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Effect of Weather Parameters on Yield and Yield Attributes under Aerobic Rice Cultivation during *Navarai* Season

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Authors' contributions

This research work was carried out in collaboration among all authors. Authors SP and AN conceptualized, designed and carried out this research. Authors SP and VS recorded the data and performed statistical analysis. Authors SP, VS, AN and AS wrote the protocol and wrote the first original draft of the manuscript. Authors SP, VS and AS managed the literature searches. Author AKS reviewed and edited the manuscript. Authors AN and AKS supervised the whole study. All authors have read and approved the final manuscript for publishing in the journal.

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ABSTRACT

A field experiment was conducted during *Navarai* season of 2017 at research farm of Agronomy, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry, India on investigate the performance of seed priming practices at different dates of sowing (February 6th, February 13th and February 20th) under aerobic condition. The results indicated that among the dates of sowing, crop sown on 6th February produced higher grain yield of 2591 kg ha^{-1}. Correlation studies revealed that the direct weather parameters such as maximum and minimum temperature, rainfall, morning and evening relative humidity, total evaporation were significantly contributing to the rice grain yield and DMP. Similarly, the derived weather parameters *viz*., mean Diurnal Variation Temperature (DVT) total Growing Degree Day (GDD), total Helio Thermal Units (HTU),

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total Photo Thermal Units (PTU) and total Heat Unit Efficiency (HUE) were also significantly contributing to the rice grain yield. From the studyprovedthatthe sowing window February 6th to be more effective for realizing higher productivity of aerobic rice during *Navarai* season at Karaikal district of Puducherry.

Keywords: Aerobic rice; direct weather parameters; derived weather parameter; yield and yield attributes.

1. INTRODUCTION

Rice is a unique crop among the major food crops by virtue of its extent and adaptability to wider range of climatic, edaphic and cultural conditions. About 90 per cent of the rice production takes place in the tropical and sub-tropical Asia, where more than 60 per cent of the world population exists. It is also the major staple food for more than half of the World's population [1]. Rice consumes 40 per cent of all fresh water used in Asia. The productivity of Asian irrigated rice system is increasingly threatened by water scarcity. Tuong and Bouman [2] estimated that by 2025, two million hectares of Asian irrigated dry season rice and 13 million hectares of its irrigated wet season rice may experience "Physical water scarcity". Therefore,Aerobic rice technology isone way to reduce water scarcity instead of the puddled transplanted rice [3]. The term aerobic rice coined by the International Rice Research Institute (IRRI), it has been developed and adopted by farmers in Brazil, China and other Asian countries [4]. Aerobic rice refers to growing rice in condition of non-flooded and non-puddled low land soil with supplemental irrigation. Aerobic rice recorded substantial water savings by minimizing seepage, percolation and greatly reduced evaporation [5]. Aerobic rice generally requires 30 to 50 per cent less water even though it resulted in a yield penalty of 20 to 30 per cent [6]. Rice production in the tropics is sensitive to weather which affects the crop in various ways during different stages of its growth [7] and certain stages are more sensitive to weather than others [8]. The potential productivity of the aerobic rice could be positively changed by altering the sowing window in tune with favorable weather conditions [9]. Hence, the present investigation was made in aerobic rice towards establishing the ways and mean stomitigate the unfavorable weather conditions during *Navarai* season at Karaikal.

