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RESEARCH PAPER

Agronomic and physiological measures to enhance the yield and water productivity of aerobic rice in coastal deltaic region of Karaikal

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Abstract : A field investigation was carried out at east farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal during winter (*Navarai*), 2017. Two rice varieties *viz*., V_1 - ADT 46 and V_2 - KMP 175 were evaluated under two irrigation methods *viz*., I_1 - Surface irrigation as flooding and I_2 - Drip irrigation at 1.2 CPE each with six foliar spray treatments on 55 and 75 DAS *viz*., F_1 – Water spray, F_2 – Silica @ 500 ppm, F_3 – KCl @ 10000 ppm, F_4 – Boric acid @ 0.4 ppm, F_5 – Triacontanol @ 2 ppm, F_6 – Brassinosteroids @ 1 ppm along with F_0 - control. The aerobic rice experiment was laid in Split split plot design. The variety KMP 175 had significantly out-yielded ADT 46 and produced the highest grain and straw yields. Similarly, Brassinosteroids and KCl treated plots had recorded statistically at par and higher grain and straw yields. On the other hand, the surface irrigation and drip irrigation had produced statistically similar grain yield. The harvest index of aerobic rice was averaged at 0.23 which was considerably low when compared to the other irrigated rice growing environments. The total water use by aerobic rice under drip irrigation method was almost 35 per cent lesser than surface irrigation but its use efficiency was almost 21 per cent higher than surface irrigation. Similarly, the variety KMP 175 under both irrigation methods registered 70 per cent higher water use efficiency than ADT 46. The highest gross income, net income and B:C ratio could be achieved if KMP 175 was chosen to grow under surface irrigation along with Brassinosteroids foliar spray. Hence, it is concluded from the experiment that the variety KMP 175 could be chosen to grow as aerobic in the coastal deltaic region of Karaikal coupled with either Brassinosteroids or KCl foliar spray under either surface irrigation if water is not a constraint or with drip irrigation if water is a constraint to achieve higher grain yield and net profit.

Key Words : Aerobic rice, Irrigation methods, Foliar spray, Varieties, Grain yield, Water productivity, Economics

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INTRODUCTION

Rice is consumed by about three billion people and is a staple food for a large people on the earth (Wassman *et al.,* 2009). It is cultivated in an area of 18.45 and 0.21 lakh hectares, in Tamil Nadu and Union Territory of Puducherry with an average production of 56.63 and

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0.52 lakh tonnes and productivity of 3070 and 2507 kg ha^{-1}, respectively (DRD, 2011). Karaikal, a separate enclave of Union Territory of Puducherry in the east coast of Tamil Nadu is considered as the rice bowl of Puducherry and rice is grown in an area of 6,011 ha with an average productivity of 2,400 kg ha^{-1} (DES, 2012).

Rice cultivation which is pre-dominant in the Cauvery river command area is now under a serious threat of water availability owing to distinct reasons. Irrigated lowland rice is one of the major consumers of fresh water as it utilizes 24–30 per cent of the world's accessible freshwater resources (IWMI, 2007 and Singh *et al.*, 2013). Tuong and Bouman (2002) have predicted that by the year 2025, about 17 m. ha of irrigated rice area in Asia may experience 'physical water scarcity' and 22 m ha may face 'economic water scarcity'. The average overall efficiency of canal irrigation projects in rice growing areas of the world is estimated at a miserably low of 23 per cent (Walters and Bos, 1999) while on the contrary, efficiency of trickle (drip) irrigation can approach 90-96 per cent (Bucks *et al.*, 1982). Hence, there is an urgency to adopt rice cultivation to consume less water while sustaining the productivity.

Aerobic rice is a new technique of rice cultivation that saves water to a tune of 73 per cent in land preparation and 56 per cent during crop growth compared to conventional method (Castaneda *et al.,* 2003). Similarly, the water required for pipe conveyance was 152 mm as against 240 mm under open channel irrigation resulting in a saving of 36.6 per cent water with the same or a slightly higher yield of rice (Srivastava, 2009). On the other hand, as rice is from time immemorial adopted to puddled soil condition, aerobic rice cultivation results in water stress to the plants which could be mitigated by applications of foliar chemicals and leaves a better scope to enhance the growth of aerobic rice. Therefore, an investigation on aerobic rice under both surface and drip irrigation with six different foliar chemicals was carried out on two varieties to study its performance.

