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Influence of sowing dates on growth and yield of aerobic rice

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Abstract
A field experiment was conducted during *rabi* season from September 2013 to February 2014 at PAJANCOA & RI, Karaikal, Puducherry to study the relationship between weather parameters and yield of rice varieties at different dates of sowing under aerobic condition. The treatments consisted five dates of sowings *ie*., September 20th, September 27th, October 4th, October 11th and October 18th and three genotypes namely TRY 1, Improved White Ponni and ADT 39 varieties. The study revealed that the Growing Degree Days (GDD) during total lifespan decreased as the sowings were delayed. The accumulated GDD varied from 1507 to 1885.9 with different dates of sowing for total lifespan. The first date of sowing (D_1 - Sep. 20th) had produced significantly higher yield (4,337 kg ha^{-1}) over the subsequent sowing dates. Thus, the reduction of grain yield of rice was observed to the tune of 9-11 percent with delayed sowing. Days taken from sowing to physiological maturity reduced with subsequent delay sowings. From the study it was evident that under aerobic condition, the rice productivity would be reduced if sowings are delayed beyond the September 20th in *rabi* season.

Keywords: aerobic rice, sowing dates, GDD and yield

Introduction
The productivity of rice is influenced by improved varieties with us of improved technology. The high yielding varieties suitable to a particular agro climate is the most important factor in realizing their yield potential. Performance and yielding ability of a crop depends on the time of sowing or transplanting. Too early and too late sowing results in yield reduction which cannot be compensated by any other input or practice. There is vital role of time of sowing in paddy crop because of the fact variation in the duration, photo sensitiveness, thermosensitivity and vegetative lag period of the variety. A variety of short duration may suit better from early sowing to late sowing because of the fact that such varieties complete their life cycle with in short period with less effect of photoperiod and temperature. In case of longer duration varieties photo and thermo sensitive varieties may not perform better under late sowing condition while photo and thermo insensitive varieties may perform better under normal to late sowing condition with limited effect on yield of crop. The extent of reduction in yield under late sowing or transplanting may be differ with variety (Singh *et al*., 2005) [9] and their duration (Ram *et al*., 2005) [8]. Sowing time of crop can be adjusted for maximum advantages of the environmental factors best suited of various growth stages of crop. Long/medium/short duration, high yielding varieties of rice have been developed for cultivation in different rice growing areas of agroclimatic zones of India. Similarly, the characteristics of crop genotypes play an important role ignoring optimum yield with optimum weather conditions. For regions facing water scarcity, the aerobic rice system is proving to be a promising technology by reducing the water use (Bouman *et al.,* 2007) [2]. Among the crops, rice is mostly vulnerable to change with deviations in weather parameters. Being a thermo sensitive crop, choice of suitable variety for different seeding times of rice in future gets prime importance. Hence by keeping these views in mind an experiment was conducted to study the effect of weather on phonological stages of crop growth and development of rice varieties under aerobic.

Material and methods
A field experiment was conducted during *rabi* season at Agronomy Eastern Farm in Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Union Territory of Puducherry. It is situated at 10º55’ N latitude and 79º 49’ E longitude with an altitude of 4 m above Mean Sea Level (MSL).

The soil of the experimental site was loamy sand having alkalinity ie., P^H 8.2, EC 0.09 dSm^{-1}, organic carbon 0.24 %, available N (97.21 kg ha^{-1}), available P (30.96 kg ha^{-1}) and K (161.28 kg ha^{-1}). The experiment was laid out in factorial RBD with three replications and the treatments combination consisted of three varieties *viz.,* Improved White Ponni, TRY 1 and ADT 39 under five dates of sowing at weekly intervals *viz.,* September 20th (D_1), September 27th (D_2), October 4th (D_3), October 11th (D_4) and October 18th (D_5). Seeds were direct sown in line manually with 20 X 10 cm spacing in the well prepared field. Irrigation was given immediately after sowing. Later, life saving irrigations was given when hair line cracks were formed. Recommended fertilizer (150:50:50 NPK) was applied in splits (Phosphorus as basal, nitrogen and potassium at 15 DAS, tillering phase, panicle initiation and flowering phase equally). Additionally $ZnSO_4$ was applied @ 25 kg ha^{-1} at tillering phase and panicle initiation phase. 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 indice Growing degree Day (GDD) was calculated using the following formula:

$$GDD = \sum_{i=1}^{n} [Ti - T\,b]$$

Where,

Ti = Mean temperature of i^{th} day, Tb = Base temperature of rice, A base temperature of 13°C was adopted for rice reported (Arjunan *et al.* 1993) [1].

Results and Discussion

The Growing degree days (GDD) at different phenophase varied with date of sowing are presented in Table 1. In early sown crop the GDD was larger value at seedling and vegetative phase. Whereas, it was reversed in late sown crops. The highest total GDD (1885.9) for whole life span was observed for TRY 1 when sown on 20th September (D1) and lowest GDD (1507) was in ADT 39 when the crop was sown on 18th October (D5). Murthy (2016) [6] also reported lower consumption of heat units under delayed sowing in rice. Among the varieties, TRY 1 utilized higher GDD when compared to other varieties *viz.,* improved white ponni and ADT 39. For variety TRY 1, GDD required for attaining maturity was more due to its longer duration (Goswami *et al*., 2003) [4].

