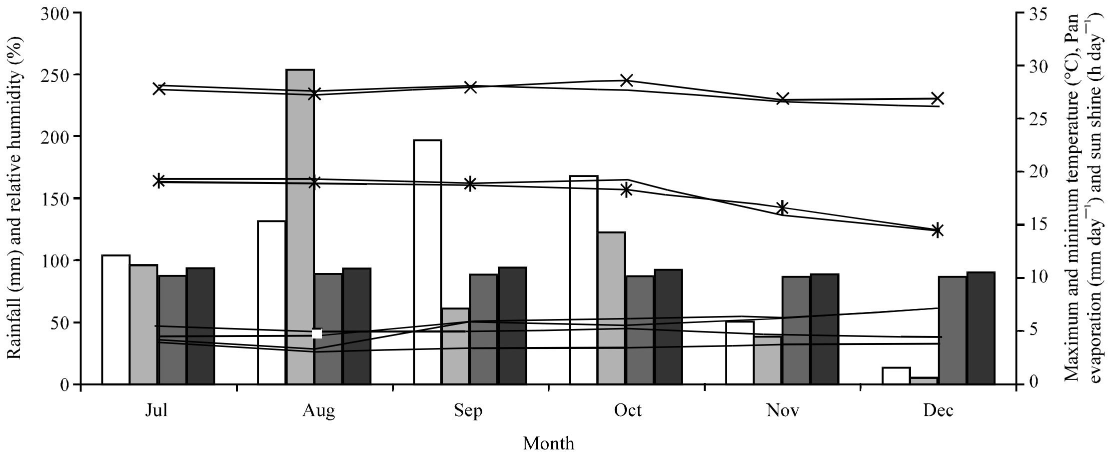

Fig. 1: Mean monthly weather data during the crop growth period at ZARS, GKVK and Bengaluru 2011

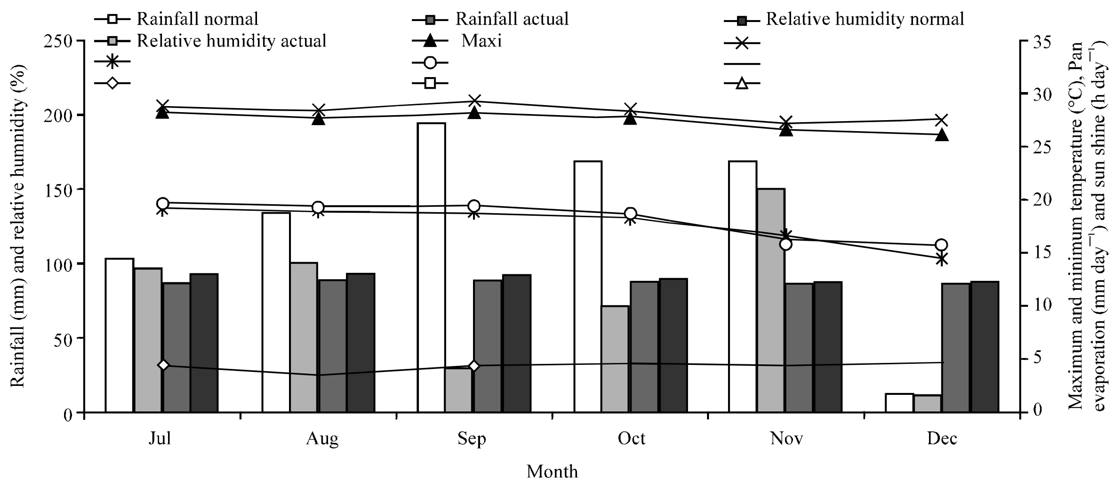

Fig. 2: Mean monthly weather data during the crop growth period at ZARS, GKVK and Bengaluru 2012

Experimental setup

Treatments details: The experiment was setup in a completely randomized design repeated thrice. There were ten treatments as follows T_1: Recommended dose of Fertilizers (RDF-100: 50: 50: 20 kg NPK and $ZnSO_4$ ha^{-1})+Farmyard manure (FYM) at 10 t ha^{-1}+Pyrazosulfuron ethyl at 25 g a.i. ha^{-1}; T_2: RDF+FYM+$FeSO_4$ at 12.5 kg ha^{-1}+Pyrazosulfuron ethyl at 25 g a.i. ha^{-1}; T_3: RDF+FYM+Biofertilizers (Soil application of Azospirillum and PSB (*Bacillus megaterium*) at 4 kg ha^{-1} each mixed with 80 kg of farm yard manure)+Pyrazosulfuron ethyl at 25 g a.i. ha^{-1}; T_4: RDF+FYM+Biofertilizers+$FeSO_4$+Pyrazosulfuron ethyl at 25 g a.i. ha^{-1}; T_5: RDF+FYM+Integrated weed management practices (Pre emergence application of pyrazosulfuron ethyl at 25 g a.i. ha^{-1}+One hand weeding at 20 days after sowing+First intercultivation at 25 days after sowing and subsequent intercultivations at 15 days interval upto panicle initiation); T_6:

