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Influence of Integrated Package of Agrotechniques on Quality Parameters of Aerobic Rice

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Abstract: Aerobic rice is an alternative system of rice cultivation under non puddled and non flooded soil condition by saving 30-40% of water by yielding 60-70% of yield as compared to conventional method of rice cultivation. In this context, a field experiment was conducted during 2011 and 2012 at Zonal Agricultural research station, GKVK, Bengaluru, Karnataka to investigate the influence of integrated package agrotechniques on grain yield and grain quality parameters of aerobic rice. Application of RDF+FYM+Biofertilizers+$FeSO_4$+IWMP (T_8) recorded significantly higher grain yield and lower per cent chaffyness as compared to SSNM+IWMP treatments (T_9 and T_{10}) and was being on par with RDF+FYM+Biofertilizers+IWMP (T_7). Apart from the grain yield the grain quality parameters were also significantly influenced by the integrated package of agrotechniques except cooking quality parameters. Grain quality parameters viz., hulling percent, milling percent head rice recovery, protein content, protein yield, amylose content, zinc content and iron content of rice registered significantly highest values with application of RDF+FYM+Biofertilizers+$FeSO_4$+IWMP (T_8). But the results pertaining to cooking quality parameters (length and breadth of kernel, L/B ratio, elongation ratio, water uptake, volume expansion ratio, cooking time and keeping quality parameters) were not significant.

Key words: Aerobic rice, milling percent, protein content, polished and unpolished

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal in human nutrition, consumed by 2/3 of the global population. Due to its daily consumption it supplies 21, 14 and 2% of the global energy, protein and fat, respectively (Juliano, 1993). Rice crop represents one of the most important food source within the agricultural sector of India, not only by its adaptability to the soil quality, climatic conditions and economic magnitude but due to of the preference as staple food. Rice cultivation is the primary source of income and employment for more than 100 million households in Asia and Africa. According to FAO, the global requirement of rice by 2025 will be in the order of 800 million tonnes while the present production is less than 600 million tonnes. Further, the land for agriculture is decreasing because of urbanization and industrialization on one hand and declining water availability as a result of population explosion, over-consumption and pollution. With such constraints, producing more rice in the future to feed additional population is a great challenge. Hence, to fulfill the increased demand for rice with shrinking resources it will be necessary to increase yield per unit area with less water (Zhao *et al*., 2006).

In this context the new system of rice growing, "Aerobic culture" gains importance. The aerobic rice is a new system of rice cultivation where fields remain unsaturated throughout the season like an upland irrigated dry crop. This method of growing rice saves water by eliminating continuous seepage and percolation losses. Weeds are the greatest constraint in aerobic rice systems, resulting in 30-98% yield losses (Zhao *et al*., 2006) as well as loss of grain quality due to rigorous competition among crop and weeds for nutrients, space, light and carbon dioxide (Tindall *et al*., 2005). Shifting from submerged rice to aerobic system of rice cultivation has led to changes in soil physical, chemical and biological properties resulting in iron deficiency (Sahrawat, 2012). However, rice is a poor source of

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essential micronutrients such as Fe and Zn (Bouis and Welch, 2010). Micronutrient malnutrition and particularly Fe and Zn deficiency affected over three billion people worldwide, mostly in developing countries (Sperotto *et al*., 2010). Moreover, the chemical and nutritional quality of rice grain varies considerably and this may be attributed to genetic factors, environmental influences and fertilizer treatments, degree of milling and storage conditions (Juliano, 1993). Keeping the above information in view, the present investigation was under taken to study the influence of integrated package of agrotechniques on grain yield and grain quality of aerobic rice.

MATERIAL AND METHODS

Study area: A field 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 loam 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 data: 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. 1a). 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. 1b).

