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Agrometeorological indices in relation to phenology of aerobic rice

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ABSTRACT

Field experiment was conducted during *kharif* seasons of 2003 and 2004 at College farm, College of Agriculture, Rajendranagar, Hyderabad to study the phenology and, heat and radiation use efficiency in aerobic rice. Crop was sown on four different dates *viz.,* 16 June, 26 June, 07 July and 18 July as main plots and two varieties *viz.,* Jagtiala Sannalu and Polasa Prabha as sub-plots in split plot design and replicated thrice. Results revealed that, from emergence to physiological maturity, Jagtiala Sannalu has accumulated mean growing degree days of 2017±55 and heliothermal units of 11526±817 with coefficient of variation of 3% and 7%, respectively. While Polasa Prabha has accumulated 2102±33 mean growing degree days and 12031±716 heliothermal units from emergence to physiological maturity with coefficient of variation of 2 % and 6%, respectively. In both the cultivars i.e.,Jagtila Sannalu and Polasa Prabha higher heat use efficiency (6.61 and 6.29), heliothermal use efficiency (1.30and 1.19) and radiation use efficiency (6.28 and 5.88) were obtained in crop sown on 16 June. In Jagtila Sannalu and Polasa Prabha, physiological maturity can be predicted using AGDD HTU which accounted for 84% and 86% varibility.

Key words: Aerobic rice, GDD, Phenology, HUE, RUE

Weather variability is considered one of the major factors of inter-annual variability of crop growth and yield in all environments. In arid and semi-arid environments, besides rainfall, temperature and bright sun shine hours also have bearing on crop growth and development, and yield. Response of different species to one environment, or single species to different environments, can be quite different. Evaluation of genotypic influence on energy utilization environment and final yield could improve efficiency of an agricultural system. The variations in the agricultural production are mostly attributed to the effect of seasonal weather conditions on plant growth (Sastry *et al*, 2000). Shift in sowing dates directly influence both thermo and photo period, and consequently a great bearing on the phasic development and partitioning of drymatter. Quantification of these effects may help in the choice of sowing time and match phenology of crop in specific environment to achieve higher heat and radiation use efficiency. Temperature based agrometeorological indices such as Growing degree days (GDD), Heliothermal units (HTU) can be quite useful in predicting the growth and yield of crops. Growing degree days are based on the concept that, real time to attain a phonological stage is linearly related to temperature range between base temperature (T_b) and optimum temperature (Monteith, 1981). Heat and radiation use efficiencies in terms of drymatter or yield are important aspects, which have great practical application. The total heat and radiant energy available to any crop is never completely converted to drymatter under even the most favourable agroclimatic conditions. Efficiency of conversion of heat and radiant energy in to drymatter depends upon genetic factors, sowing time and crop type (Rao *et al*, 1999).

During rainy season, irrigated rice in Andhra Pradesh is subjected to water deficit resulting from inadequate irrigation supply. As a result, the transplanting of rice in the tail end of canal, tankfed and well irrigated areas is delayed. Under such circumstances, there is a scope to establish the rice crop with dry seeding and irrigating it with receipt of water. The success of dry seeded irrigated rice mainly depends on time of sowing which accounts for 23 per cent of yield variation. Information has been generated on prediction of phenology using agrometeorological indices (growing degree days) in low land rice (Reddy *et al*, 2004). In view of the gaining importance to aerobic rice due to late filling of reservoirs and decrease water availability to rice cultivation as a result of competition for water from other sectors, there is a need to generate information on prediction of phenology and, heat and radiation use efficiency. By keeping above facts in view an attempt has been made to study the phenological behaviour and, heat and radiation use efficiency in different cultivators to obtain higher grain yield of aerobic rice.

MATERIALS AND METHODS

Field experiment was conducted during *kharif* seasons of 2003 and 2004 at College farm, College of Agriculture, Rajendranagar, and Hyderabad. The experimental site was sandy clay loam in texture with pH 7.7, low in available N (275.9 kg ha^{-1}), P_2O_5 (10.8 kg ha^{-1}) and K_2O (128.9 kg ha^{-1}).