2. METHODOLOGY

A field experiment was conducted at Agronomy farm (Eastern farm) of Department of Agronomy at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry during *Navarai* from February to June, 2017 to evaluate the influence of weather factors and seed priming practices on rice productivity under aerobic condition at Karaikal. It is situated at 10^{o} 55' N latitude and 79^{o} 49' E longitude with an altitude of 4 meters above Mean Sea Level (MSL). Karaikal enjoys a tropical climate and receives a normal rainfall of 1397 mm in a year with an average maximum and minimum temperatures of 35.4 and 25.6°C respectively. The normal relative humidity is 87.9 and 59.9 per cent. The soil of the experimental site was clayey having normal i.e., pH 7.1 ,EC 0.1 dSm-1,organic carbon 0.60%, low available N 191.29 kg ha^{-1}, high available P 163.00 kg ha^{-1} and normal K 279.6 kg ha^{-1}. The experiment was laid out in the Randomized Block Design (Factorial) and the treatments were replicated thrice and the treatments combination consist of three dates of sowing at weekly intervals *viz*., 6th February (S_1), 13th February (S_2), and 20th February, (S_3) with five seed priming practice *viz.,* P_1: Water P_2: KCl (1%) P_3: Moringa leaf extract (2%) P_4: Pungam leaf extract (1%) P_5: Fresh cow dung solution (5%).The selection of date of sowing based on traditional cropping system practices in the deltaic region of Karaikal (Rice-Rice-Rice cropping system). Rice variety PMK (R) 3 seeds were direct sown in line manually with 20 X 10 cm spacing in the well prepared field. Irrigation was immediately given after sowing. Later, the number of lifesaving irrigation was given in equal manner to respective dates of sowing when, hair line cracks were formed. Recommended fertilizer (150:50:50 NPK)doses was applied in splits (Phosphorus as basal, nitrogen and potassium at 15 DAS, tillering phase (35 DAS), panicle initiation (55 DAS) and flowering phase (75 DAS) equally). Additionally, $ZnSO_4$ was applied @ 25 kg ha^{-1} at tillering phase (35 DAS) and panicle initiation phase (55 DAS).Biometric observations were recorded as per the guidelines of All India Coordinated Rice Improvement Project (AICRIP), Hyderabad. In each plot, five hills were selected and tagged at random in the net plot area for recording the biometric observations at various

Table 1. Effect of dates of sowing on yield attributes

Treatments	Panicleshill^{-1}	Panicle length (cm)	Panicle weight (g)	Number of spikelets panicle^{-1}	Number of fil ledgrainspanicle^{-1}	Grain filling percentage	Test weight (g)
Dates of sowing(S)							
S_1: 6th February	9.4	27.5	3.6	185.9	139.5	74.1	22.8
S_2: 13th February	8.7	26.7	3.3	169.1	120.8	73.1	22.4
S_3: 20th February	8.6	26.4	2.4	166.0	112.7	66.8	21.9
SEm±	0.31	0.26	0.06	3.92	4.39	2.36	0.19
CD (p= 0.05)	0.63	0.53	0.12	8.04	8.99	4.83	0.38
Seed Priming (P)							
P_1: Water	8.1	26.2	2.8	165.8	115.4	68.0	22.2
P_2: 1% KCl	8.7	26.7	3.0	171.2	118.4	70.3	22.5
P_3: 2% Moringa leaf extract	9.3	27.6	3.3	179.6	134.8	74.5	22.6
P_4: 1% Pungam leaf extract	9.1	26.4	3.1	176.3	125.4	70.8	22.2
P_5: 5%Cow dung slurry	9.2	27.5	3.2	175.6	127.6	73.0	22.4
SEm±	0.40	0.34	0.08	5.06	5.67	3.04	0.19
CD (p= 0.05)	0.81	0.69	0.17	NS	11.61	NS	0.38
Interaction (SXP)							
SEm±	0.69	0.58	0.14	8.78	9.81	5.27	0.42
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	0.86

growth phases *viz*., vegetative (30 DAS), reproductive (60 DAS), maturity phase (90 DAS) and the yield attributes were recorded at the time of harvest.

Meteorological data were obtained from the meteorological observatory of PAJANCOA&RI, Karaikal for various phenophases *viz.,* seedling phase, vegetative, reproductive and maturity phases of the respective treatments to study their influence on aerobic rice.

The Agro-meteorological indices like mean Diurnal Variation Temperature (DVT) total Growing Degree Day (GDD), total Helio Thermal Units (HTU), total Photo Thermal Units (PTU) and total Heat Unit Efficiency (HUE) was calculated using the respective formulas.