MATERIAL AND METHODS

The field experiment was conducted at East farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA and RI), Karaikal during winter (*Navarai*) season (2016-17). The farm is situated at 10° 55'N latitude and 79°49'E longitude at an altitude of four meters above MSL with relatively flat and uniform gentle slope. Karaikal region comprises within the eleventh agro ecological zone of India and it is classified as PC_2 -Coastal deltaic alluvial plain. The region enjoys tropical climate and receives an annual average rainfall of 1368.4 mm in 55.8 rainy days. The beneficial monsoon is north- east monsoon (October – December) which accounts for nearly 75 per cent of total rainfall while the south- west monsoon (June – September) contributes nearly 16 per cent and the rest of the rainfall occurs during summer (March to May) and winter (January – February) seasons. The soil of the experimental field is sandy clay in texture as per the USDA classification and is near neutral, non – saline. The fertility status (Organic C) of the experimental field soil was medium (0.5), low in available nitrogen, high in phosphorus and medium in potassium availability. The field experiment was conducted in Split-split plot design and replicated thrice with irrigation methods as main plot (I_1 - Surface irrigation as flooding and I_2 - Drip irrigation at 1.2 CPE), two varieties (V_1 - ADT 46 and V_2 - KMP 175) as sub plot and six foliar spray treatments on 55 and 75 DAS as sub-sub plot (F_1 – Water spray, F_2 – Silica @ 500 ppm, F_3 – KCl @ 10000 ppm, F_4 – Boric acid @ 0.4 ppm, F_5 – Triacontanol @ 2 ppm, F_6 – Brassinosteroids @ 1 ppm along with F_0 – control). The net plot area was 4.8m x 1.8m (8.64 m^2) and the seeds were dibbled manually in the dry soil at 20 cm inter and 20 cm intra row spacing.

Irrigation scheduling:

The first irrigation and the lifesaving irrigation were given as common to all the treatments. Subsequently, for the I_1 – Surface flood irrigation treatments, irrigation was scheduled as per the climatological approach (IW/CPE) with the "r" value of 1.0 at all the growth stages. A depth of 5 cm irrigation water was provided each time in the surface flooding irrigation method. The interval of irrigation for was calculated as per the formula given below:

$$\textbf{Irrigation interval (days)} = \frac{\textbf{Cumulative pan evaporation (CPE)}}{\textbf{Average daily pan evaporation (mm)}}$$

where,

$$\textbf{(CPE)} = \frac{\textbf{Irrigation water depth (mm)}}{\textbf{r}}$$

However, in I_2 - drip irrigation treatments, irrigation water quantity of 1.2 times the open pan evaporation (mm) was provided through the laterals once in alternate days. The time of operation of drip system in the drip irrigation plots was calculated as below:

$$\text{Time of operation (hours)} = \frac{\text{Volume of water (V) in litres required per plot}}{\text{Emitter rate (LPH) x No. of emitters in the plot}}$$

where, Volume of water (V) in liters required per plot is calculated based on the following formula:

V = Eo x 1.2 x A

where,

Eo = Daily USWA open pan evaporation data (mm/day)

A = Area of the plot (m^2)

RESULTS AND DISCUSSION

In contrast to the diverse growth response of the varieties to aerobic soil condition, almost all the yield attributing characters were favourably higher in the variety KMP 175 than ADT 46. Similarly, between the two irrigation methods, few of the growth and yield parameters were favored by surface irrigation method whereas few other growth and yield parameters were favored by drip irrigation method. In the same analogy, most of growth and yield attributing characters was significantly influenced by Brassinosteroids @ 1 ppm foliar spray twice on 55th and 75th DAS. However, the grain and straw yield of aerobic rice was significantly influenced only by varieties and foliar spray and not with any other factor or interaction of factors. The variety KMP 175 had consistently out yielded (Table 1 and Fig. 1) the performance of ADT 46 in terms of majority of growth and nearly all yield attributing characters ultimately resulting in significantly higher grain and straw yields. In a comprehensive expression, the variety KMP 175 had out yielded the grain yield of ADT 46 with a magnitude of 59 per cent.