Experimental setup

Treatments details: The experiment was setup in a randomized block design with three replications. 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

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

Particulars				Values
Physical properties				
Coarse sand (%)				55.7
Fine sand (%)				23.5
Clay (%)				13.5
Silt (%)				07.3
Soil type				Red sandy loam
Chemical properties				
	Kharif, 2011		Kharif, 2012	
	Values	Status	Values	Status
pH	6.58	Normal	6.57	Normal
EC (dSm^{-1})	0.28	Low	0.25	Low
Organic Carbon (%)	0.46	Low	0.45	Low
Available Nitrogen (kg ha^{-1})	292.30	Medium	297.10	Medium
Available Phosphorus (kg ha^{-1})	20.00	Medium	21.20	Medium
Available Potassium (kg ha^{-1})	119.90	Medium	137.80	Medium
DTPA Fe (ppm)	10.70	Above critical limit	9.82	Above critical limit
DTPA Zn (ppm)	0.45	Below critical limit	0.46	Below critical limit

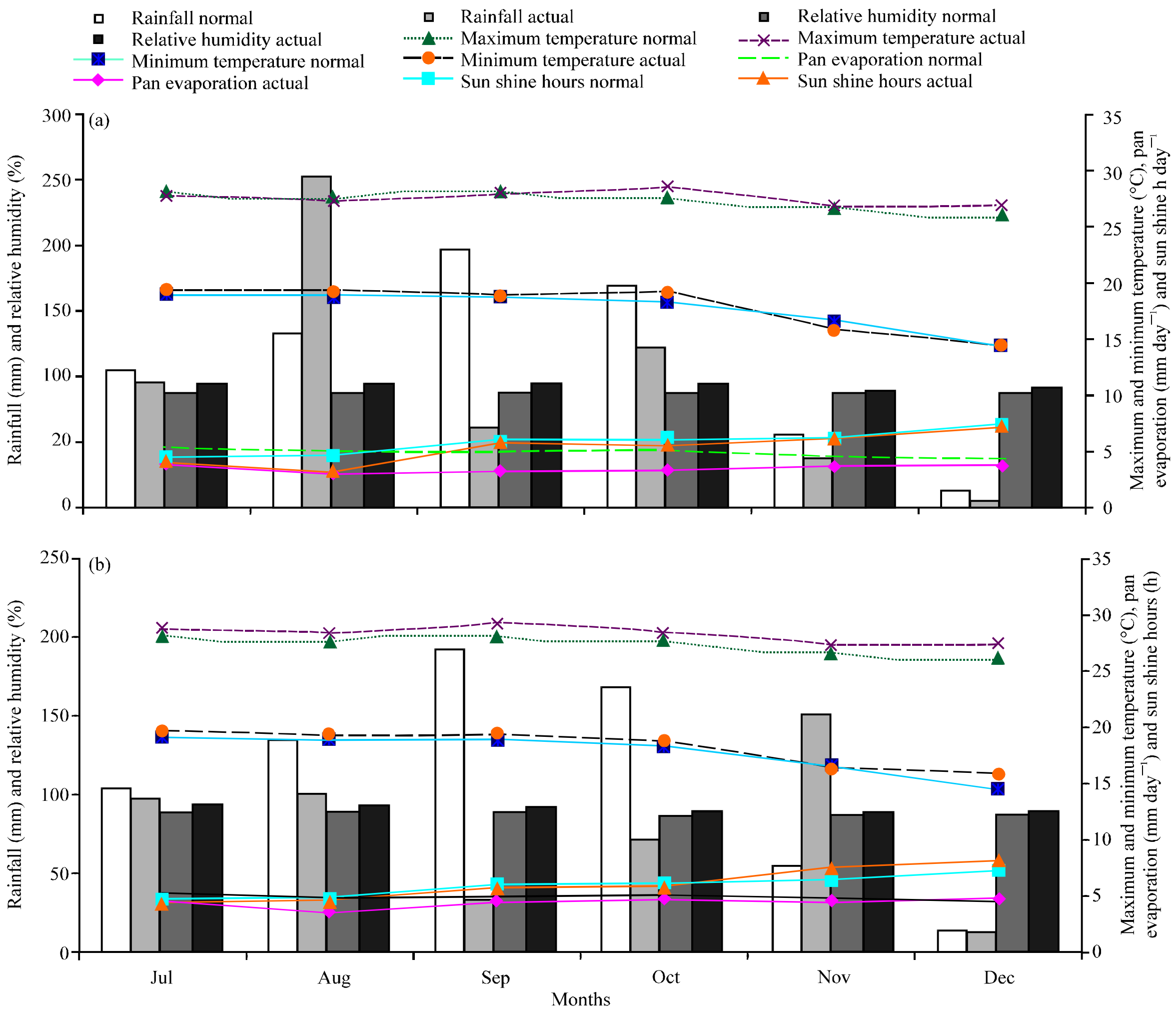

Fig. 1(a-b): Mean monthly weather data during the crop growth period at ZARS, GKVK, Bengaluru in (a) 2011 and (b) 2012

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. Irrigation was stopped a week prior to harvest of the crop.