RDF+FYM+$FeSO_4$+Integrated weed management practices; T_7: RDF+FYM+Biofertilizers +Integrated weed management practices; T_8: RDF+FYM+Biofertilizers+$FeSO_4$+Integrated weed management practices; T_9: Site Specific Nutrient Management (SSNM) for targeted yield of 6.5 t ha^{-1}+Integrated weed management practices; T_{10}: Site Specific Nutrient Management (SSNM) for targeted yield of 7.5 t ha^{-1}+Integrated Weed Management Practices (IWMP).

Materials used: MAS-26 a popular Semi dwarf, medium duration and deep rooted aerobic rice variety developed by using Marker Assisted Selection at University of Agricultural Sciences, Bengaluru was sown in July with a spacing of 30×30 cm. All the plots were irrigated with a depth of 5 cm immediately after sowing and subsequent irrigations were given with a depth of 4 cm at 5 days interval during vegetative growth stage followed by 3 days interval during reproductive growth stage of the crop farm yard manure was applied at the rate of 10 t ha^{-1} to each plot three weeks prior to sowing. A common dose of fertilizer was applied at the rate of 50 kg of N, 50 kg of P, 50 kg of K and 20 kg of $ZnSO_4$ ha^{-1} as basal dose at the time of sowing in the form of urea, single super phosphate, muriate of potash and zinc sulphate, respectively. The remaining 50 kg nitrogen was applied in two equal splits each at 30 and 60 days after sowing in the form of urea to the treatments. Iron as $FeSO_4$ at 12.5 kg ha^{-1}, Azospirillum and PSB (*Bacillus megaterium*) at 4 kg each ha^{-1} mixed with 80 kg of farm yard manure were applied as per the treatments. In site specific nutrient management for targeted yield of 6.5 t ha^{-1} 130: 32: 162 kg N, P and K ha^{-1} and for targeted yield of 7.5 t ha^{-1} 150: 37: 187 kg N, P and K ha^{-1} was applied. Pre-emergence application of herbicides was done at three day after sowing. Irrigation was stopped a week prior to harvest of the crop.

Methods followed to record the observations:

- **Root length:** Plant was uprooted by giving a deep dig near the base after watering and the maximum root length of the longest root was recorded in centimeter
- **Total no. of roots:** Total number of roots per plant at crown region were counted and recorded
- **Root dry weight:** Roots of the plant was cut from the stem, dried moisture free in a hot air oven at 80°C for 48 h (till attaining constant weight), weighed and recorded in gram
- **Root volume:** Root volume was determined in 'cc' using water displacement method
- **Root: Shoot ratio:** The root weight of plant was recorded as mentioned above. The shoot weight was recorded separately after drying the shoot portion in hot air oven at 80°C for 48 h till reaching constant weight. Then, root: Shoot ratio was worked out
- **Grain yield:** Weight of filled grains per hill was recorded in grams after drying
- **Straw yield:** Weight of straw per hill was recorded in grams after drying

Statistical analysis: The data obtained from pot experiment was analysed statistically by analysis of variance method for completely randomized design (Gomez and Gomez, 1984). Critical difference was worked out at 1% probability level. Correlation studies were made between grain yield of aerobic rice and root traits. The values of correlation coefficient (r) were calculated and tested for their significance at 1% (indicated by **) as per the procedure outlined by Gomez and Gomez (1984). The response of aerobic rice to integrated package of agrotechniques was similar in both the years of study. Therefore, only pooled data of two years is discussed.

RESULTS AND DISCUSSION

Root characters: The root characters recorded at panicle initiation stage and at maturity differed significantly due to integrated package of agrotechniques (Fig. 3a, b and Table 2, 3). At both the stages the root characters followed the similar trend.

Root length: Application of RDF+FYM+Biofertilizers+$FeSO_4$+Integrated weed management practices (T_8) recorded significantly higher root length at panicle initiation stage and at maturity as compared to all other treatments.