Due to constant favourable performance of Brassinosteroids and KCl foliar spray on all the growth and yield attributing characters, their ultimate and combined influence had resulted in significantly higher grain and straw yields. The magnitude of influence of Brassinosteroids and KCl foliar spray over the control was 91 and 82 per cent, respectively. Similarly, the magnitude of grain yield variation by surface and drip irrigation was insignificant with a minor difference of 13 per cent. In respect of straw yield of aerobic rice, the variety KMP 175 and among the foliar spray treatments, Brassinosteroids had recorded significantly higher straw

Table 1 : Grain yield and straw yield (kg ha^{-1}) of aerobic rice at harvest stage as influenced by varieties, irrigation methods and foliar treatments

Treatments		Grain yield (kg ha^{-1})							Mean	Straw yield (kg ha^{-1})							Mean
		F_0	F_1	F_2	F_3	F_4	F_5	F_6		F_0	F_1	F_2	F_3	F_4	F_5	F_6	
I_1 –	V_1- ADT 46	928	1606	1765	1900	1670	1613	1939	1631	5976	5372	5844	5839	6096	6198	6520	5978
Surface	V_2- KMP 175	1670	2717	3061	3091	2580	2884	3209	2745	7013	9287	7076	7972	6385	8785	9069	7941
irrigation	Mean	1299	2161	2413	2495	2125	2249	2574	2188	6494	7330	6460	6906	6241	7492	7795	6960
I_2 – Drip	V_1- ADT 46	904	1441	1554	1820	1748	1519	1874	1551	5954	5339	5606	5528	6281	6796	6543	6007
irrigation	V_2- KMP 175	1642	2222	2294	2561	2304	2445	2800	2324	7230	6372	8293	7474	7909	7039	9235	7650
	Mean	1273	1831	1924	2191	2026	1982	2337	1938	6592	5856	6949	6501	7095	6918	7889	6828
	V_1 – ADT 46	916	1523	1659	1860	1709	1566	1906	1591	5965	5356	5725	5683	6189	6497	6531	5992
	V_2 – KMP 175	1656	2469	2678	2826	2442	2665	3005	2534	7121	7830	7684	7723	7147	7912	9152	7796
Foliar mean		1286	1996	2169	2343	2075	2115	2456	-	6543	6593	6705	6703	6668	7205	7842	-
Sources		S.E.±			C.D. (P=0.05)					S.E.±			C.D. (P=0.05)				
Irrigation (I)		125.9			NS					285.0			NS				
Varieties (V)		125.1			267					65.6			140				
V x I		177.0			NS					92.7			NS				
Foliar (F)		135.6			228					359.8			604				
V x F		191.8			NS					508.8			NS				
I x F		191.8			NS					508.8			NS				
V at IF		307.2			NS					672.6			NS				
I at VF		1184.8			NS					3808.7			NS				

F_0 – Control (No foliar spray), F_1 – Water spray on 55 and 75 DAS, F_2 – Silica @ 500 ppm on 55 and 75 DAS, F_3 – KCl @ 10000 ppm on 55 and 75 DAS, F_4 – Boric acid @ 0.4 ppm on 55 and 75 DAS, F_5 – Triacontanol @ 2 ppm on 55 and 75 DAS, F_6 – Brassinosteroids @ 1 ppm on 55 and 75 DAS
NS= Non-significant

yield. The harvest index of aerobic rice was averaged at 0.23 which was considerably low when compared to other irrigated rice growing environments.