Table 1: Calander days, accumulated growing degree days (AGDD) and heliothermal units (HTU) during different phenophases of rice under aerobic conditions

Date of	Emergence to panicle initiation			Panicle initiation to flowering			Flowering to physiological maturity			Emergence to physiological maturity		
sowing	Cal days	AGDD	HTU	Cal days	AGDD	HTU	Cal days	AGDD	HTU	Cal days	AGDD	HTU
						cv. Jagtiala Sannalu						
2003												
16-Jun	70	1136	4456	25	416	2460	31	432	3167	126	1984	10084
26-Jun	71	1149	5287	26	424	2443	31	429	3157	128	2002	10887
7-Jul	71	1153	5442	26	415	2607	31	412	3078	128	1980	11126
18-Jul	70	1135	5630	26	394	2618	31	391	3325	127	1920	11572
2004												
16-Jun	72	1186	5931	23	382	2421	33	476	3250	128	2044	11602
26-Jun	74	1218	6339	26	426	2534	31	434	3121	131	2078	11995
7-Jul	76	1244	6939	26	412	2594	31	421	3028	133	2077	12562
18-Jul	77	1246	6643	25	372	2553	32	432	3180	134	2050	12376
Mean	73	1183	5834	25	405	2529	31	428	3163	129	2017	11526
SD	3	47	805	1	20	78	1	24	94	3	55	817
CV%	4	4	14	4	5	3	2	6	3	2	3	7
						cv. Polasa Prabha						
2003												
16-Jun	77	1252	5311	25	394	2314	31	422	3286	133	2068	10911
26-Jun	79	1284	5864	26	413	2648	30	390	3061	135	2087	11574
7-Jul	79	1281	5915	25	389	2505	31	404	3348	135	2074	11768
18-Jul	79	1281	6611	26	402	2705	29	398	2952	134	2081	12268
2004												
16-Jun	77	1272	5893	26	406	2450	31	434	3121	134	2112	11465
26-Jun	80	1317	6831	26	407	2625	32	445	3232	138	2169	12687
7-Jul	81	1324	7248	26	391	2735	31	412	3041	138	2127	13024
18-Jul	79	1279	6855	25	388	2546	32	432	3147	136	2099	12549
Mean	79	1286	6316	26	399	2566	31	417	3149	135	2102	12031
SD	1	23	662	1	9	141	1	19	133	2	33	716
CV%	2	2	10	2	2	5	3	5	4	1	2	6

Crop was sown on four different dates *viz.*, 16 June, 26 June, 07 July and 18 July as main plots and four varieties *viz.*, Varaalu, Erramallelu, Jagtiala Sannalu and Polasa Prabha as sub-plots in split plot design and replicated thrice. But only two cultivars *viz*. Jagtiala Sannalu (125 Days)and Polasa Prabha (135 Days) were considered in this paper. Crop was sown in rows at 20 cm interval using seed rate of 400 seeds per square meter. A fertilizer dose of 140 kg nitrogen as urea, 60 kg P_2O_5 as single super phosphate and 40 kg K_2O as muriate of potash was applied. A basal dose of 1/3rd nitrogen, entire P_2O_5 and K_2O was applied and the remaining nitrogen was applied in two equal splits at maximum tillering and panicle initiation stage. Crop was raised under rainfed conditions and 4$\pm$1 cm depth of irrigation water was applied on every fourth day of previous irrigation from 45 days after emergence (DAE) till a week before maturity. The rainfall received during crop growth period was 810.2 mm and 577.7 mm during 2003 and 2004 seasons, respectively. Effective rainfall was calculated by adopting daily balance sheet method following Gupta *et a*l. (1972). Crop was harvested at physiological maturity.

Crop growth was divided into different phases – P_1 – emergence to panicle initiation; P_2 - Panicle initiation to flowering and P_3 – flowering to physiological maturity. Growing degree days (GDD) and Heliothermal units (HTU), Heat use efficiency (HUE) and radiation use efficiency (RUE) were calculated. The base temperature (T_b) of 10^{o}C was used for calculation of growing degree days. The agrometeorological indices were computed as under:

Table 2: Radiation, drymatter, heat and radiation use efficiency of rice cultivars under aerobic conditions