The total dry matter production (DMP) at different phenophase in different sowing dates is presented in Table 2. The total dry matter varied between 2291.3 kg ha^{-1} to 5589.0 kg ha^{-1} across the dates of sowing and varieties. Among the rice varieties Improved White Ponni (IWP) produced higher DMP followed by TRY 1 and ADT 39 during all growth phases, especially at flowering stage. Whereas, in different sowing dates, the crop sown at later dates significantly produced higher DMP. This might be due to the prevalence of relatively higher maximum temperature and minimum temperature during earlier phases (Table 3 & 4). Sunil (2000) [10] reported that plant biomass increase due to higher levels of maximum temperature. The low temperature in early growth stages retarded the development of seedlings and consequently reduced the dry matter production in rice. In the present investigation the prevailed temperature was relatively higher during seedling and vegetative phases, which might be the reason for increased DMP. These results corroborate the findings of Murthy (2016) [6].

The grain yield as influenced by different dates of sowing and varieties is presented in Table 5. The results indicated that higher grain yield (4549 kg ha^{-1}) obtained by sowing rice crop in Sep. 20th (D_1), which was about 18 per cent higher than the later date of sowing Oct. 18th (D_5). Higher grain yield recorded in early sowing compared with late sowing may be due to the fact that the crop get sufficient time for its growth and development under suitable climatic conditions in comparison to late sowing. Among the varieties, TRY 1 produced significantly higher yield, which was 11 per cent and 9 per cent higher than ADT 39 and IWP respectively. The variation in grain yield of IWP between early and late sowing date was meagre. For all the three varieties, 20th Sep. (D_1) was the optimum sowing date to obtain higher yield. The variation in grain yield of IWP between early and late sowing dates was meager. Gildayal and Jana (1967) [3] revealed that the grain yield of rice increase with decreasing trend of relative humidity during reproductive phase, which was also observed in the present investigation for TRY 1 during earlier sowing dates. The low grain yield in treatments was associated with relatively poor yield attributes of rice which could be cited as an evidence as reported by Narayanan (2004) [7].

The number of days taken to complete each phenophase varied with varieties and with date of sowing (Table 6). TRY 1 had longer duration when compared to other varieties. Higher variation in phenophase was observed especially in reproductive phase than other phases. The later sown crop consumed lesser number of days for maturity period for all the varieties than the earlier sown crop, which could be one of the reasons for the possibility of higher movement of photosynthates from source to sink as evidenced by Narayanan (2004). Mallick *et al*., (2006) [5] was also reported that days from sowing to flowering decreased as date of sowing were delayed.

Table 1: Total Growing Degree Days (GDD) (day °C) prevailed at different phenophases

Rice genotypes & Phenophases	Date of sowing (D)					
	D_1	D_2	D_3	D_4	D_5	Mean
Improved White Ponni (V_1)						
1	513.7	502.8	491.4	471.9	446.5	485.26
2	583.8	526.6	538.3	532.3	485.1	533.22
3	281.3	275.6	277.1	243.2	233.1	262.06
4	468.7	472.4	414.3	401.8	392.5	429.94
5	1847.5	1777.4	1721.1	1649.2	1557.2	1710.48
Try1 (V_2)						
1	513.7	502.8	491.4	471.9	446.5	485.26
2	569.9	538.8	524.8	510.4	471.8	523.14
3	330.1	308.1	290.7	276.5	283.0	297.68
4	472.2	473.1	437.3	416.3	384.3	436.64
5	1885.9	1822.8	1744.2	1675.1	1585.6	1742.72
ADT39 (V_3)						
1	513.7	502.8	491.4	471.9	446.5	485.26
2	569.9	526.6	498.7	478.2	439.9	502.66
3	241.3	228.7	245.5	225.7	231.4	234.52
4	443.8	434.2	391.8	381.0	389.5	408.06
5	1768.7	1692.3	1627.4	1556.8	1507.3	1620.50

1.Seedling phase 2.Vegetative phase 3.Reproductive phase 4.Maturity phase 5.Sowing to maturity phase

Table 2: Dry matter production (kg ha^{-1}) at flowering phase

Dates of Sowing (D)	Varieties (V)			Mean
	V$_1$: I.W.Ponni	V$_2$: TRY 1	V$_3$: ADT 39	
D$_1$: September 20th	3456.6	2878.3	2773.6	3036.2
D$_2$: September 27th	2777.6	2291.3	2602.3	2557.1
D$_3$: October 4th	4187.6	4562.0	2855.0	3868.2
D$_4$: October 11th	4621.3	3781.6	5254.3	4552.4
D$_5$: October 18th	5589.0	3103.3	3057.6	3916.6
Mean	4126.4	3323.3	3308.6	3586.1
Interaction	S Ed		CD (P=0.05)	
V	283.42		580.58	
D	365.89		749.52	
V x D	633.75		1298.22	