The surface irrigation by flooding was provided on an average at 8 days interval, while under drip method, irrigation water was provided on every alternate day to

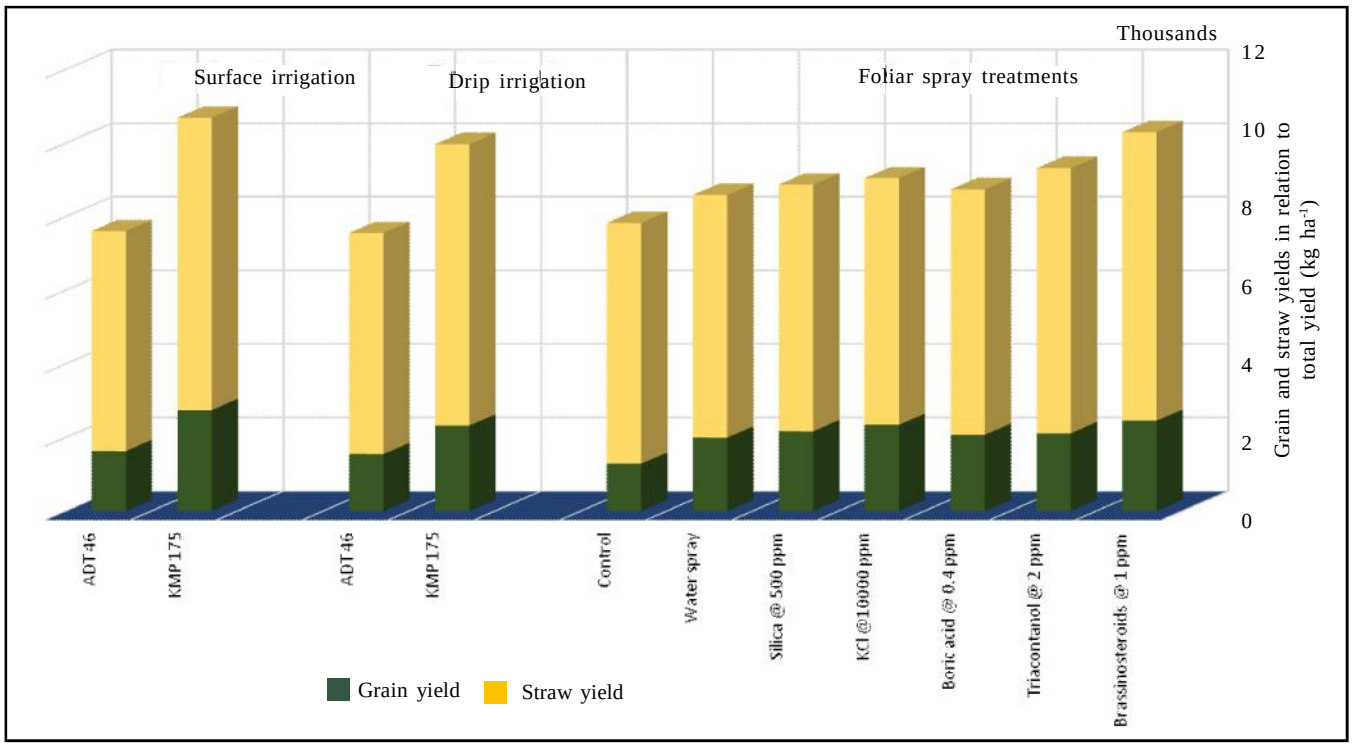

Fig. 1: Grain and straw yields (kg ha^{-1}) of aerobic rice as infleunces by varieties, irrigation methods and foliar spray treatments