Methods followed to record the observations: The grain yield was recorded during physiological maturity. Percent chaffyness is the ratio between number of unfilled grains per panicle to total number of grains per panicle multiplied by hundred. Paddy sample was cleaned and sun dried. A sample size of 300 g from each treatment was de-husked separately by using a rice sheller (Indosaw Industrial Product) and 4% polishing was given by using a polisher.

Physical parameters: The physical parameters such as hulling, milling, head rice recovery percentage and head yield were calculated by using the formulae given by Devi *et al*. (2012) are mentioned below:

$$\text{Hulling (\%)} = \frac{\text{Total brown rice}}{\text{Total rough rice}} \times 100$$

$$\text{Milling (\%)} = \frac{\text{Total milled rice}}{\text{Total rough rice}} \times 100$$

$$\text{Head rice recovery (\%)} = \frac{\text{Total head rice}}{\text{Total rough rice}} \times 100$$

$$\text{Head yield (\%)} = \frac{\text{Head rice recovery}}{\text{Milling recovery}} \times 100$$

Chemical parameters: The chemical parameters such as protein content, amylose content, zinc and iron content in brown and polished rice were analysed with the NIR (Nuclear Inclusive Resonance) analyser instrument. Protein yield is the product of percent protein content and grain yield.

Cooking quality parameters

Cooking time: Optimum cooking time was determined by pressing few kernels between two glass slides frequently taken from the cooking tube and noting the time when opaque core has just disappeared (Bhattacharjee and Kulkarni, 2000).

Water uptake ratio: The water uptake ratio was obtained by dividing the apparent water uptake at 80°C by the apparent water uptake at 96°C and the value was expressed in percentage (Bhattacharjee and Kulkarni, 2000).

Volume expansion ratio: 15 mL of water was taken in 50 mL graduated centrifuge tubes and 5 g of rice sample was added. Then initially increase in volume after adding 5 g of rice was measured (Y) and soaked for 10 min. Increase in volume before cooking was noted (Y-15). Then all the 5g of cooked rice were placed in 50 mL water taken in 100 mL measuring cylinder and increase in volume of cooked rice in 50 mL of water was measured (X). Later, the volume raise was recorded (X-50). Then volume expansion ratio was calculated (Bhonsle and Sellappan, 2010).

Elongation ratio: Elongation ratio was obtained by cooking rice in wire basket for 10 min after 15 min of presoaking and then dividing the cumulative length of 20 cooked kernels by respective length of raw kernels.

Length and breadth of grain (cm): Length and breadth of a grain was measured by using standard scale and expressed in centimetre.

Length/breadth ratio (L/B ratio): The L/B ratio was arrived by using the formula given below:

$$\text{Length/breadth ratio} = \frac{\text{Length of cooked grain (cm)}}{\text{Breadth of cooked grain (cm)}}$$

Statistical analysis: The data obtained from field experiments, laboratory analysis were analysed statistically by analysis of variance method for randomized block design (Gomez and Gomez, 1984). Critical differences were worked out at 5% probability level. 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.

EXPERIMENTAL RESULTS

Grain yield and percent chaffyness: Application of RDF + FYM + Biofertilizers + $FeSO_4$ + IWM practices being on par with RDF + FYM + Biofertilizers + IWM practices resulted in significantly higher grain yield than SSNM + IWM practices and RDF + FYM + $FeSO_4$ + IWM practices. The lowest grain yield was obtained in RDF + FYM + IWM practices. Percent chaffyness was lowest with RDF + FYM + Biofertilizers + $FeSO_4$ + IWM practices as compared all other treatments (Table 2).

Quality parameters

Physical parameters: The physical parameters such as hulling, milling, head rice recovery percentage and head yield were significantly higher with the application of RDF + FYM + Biofertilizers + $FeSO_4$ + IWM practices than RDF + FYM + IWM practices and SSNM + IWM practices and was being on par with RDF + FYM+ Biofertilizers + IWM practices (Table 2).