Table 3: Mean maximum temperature (ºC) prevailed at different phases of aerobic rice

Rice genotypes & Phenophases	Date of sowing (D)					
	D$_1$	D$_2$	D$_3$	D$_4$	D$_5$	Mean
Improved White Ponni (V$_1$)						
1	34.93	34.34	33.71	32.54	31.43	33.39
2	31.10	30.65	29.87	29.49	29.34	30.09
3	28.80	28.72	28.38	28.31	28.39	28.52
4	28.71	28.86	29.28	29.62	29.73	29.24
5	30.88	30.64	30.31	29.99	29.72	30.30
Try1 (V$_2$)						
1	34.93	34.34	33.71	32.54	31.43	33.39
2	31.10	30.59	29.84	29.56	29.35	30.08
3	28.87	28.68	28.48	28.32	28.45	28.56
4	28.83	29.05	29.33	29.70	29.93	29.36
5	30.93	30.66	30.34	30.03	29.79	30.35
ADT 39 (V$_3$)						
1	34.93	34.34	33.71	32.54	31.43	33.39
2	31.10	30.65	29.76	29.70	29.41	30.12
3	29.27	28.72	28.78	28.35	28.29	28.68
4	28.45	28.65	28.87	29.07	29.52	28.91
5	30.93	30.59	30.28	29.91	29.66	30.27

1. Seedling phase 2. Vegetative phase 3. Reproductive phase 4. Maturity phase 5. Sowing to maturity phase

Table 4: Mean minimum temperature (ºC) prevailed at different phases of aerobic rice

Rice genotypes & Phenophases	Date of sowing (D)					
	D$_1$	D$_2$	D$_3$	D$_4$	D$_5$	Mean
Improved White Ponni (V$_1$)						
1	25.31	25.17	25.04	24.92	24.33	24.95
2	24.08	23.81	23.04	22.47	22.18	23.11
3	21.65	21.24	20.71	20.84	20.92	21.07
4	20.72	20.75	20.39	20.00	20.05	20.38
5	22.94	22.74	22.29	22.05	21.87	22.37
Try1 (V$_2$)						
1	25.31	25.17	25.04	24.92	24.33	24.95
2	24.12	23.76	23.06	22.60	22.14	23.13
3	21.57	21.02	20.76	20.71	21.13	21.03
4	20.78	20.60	20.30	20.09	20.09	20.37
5	22.94	22.63	22.29	22.08	21.92	22.37
ADT 39 (V$_3$)						
1	25.31	25.17	25.04	24.92	24.33	24.95
2	24.12	23.81	23.19	22.86	22.43	23.28
3	22.23	21.34	20.60	20.21	20.85	21.04
4	20.90	20.81	20.86	20.73	20.07	20.67
5	23.14	22.78	22.42	22.18	21.92	22.48

1. Seedling phase 2. Vegetative phase 3. Reproductive phase 4. Maturity phase 5. Sowing to maturity phase

Conclusion

The study has clearly demonstrated that the climatic requirement of rice could suitably be matched by altering the sowing period. For higher yield of rice in *rabi* season under aerobic condition, the sowing should not be delayed beyond the 38th meteorological week (September 20th).

Table 5: Effect of varieties and times of sowing on grain yield (kg ha^{-1}) at harvest

Dates of Sowing (D)	Varieties (V)			Mean
	V$_1$: I.W. Ponni	V$_2$: TRY 1	V$_3$: ADT 39	
D$_1$: September 20th	4128.0	4579.3	4940.3	4549.2
D$_2$: September 27th	4128.0	4257.0	4128.0	4171.0
D$_3$: October 4th	3741.0	3999.0	3612.0	3784.0
D$_4$: October 11th	3870.0	4540.3	3483.0	3964.4
D$_5$: October 18th	4024.6	4308.3	3225.0	3852.6
Mean	3978.3	4336.8	3877.6	4064.2
Interaction	S Ed		CD (P=0.05)	
V	137.20		281.06	
D	177.13		362.85	
V x D	306.80		628.48	

Table 6: Duration (days) of major phenophase of aerobic rice (data statistically not analysed)

Rice genotypes & Phenophases	Date of sowing (D)					
	D$_1$	D$_2$	D$_3$	D$_4$	D$_5$	Mean
Improved White Ponni (V$_1$)						
1	30	30	30	30	30	30.0
2	40	37	40	41	38	39.2
3	23	23	24	21	20	22.2
4	40	40	35	34	33	36.4
5	133	130	129	126	121	127.8
Try 1 (V$_2$)						
1	30	30	30	30	30	30.0
2	39	38	39	39	37	38.4
3	27	26	25	24	24	25.2
4	40	40	37	35	32	36.8
5	136	134	131	128	123	130.4
ADT 39 (V$_3$)						
1	30	30	30	30	30	30.0
2	39	37	37	36	34	36.6
3	15	19	21	20	20	19.0
4	38	37	33	32	33	34.6
5	122	123	121	118	117	120.2

1.Seedling phase 2.Vegetative phase 3.Reproductive phase 4.Maturity phase 5.Sowing to maturity phase

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