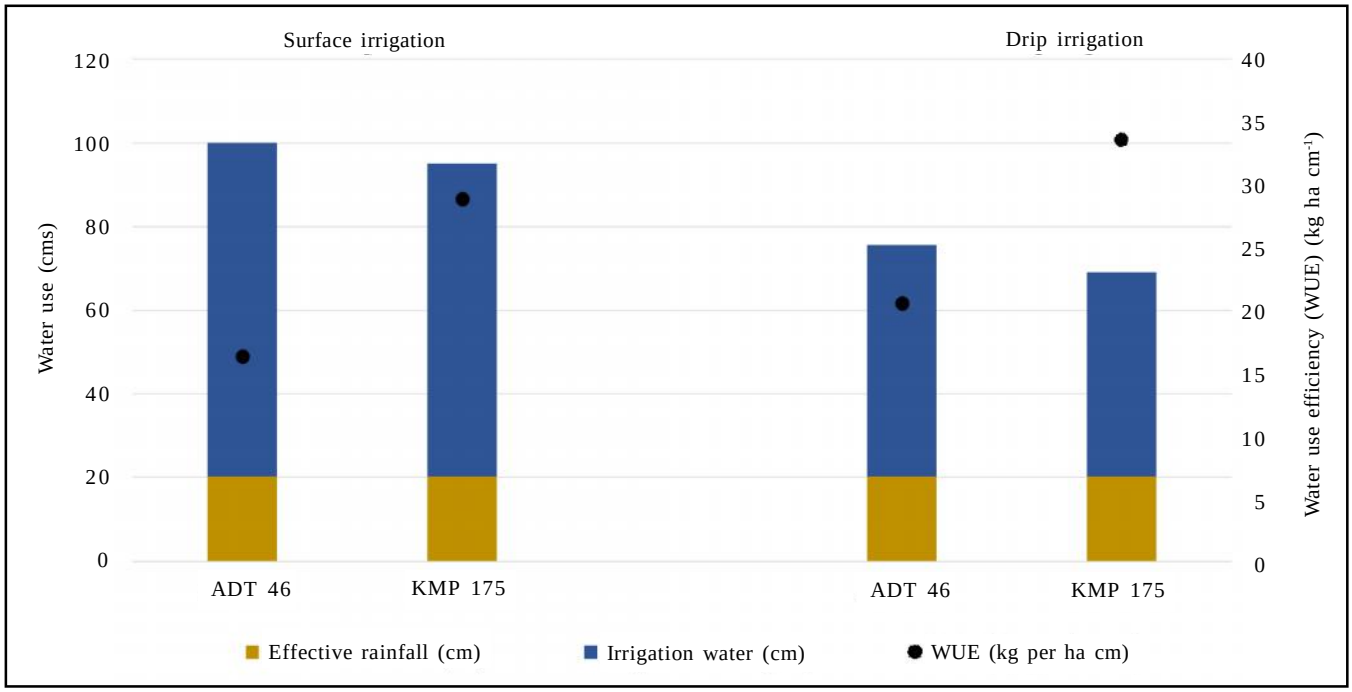

Fig. 2 : Water use (cm) and water use efficiency (kg ha cm^{-1}) of aerobic rice varieties under two different irrigation methods

maintain 1.2 Cumulative Pan Evaporation (CPE). Thus, under the surface irrigation method high quantity of water was provided with less frequency whereas, under drip method, low quantity of water with high frequency was provided. The varietal duration of ADT 46 was also longer than KMP 175 and hence, the total water use by the varieties varied marginally (Fig. 2). The total water use by aerobic rice varieties ADT 46 and KMP 175 under drip irrigation method was almost 35 per cent lesser than surface irrigation method. The computation of water use efficiency for both the varieties indicated a marginal difference between irrigation methods but larger difference between varieties. Owing to the low water use by the drip irrigation method, its use efficiency was almost 21 per cent higher than surface irrigation. Similarly, owing to the high yielding potential of the variety KMP 175 under both irrigation methods, its use efficiency was 70 per cent higher than ADT 46.

Due to higher grain and straw yield, the highest gross income of Rs. 63,622 ha^{-1} was obtained by the variety KMP 175 when grown under surface irrigation with Brassinosteroids foliar spray (Fig.3). The surface irrigation gross income (Rs. 44,156 ha^{-1}) was slightly higher than drip irrigation (Rs. 39,774 ha^{-1}) owing to the edge over yielding ability of the varieties under surface irrigation (Fig. 3).