3. RESULTS AND DISCUSSION

3.1 Effect of Weather Parameters on Yield Attributes

The dates of sowing revealed that, earlier crop sown at 6th February had comparatively higher values for various yield attributes like number of panicles hill^{-1}, panicle length and panicle weight than the crop sown in later dates i.e. 13th February and 20th February. Similar results were obtained for number of spikelets panicle^{-1}, number of filled grains panicle^{-1} and grain filling percentage (Table 1). The possible reason for yield attributes influenced by early sowing may be due to relatively higher solar radiation during the cropping period with low temperature

Table 2. Mean maximum temperature (^{o}C) prevailed at different phases of aerobic rice (Data statistically not analyzed)

Seed priming and phenol phases	Dates of sowing (S)			
	S_1	S_2	S_3	Mean
Priming with water (P_1)				
Seedling phase	30.6	31.0	31.8	31.1
Vegetative phase	32.4	32.7	33.2	32.8
Reproductive phase	35.7	36.7	37.0	36.8
Maturity phase	37.8	38.1	38.8	38.2
Full lifespan	34.5	35.1	35.7	35.1
Priming with one percent KCl(P_2)				
Seedling phase	30.6	30.9	31.8	31.1
Vegetative phase	32.4	32.7	33.3	32.8
Reproductive phase	35.9	36.2	36.9	36.3
Maturity phase	37.8	37.9	38.7	38.1
Full lifespan	34.5	35.0	35.6	35.0
Priming with two percent moringa leaf extract(P_3)				
Seedling phase	30.6	30.8	31.8	31.1
Vegetative phase	32.3	32.7	33.1	32.7
Reproductive phase	35.2	36.3	36.8	36.1
Maturity phase	37.8	37.9	38.8	38.2
Full life span	34.5	35.0	35.6	35.0
Priming with one percent pungam leaf extract (P_4)				
Seedling phase	30.6	30.9	31.8	30.1
Vegetative phase	32.3	32.7	33.3	32.8
Reproductive phase	35.8	36.6	37.0	36.5
Maturity phase	37.8	38.0	38.8	38.2
Full lifespan	34.5	35.0	35.6	35.1
Priming with five percent cow dung slurry(P_5)				
Seedling phase	30.6	31.0	31.8	31.1
Vegetative phase	32.3	32.7	33.2	32.8
Reproductive phase	35.5	36.7	36.9	36.4
Maturity phase	37.8	38.3	38.9	38.4
Full lifespan	34.5	35.1	35.7	35.1

S_1: 6th February, S_2: 13th February, S_3: 20th February

(Table 2) increased the length of the crop growth period and tillering rate. Joseph et al. [10] reported that accumulated solar radiation during tillering phase resulted in more number of panicles m^{-2}. Among the dates of sowing, crop sown earlier (6th February) had higher test weight than other dates of sowing (Table 3). This might be due to lower temperatures during the ripening phase of the crop (Table 2), which extended the ripening period, translocation of photosynthates to grain took place at a slower rate and thus increasing the grain filling percentage. Temperatures influenced the ripening of rice in two ways first, low temperature favored in increase in grain weight and second, low daily mean temperature increased the length of ripening period. At lower temperature, the maturity period got delayed. Temperature less than 28°C during grain filling increased its duration and seed size [11,7].

3.2 Weather Factors Effect on Grin Yield, Straw Yield and Harvest Index (HI)

The results showed a significant difference in grain yield by dates of sowing. With respective to dates of sowing, seeds sown on 6th February produced significantly the highest grain yield of 2592 kg ha^{-1} (Table 4). This was followed by 13th February and 20th February sown yielded 1977.7 and 1236.8 kg ha^{-1}, respectively. In general, among the dates of sowing earlier dates of sowing *viz.,* 6th February recorded a grain yield of 2592 kg ha^{-1}, which is about 63.3 per cent higher than the later sown crop 20th February. The success of aerobic rice mainly depends on time of sowing. The potential yield of rice crop can be achieved only by growing at its appropriate sowing window in a cropping season (Singh *et al*., 1990). Haridassan [12] opined that the grain yield of rice increase with increasing trend of radiation and lesser temperature during reproductive phase (Table 3). Low diurnal variation (Table 4) produced increased fertility coefficient in hybrid rice [13]. Low temperature (Table 3) increases the grain yield by delaying the grain maturation and extending the grain filling and high temperature reduces grain yield by reducing the percentage of ripened grains [14]. Also, Jana et al. [15] reported that higher temperature during the flowering period results in poor seed setting and causes spikelet sterility reducing the yield. Later sowing had high temperature when compared to its earlier sowing which may have resulted in the reduced grain yield by increasing the spikelet sterility.