Total No. of roots: At panicle initiation stage application of RDF+FYM+Biofertilizers +$FeSO_4$+IWMP (T_8) significantly recorded more number of roots per hill as compared to all other treatments. Similar trend was also observed with total number of roots at maturity stage.

Root volume: Application of RDF+FYM+Pyrazosulfuron ethyl at 25 g a.i. ha^{-1} (T_5) recorded significantly lower root volume but RDF+FYM+Biofertilizers+$FeSO_4$+IWMP (T_8) recorded significantly higher root volume followed by RDF+FYM+Biofertilizers+IWMP (T_7). At maturity also, similar trend was noticed.

Root dry weight: At panicle initiation stage, significantly higher root dry weight was observed with RDF+FYM+Biofertilizers+$FeSO_4$+IWMP (T_8) as compared to that with RDF+FYM+Biofertilizers+IWMP (T_7) which inturn was significantly superior to other treatments.

Table 2: Root length, total No. of roots and root volume as influenced by integrated package of agrotechniques

	Root length (cm)		Total No. of roots		Root volume (cc)	
Treatments	Panicle initiation stage	Maturity	Panicle initiation stage	Maturity	Panicle initiation stage	Maturity
T_1: RDF+FYM+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	12.8	13.2	69.0	74.0	20.7	25.30
T_2: RDF+FYM+$FeSO_4$ at 12.5 kg ha^{-1}+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	15.9	18.0	76.0	78.3	28.0	31.00
T_3: RDF+FYM+biofertilizers+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	16.7	18.6	82.3	94.3	31.7	35.70
T_4: RDF+FYM+biofertilizers+$FeSO_4$ at 12.5 kg ha^{-1}+ pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	19.5	20.7	91.3	99.7	33.2	36.90
T_5: RDF+integrated weed management	25.0	27.0	129.0	131.7	56.0	61.00
T_6: RDF+$FeSO_4$ at 12.5 kg ha^{-1}+integrated weed Management	24.8	28.2	138.0	143.7	62.7	67.20
T_7: RDF+biofertilizers+integrated weed management	31.6	36.9	178.0	183.7	98.7	101.70
T_8: RDF+biofertilizers+$FeSO_4$ at 12.5 kg ha^{-1}+integrated weed management	35.2	41.2	194.7	199.3	110.0	115.50
T_9: Site Specific Nutrient Management (SSNM) for targeted yield of 6.5 t ha^{-1}+integrated weed management practices	28.7	30.1	165.3	167.0	86.0	92.70
T_8: Site Specific Nutrient Management (SSNM) for targeted yield of 7.5 t ha^{-1}+integrated weed management practices	24.8	27.7	161.0	163.7	75.0	85.20
SEM ±	0.87	1.01	4.3	4.68	2.80	3.570
CD (p = 0.01)	3.54	4.09	17.32	18.83	11.41	12.55

Table 3: Root dry weight, shoot dry weight and root: Shoot ratio as influenced by integrated package of agrotechniques

	Root dry weight ($g\ hill^{-1}$)		Shoot dry weight ($g\ hill^{-1}$)		Root: Shoot ratio	
Treatments	Panicle initiation stage	Maturity	Panicle initiation stage	Maturity	Panicle initiation stage	Maturity
T1: RDF+FYM+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	3.67	4.3	5.4	19.13	0.68	0.23
T2: RDF+FYM+$FeSO_4$ at 12.5 kg ha^{-1}+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	3.68	4.9	5.38	21.98	0.68	0.22
T3: RDF+FYM+biofertilizers+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	4.9	5.77	6.47	25.38	0.76	0.23
T4: RDF+FYM+biofertilizers+$FeSO_4$ at 12.5 kg ha^{-1}+ pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	5.47	6.85	7.28	29.2	0.75	0.24
T5: RDF+integrated weed management	7.52	8.73	9.27	44.5	0.81	0.2
T6: RDF+$FeSO_4$ at 12.5 kg ha^{-1}+integrated weed management	8.28	10.1	9.92	55.87	0.84	0.18
T7: RDF+biofertilizers+integrated weed management	10.9	12.33	11.62	72.51	0.94	0.17
T8: RDF+biofertilizers+$FeSO_4$ at 12.5 kg ha^{-1}+integrated weed management	12.57	13.48	12.97	82.1	0.97	0.16
T9: Site Specific Nutrient Management (SSNM) for targeted yield of 6.5 t ha-1+integrated weed management practices	9.12	10.57	10.92	56.33	0.84	0.19
T8: Site Specific Nutrient Management (SSNM) for targeted yield of 7.5 t ha-1+integrated weed management practices	8.65	9.7	10.52	50.63	0.82	0.19
SEM±	0.36	0.33	0.38	2.38	0.04	0.01
CD (p = 0.01)	1.49	1.05	1.54	9.69	NS	NS

NS: Not significant

It is very interesting to note that root dry weight was very low in the treatments without IWMP. The root dry weight at maturity also followed the similar trend.