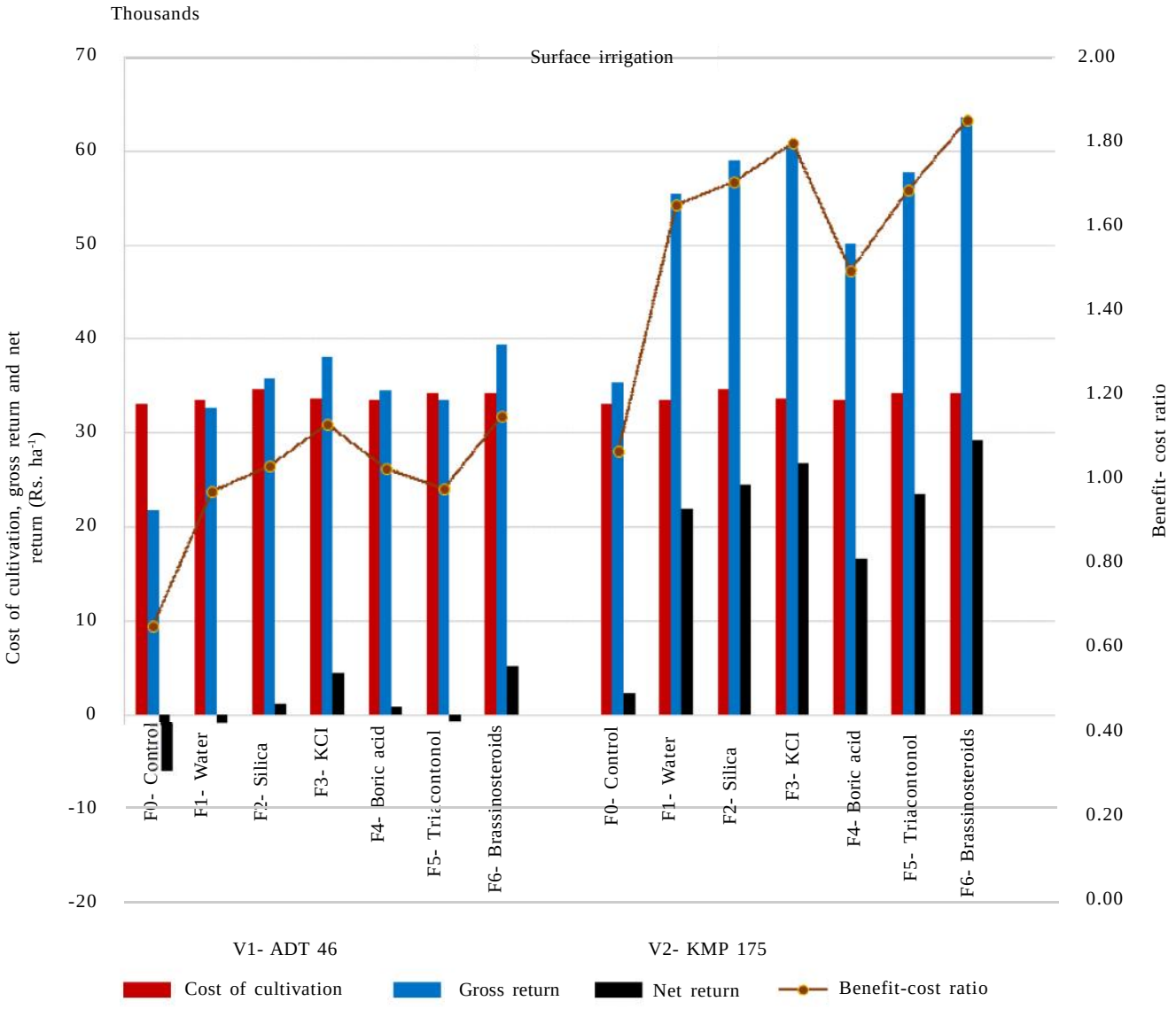

Fig. 3 : Economics of aerobic rice varieties as influenced by the varieties irrigation methods and foliar spray treatments

Conclusion:

It is concluded from the experiment that the variety KMP 175 could be chosen to grow in the coastal deltaic region of Karaikal under aerobic soil condition with either surface irrigation if water is not a constraint or with drip irrigation if water is a constraint coupled with either Brassinosteroids or KCl foliar spray to achieve higher grain yield and net profit.

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