Similar trend was visualized for the straw yield (8882.2 kg ha^{-1}) and harvest index (23.2). Earlier sowing on 6th February was the best sowing window for all priming practices and when sowing window was delayed, the poor performance of aerobic rice was visualized (Table 3). High light intensity may have supported in increased straw yield with more photosynthesis. Greater demand for photosynthates occur with low light intensity thereby reducing photosynthesis followed by DMP and finally reduces straw yield [16].

Table 3. Effect of dates of sowing and seed priming on test weight (g), grain yield (kg h^{1}), straw yield (kg ha^{-1}) and harvest index (%) ofaerobic rice

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index (%)
Dates of sowing(S)			
S_1: 6th February	2591.5	8882.2	23.2
S_2: 13th February	1977.7	8649.9	18.9
S_3: 20th February	1236.8	7986.7	13.5
SEm±	52.32	162.20	0.57
CD (p= 0.05)	107.18	332.26	1.17
Seed Priming (P)			
P_1: Water	1725.1	8309.2	17.1
P_2: 1% KCl	1837.7	8235.4	17.8
P_3: 2% Moringa leaf extract	2256.5	8963.9	20.0
P_4: 1% Pungam leaf extract	1912.3	8380.4	19.2
P_5 : 5%Cow dung slurry	1945.1	8642.3	18.6
SEm±	52.32	162.20	0.57
CD (p= 0.05)	107.18	332.26	1.17
Interaction (SXP)			
SEm±	116.99	362.69	1.27
CD (p= 0.05)	239.65	NS	NS

Table 4. Mean Diurnal variation temperature (DVT) (degrees) prevailed at different phases of aerobic rice (Data statistically not analyzed)

Seed priming and pheno phases	Dates of sowing (S)			
	S_1	S_2	S_3	Mean
Priming with water (P_1)				
Seedling phase	9.2	9.4	8.7	9.4
Vegetative phase	8.2	8.7	9.0	8.6
Reproductive phase	9.7	10.1	9.9	10.0
Maturity phase	10.1	10.2	11.0	10.5
Full lifespan	37.2	38.5	38.6	38.5
Priming with one percent KCl(P_2)				
Seedling phase	9.2	9.4	8.7	9.5
Vegetative phase	8.2	8.6	9.1	8.7
Reproductive phase	9.8	9.9	10.1	10.0
Maturity phase	10.1	10.2	10.8	10.4
Full lifespan	37.3	38.2	38.8	38.5
Priming with two percent moringa leaf extract(P_3)				
Seedling phase	9.4	9.5	8.8	9.6
Vegetative phase	8.0	8.5	9.0	8.5
Reproductive phase	9.7	9.9	10.1	9.9
Maturity phase	10.2	10.2	10.9	10.4
Full lifespan	37.3	38.2	38.8	38.5
Priming with one per cent pungam leaf extract (P_4)				
Seedling phase	9.3	9.4	8.7	9.5
Vegetative phase	8.3	8.7	9.0	8.7
Reproductive phase	9.9	10.1	10.1	10.0
Maturity phase	10.0	10.2	10.9	10.5
Full lifespan	37.5	38.4	38.7	38.6
Priming with five per cent cow dung slurry(P_5)				
Seedling phase	9.4	9.4	8.8	9.5
Vegetative phase	8.2	8.7	9.0	8.7
Reproductive phase	9.8	10.1	10.0	10.0
Maturity phase	10.3	10.4	11.1	10.6
Full lifespan	37.7	38.6	39.0	38.7

S_1: 6th February, S_2: 13th February, S_3: 20th February

4. CONCLUSION

From the study resulted that during *Navarai* season 6th February sowing window was offered the higher productivity and an opportunity to mitigate the untoward incidence of drought under aerobic rice cultivation in the coastal deltaic areas of Karaikal.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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