Table 2: Grain yeild, percent chaffyness and physical quality parameters of aerobic rice as influenced by the integrated packege of agrotechniques (pooled date of 2 years

Treatments	Grain yield (kg ha^{-1})	Percent chaffyness (%)	Hulling (%)	Milling (%)	Head rice recovery (%)	Head yield (%)
T_5	3053	10.70	70.40	66.00	47.00	30.78
T_6	3213	10.90	70.60	66.10	47.90	31.43
T_7	3479	8.90	71.30	67.50	48.90	32.64
T_8	3880	7.90	72.40	68.00	50.30	34.00
T_9	3263	10.80	69.40	65.50	47.00	30.55
T_{10}	3086	12.70	69.70	64.90	46.00	29.64
Mean±SE	142	0.64	0.47	0.38	0.53	0.47
CD (p = 0.05)	423	10.90	1.40	1.10	1.60	1.39

Aerobic rice in treatments receiving pre emergence application of pyrazosulfuron ethyl alone (without IWMP) (T_1-T_4) experienced severe weed competition resulting in complete death of all rice plants, statistical analysis therefore was done for only six treatments (T_5-T_{10}) by leaving first four treatments (T_1 to T_4)

Table 3: Protein yeild, amylose, zinc and iron content in unpolished (UP) and polished (P) grains of aerobic rice as influenced by integrated package of agrotechniques (Pooled data of 2 years)

	Protein content (%)		Protein yield (kg ha^{-1})		Amylose content (%)		Zinc (mg kg^{-1} grain)		Iron (mg kg^{-1} grain)	
Treatments	UP	P	UP	UP	UP	P	UP	P	UP	P
T_5	9.43	7.69	287.59	234.52	16.17	14.69	25.56	21.84	12.88	12.01
T_6	9.60	7.87	308.57	252.66	16.51	14.80	25.44	21.98	13.00	12.18
T_7	10.22	8.68	355.15	302.04	17.41	15.85	26.20	22.60	13.55	12.87
T_8	10.41	8.88	403.76	344.65	17.89	16.21	26.62	23.01	13.83	13.10
T_9	9.89	8.12	322.72	264.93	16.36	14.97	25.23	21.92	12.63	11.79
T_{10}	9.76	7.85	300.66	242.52	15.79	14.38	25.65	22.19	12.69	11.81
Mean±SE	0.12	0.12	16.90	16.48	0.28	0.23	0.18	0.22	0.18	0.16
CD (p = 0.05)	0.34	0.37	50.20	48.95	0.83	0.67	0.53	0.67	0.52	0.48

Aerobic rice in treatments receiving pre emergence application of pyrazosulfuron ethyl alone (without IWMP) (T_1-T_4) experienced severe weed competition resulting in complete death of all rice plants, statistical analysis therefore was done for only six treatments (T_5-T_{10}) by leaving first four treatments (T_1-T_4)

Table 4: Cooking quality parameters of aerobic rice as influenced by integrated package of agrotechniques

Treatments	Length of kernel (mm)	Breadth of kernel (mm)	Length/breadth ratio (L/B)	Elongation ratio	Water Uptake (%)	Volume expansion ratio	Cooking time (min)	Keeping quality (h)
T_5	8.70	3.60	2.41	1.32	34.52	2.50	21.5	19.28
T_6	8.70	3.60	2.42	1.32	34.52	2.50	21.5	19.28
T_7	8.80	3.70	2.40	1.33	34.51	2.52	20.5	19.28
T_8	8.90	3.70	2.42	1.34	34.53	2.55	20.5	19.28
T_9	8.80	3.60	2.42	1.33	34.54	2.53	21.0	19.28
T_{10}	8.80	3.60	2.41	1.33	34.44	2.50	22.0	19.28
Mean±SE	0.04	0.03	0.02	0.01	0.05	0.02	0.38	0.00
CD (p = 0.05)	ns	ns	ns	ns	ns	ns	ns	ns

Aerobic rice in treatments receiving pre emergence application of pyrazosulfuron ethyl alone (without IWMP) (T_1-T_4) experienced severe weed competition resulting in complete death of all rice plants, statistical analysis therefore was done for only six treatments (T_5-T_{10}) by leaving first four treatments (T_1-T_4)

Chemical parameters: Among different integrated package of agrotechniques, application of RDF + FYM+ Biofertilizers + $FeSO_4$ + IWM practices and RDF + FYM+ Biofertilizers + IWM practices gave significantly higher protein content, protein yield, zinc content and iron content in unpolished and polished rice grains than other treatments (Table 3).