Shoot dry weight: The maximum shoot dry weight was observed with RDF+FYM+Biofertilizers+$FeSO_4$+IWMP (T_8) than with treatments not receiving IWMP and SSNM+IWMP (T_9 and T_{10}) and was on par with RDF+Biofertilizers+IWMP (T_5). Similar trend was observed in respect of shoot dry weight at maturity.

Root to shoot ratio: The root to shoot ratio did not differ significantly at panicle initiation stage and at maturity due to integrated package of agrotechniques.

Yield: Application of RDF+FYM+Biofertilizers+$FeSO_4$+IWM practices resulted in significantly higher grain yield than SSNM+IWM practices and RDF+FYM+IWM practices. The lowest grain yield was obtained in RDF+FYM+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}. Similar trend was also observed with straw yield (Table 4).

Harvest index: The harvest index did not differ significantly due to integrated package of agrotechniques (Table 4).

Table 4: Grain yield, straw yield and harvest index of aerobic rice as influenced by integrated package of agrotechniques

Treatments	Grain yield (g plant^{-1})	Straw yield (g plant^{-1})	Harvest index
T_1: RDF+FYM+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	7.36	11.61	0.387
T_2: RDF+FYM+$FeSO_4$ at 12.5 kg ha^{-1}+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	8.85	13.14	0.402
T_3: RDF+FYM+Biofertilizers+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	10.42	14.96	0.411
T_4: RDF+FYM+Biofertilizers+$FeSO_4$ at 12.5 kg ha^{-1}+pyrazosulfuron ethyl at 25 g a.i. ha^{-1}	12.95	16.25	0.442
T_5: RDF+integrated weed management	19.48	25.02	0.437
T_6: RDF+$FeSO_4$ at 12.5 kg ha^{-1}+integrated weed management	24.71	31.16	0.441
T_7: RDF+Biofertilizers+integrated weed management	32.50	40.68	0.444
T_8: RDF+Biofertilizers+$FeSO_4$ at 12.5 kg ha^{-1}+integrated weed management	36.66	45.78	0.445
T_9: Site Specific Nutrient Management (SSNM) for targeted yield of 6.5 t ha^{-1}+ integrated weed management practices	24.62	31.72	0.437
T_8: Site Specific Nutrient Management (SSNM) for targeted yield of 7.5 t ha^{-1}+ integrated weed management practices	21.71	28.93	0.429
S.Em±	1.10	1.35	0.034
CD (P = 0.01)	4.46	5.49	NS

NS: Not significant

Fig. 3(a-b): Effect of integrated agrotechniques on root growth of aerobic rice at (a) Panicle initiation stage and (b) Maturity

DISCUSSION

Application of RDF+FYM+Biofertilizers+$FeSO_4$+IWMP recorded better root growth traits (Fig. 3a and b) was mainly due to loosening of soil through repeated intercultivations and hand weeding encouraged better root aeration by reducing bulk density of the soil and enhancing the infiltration rate (Shashidhar, 2010; Sunil *et al.*, 2010). The combined application of Zinc and Fe and biofertilizers (Azospirillum and *Bacillus megaterium*) enhanced the N fixation, phytohormone production, synthesis of phytosedirosphores, increased Zn absorption in plants and also enhanced the phosphate and iron solubilization by the production of organic acids by encouraging the growth of microbial population in soil resulted in better development and proliferation of roots (Ardakani *et al.*, 2011). Chinnusamy *et al.* (2006), Davis and Bayer (1971) helped in better uptake of water, nutrients by rice inturn recorded higher grain and straw yield per plant. Correlation studies also revealed significant and positive correlation between grain yield per plant and root length (0.990**), total number of roots (0.974**), root volume (0.968**) and root dry weight (0.994).There was a significant and negative correlation between grain yield and root shoot ratio (-0.948**).

CONCLUSION

In aerobic rice cultivation well developed root system plays a vital role in uptake of nutrients and water. Thus, application of RDF, FYM, Biofertilizers and $FeSO_4$ along with integrated weed management practices is helpful in getting better development of roots consequently helpful in getting higher grain and straw yield.

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