Sowing Date	Radiation MJ m^{-2} Day^{-1}	Drymatter kg ha^{-1}	HUE kg $^0C^{-1}$ day	HTUE kg ^0C hr	RUE kg MJ^{-1}
cv. Jagtiala Sannalu					
2003					
16-Jun	2090	13120	6.61	1.30	6.28
26-Jun	2128	12510	6.25	1.15	5.88
7-Jul	2129	12277	6.20	1.10	5.77
18-Jul	2133	10843	5.65	0.94	5.08
2004					
16-Jun	2097	10730	5.25	0.92	5.12
26-Jun	2135	10697	5.15	0.89	5.01
7-Jul	2166	9093	4.38	0.72	4.20
18-Jul	2160	7110	3.47	0.57	3.29
cv. Polasa Prabha					
2003					
16-Jun	2212	13000	6.29	1.19	5.88
26-Jun	2246	12423	5.95	1.07	5.53
7-Jul	2247	12153	5.86	1.03	5.41
18-Jul	2241	10893	5.23	0.89	4.86
2004					
16-Jun	2191	11223	5.31	0.98	5.12
26-Jun	2243	10630	4.90	0.84	4.74
7-Jul	2248	9007	4.23	0.69	4.01
18-Jul	2192	7003	3.34	0.56	3.20

Table 3: Correlation coefficients between calander days and, AGDD and HTU during different phenophases of rice under aerobic conditions

Phenophase	Jagtiala Sannalu		Polasa Prabha	
	AGDD	HTU	AGDD	HTU
Emergence to panicle initiation	0.9828**	0.8856**	0.9117**	0.8333*
Panicle initiation to flowering	0.6158	0.6354	0.7361*	0.6521
Flowering to physiological maturity	0.7896*	0.3916	0.8076*	0.6085
Emergence to physiological maturity	0.7497*	0.8687**	0.8133*	0.8674**

Growing degree days (GDD) = {(Tmax + Tmin)/2 }-T_b

Heliothermal units (HTU) = GDD* BSS (Bright sun shine hours)

Heat use efficiency (HUE) = Biomass (kg ha^{-1})/ GDD

Heliothermal unit use efficiency (HTUE) = Biomass (kg ha^{-1}) / HTU

Radiation use efficiency (RUE) = Biomass (kg ha^{-1})/ Radiation

RESULTS AND DISCUSSION

Growing degree days and heliothermal units

The short duration (125 days) cultivar Jagtiala Sannalu has accumulated mean growing degree days of 1183 with a deviation of $\pm$47 and heliothermal units of 5834$\pm$805 from emergence to panicle initiation (Table 1). Whereas medium duration (135 days) cultivar Polasa Prabha has accumulated 1286$\pm$23 mean growing degree days and heliothermal units of 6316$\pm$662 from emergence to panicle initiation stage. Jagtiala Sannalu has accumulated GDD and HTU of 405$\pm$20 and 2529$\pm$78 during panicle initiation to flowering and 428$\pm$24 and 3163 $\pm$ 94 from flowering to physiological maturity, respectively. While, Polasa Prabha has accumulated GDD and HTU of 399$\pm$9 and 2566$\pm$141 during panicle initiation to flowering and 417$\pm$19 and 3149 $\pm$ 133 from flowering to physiological maturity, respectively. From emergence to physiological.

Correlation and regression

Correlation between calendar days and AGDD and HTU indicated that, significant relationship between calendar days and AGDD and HTU were obtained during emergence to panicle initiation (0.98**, 0.88**) and emergence to physiological maturity (0.74* and 0.86**) in Jagtiala Sannalu (Table 3). While in Polasa Prabha, significant relationship was observed between calendar days and AGDD during all the groth phases and between calendar days and HTU emergence to panicle initiation (0.83*) and emergence to physiological maturity (0.86**).

Further regression equations were developed to predict phenology of rice using AGDD and HTU in both the cultivars are as under:

Jagtiala Sannalu : $Y = 63.99 + 0.019AGDD + 0.002HTU$ $R^2 = 0.84$

Polasa Prabha: $Y = 66.97 + 0.023AGDD + 0.0015HTU$ $R^2 = 0.86$

In both the cultivars Jagtiala Sannalu and Polasa Prabha, physiological maturity can be predicted using AGDD and HTU which accounted for 84% and 86%, respectively.

It can be concluded that, the prediction of phenology can be done using AGDD and HTU in both short (Jagtiala Sannalu) and medium (Polasa Prabha) duration varieties . The higher Heat and RUE can be obtained by sowing these cultivars on 16 June under aerobic conditions.

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