Cooking quality parameters: The cooking quality parameters such as water uptake ratio, volume expansion ratio, cooking time, keeping quality, length of kernel, breadth of kernel, length/breadth ratio and elongation ratio did not differ significantly due to integrated package of agrotechniques (Table 4).

DISCUSSION

No yield was harvested in the treatments (T_1 to T_4) receiving pre-emergence application of pyrazosulfuron ethyl at 25 g a.i. ha^{-1} without IWM practices since the aerobic rice completely failed due to significantly higher weed density and weed dry weight indicating that pre emergence application of pyrazosulfuron ethyl alone was not able to control weeds particularly *Eleusine indica* under aerobic conditions because it has developed resistance against this herbicide as reported by Heap (2002). Significantly higher grain yield of aerobic rice with RDF+FYM+Biofertilizers+$FeSO_4$ at 12.5 kg ha^{-1}+IWM practices over RDF+FYM+IWM practices and SSNM+IWM practices was attributed to better control of weeds throughout the crop growth period and also significant increase in growth and yield parameters (Jayadeva *et al*., 2011; Sunil *et al*., 2011).

Significant reduction in per cent chaffyness was observed with application of RDF + FYM + Biofertilizers +$FeSO_4$ at 12.5 kg ha^{-1} + IWM practices was mainly attributed to better control of weeds at proper time reduced the competition between crop and weeds for nutrients, space, light and carbon dioxide (Tindall *et al.*, 2005) resulted in better proliferation of roots inturn enhanced the availability of nutrients required for grain filling. As a consequence of this the physical quality parameters (hulling, milling, head rice recovery and head yield) of aerobic rice was higher with of RDF + FYM + Biofertilizers + $FeSO_4$ at 12.5 kg ha^{-1} + IWM practices.

In aerobic rice, integrated package of agrotechniques significantly influenced the chemical properties viz., protein content, protein yield, amylose content, zinc and iron content in rice. All these parameters were significantly higher with RDF + FYM + Biofertilizers+ $FeSO_4$ at 12.5 kg ha^{-1} + IWM practices (Table 3) under both unpolished and polished grains. Peng *et al.* (2006) revealed that growing rice under aerobic situation reduce the yield by 35-40% over flooded rice. The grain yield and protein content are negatively correlated (Govindaswami and Ghosh, 1974). Higher nitrogen supply results in enhancement in protein content of grain, suggesting that hydrocarbons synthesized during photosynthetic process are diverted to form more of proteins resulted once again in decreased amylose content (Sarita *et al.,* 2009). Ardakani *et al.* (2011) also reported that the combined application of Zn and Fe and biofertilizers (Azospirillum and *Bacillus megaterium*) enhanced the N fixation, increased Zn absorption in plants and also enhanced the phosphate and iron solubilization by the production of organic acids enhanced uptake of these nutrients, inturn the zinc and iron content in rice grain has been increased.

The chemical properties viz., protein content, amylose content, zinc and iron content were significantly higher under brown rice/unpolished rice but after polishing of rice these chemical parameters were reduced in their content was mainly attributed to removal of germ and bran layers of rice which is rich in iron, zinc, vitamin B etc.

The cooking quality parameters *viz.,* water uptake ratio, volume expansion ratio, cooking time, keeping quality, length of kernel, breadth of kernel, L/B ratio and Elongation ratio were not significantly influenced by integrated package of agrotechniques (Table 4). Cooking quality parameters are varietal characters and cannot be altered by agronomic practices (Bryant *et al*., 2009; Champagne *et al.,* 2007).

CONCLUSION

Application of recommended dose of fertilizers at 100:50:50:20 kg NPK and $ZnSO_4$ ha^{-1}+FYM at 10 t ha^{-1} + $FeSO_4$ at 12.5 kg ha^{-1} + soil application of biofertilizers viz., Azospirillum and PSB at 4 kg ha^{-1} each + IWM 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) resulted in higher grain yield of aerobic rice. It also helped in improving the physical quality parameters percent (hulling, milling, head rice recovery and head yield) and chemical quality parameters (protein content, amylose content, zinc and iron content) in rice grain.

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