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., Jagtiala Sannalu and Polasa Prabha higher heat use efficiency (6.61 and 6.29), heliothermal use efficiency (1.30 and 1.19) and radiation use efficiency (6.28 and 5.88) were obtained in crop sown on 16 June. In Jagtiala Sannalu and Polasa Prabha, physiological maturity can be predicted using AGDD HTU which accounted for 84% and 86% variability.

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 (Sasstry 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 ($T_o$) (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), P₂O₅ (10.8 kg ha⁻¹) and K₂O (128.9 kg ha⁻¹).
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$_2$O$_5$ as single super phosphate and 40 kg K$_2$O as muriate of potash was applied. A basal dose of 1/3rd nitrogen, entire P$_2$O$_5$ and K$_2$O 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±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 al. (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°C was used for calculation of growing degree days. The agrometeorological indices were computed as under:

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

<table>
<thead>
<tr>
<th>Date of sowing</th>
<th>Emergence to panicle initiation</th>
<th>Panicle initiation to flowering</th>
<th>Flowering to physiological maturity</th>
<th>Emergence to physiological maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cal days</td>
<td>AGDD</td>
<td>HTU</td>
<td>Cal days</td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-Jun</td>
<td>70</td>
<td>1136</td>
<td>4456</td>
<td>25</td>
</tr>
<tr>
<td>26-Jun</td>
<td>71</td>
<td>1149</td>
<td>5287</td>
<td>26</td>
</tr>
<tr>
<td>7-Jul</td>
<td>71</td>
<td>1153</td>
<td>5442</td>
<td>26</td>
</tr>
<tr>
<td>18-Jul</td>
<td>70</td>
<td>1135</td>
<td>5630</td>
<td>26</td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-Jun</td>
<td>72</td>
<td>1186</td>
<td>5931</td>
<td>23</td>
</tr>
<tr>
<td>26-Jun</td>
<td>74</td>
<td>1218</td>
<td>6339</td>
<td>26</td>
</tr>
<tr>
<td>7-Jul</td>
<td>76</td>
<td>1244</td>
<td>6939</td>
<td>26</td>
</tr>
<tr>
<td>18-Jul</td>
<td>77</td>
<td>1246</td>
<td>6643</td>
<td>25</td>
</tr>
<tr>
<td>Mean</td>
<td>73</td>
<td>1183</td>
<td>5834</td>
<td>25</td>
</tr>
<tr>
<td>SD</td>
<td>3</td>
<td>47</td>
<td>805</td>
<td>1</td>
</tr>
<tr>
<td>CV%</td>
<td>4</td>
<td>4</td>
<td>14</td>
<td>4</td>
</tr>
</tbody>
</table>

**cv. Jagtiala Sannalu**

<table>
<thead>
<tr>
<th>Date of sowing</th>
<th>Emergence to panicle initiation</th>
<th>Panicle initiation to flowering</th>
<th>Flowering to physiological maturity</th>
<th>Emergence to physiological maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cal days</td>
<td>AGDD</td>
<td>HTU</td>
<td>Cal days</td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-Jun</td>
<td>77</td>
<td>1252</td>
<td>5311</td>
<td>25</td>
</tr>
<tr>
<td>26-Jun</td>
<td>79</td>
<td>1284</td>
<td>5864</td>
<td>26</td>
</tr>
<tr>
<td>7-Jul</td>
<td>79</td>
<td>1281</td>
<td>5915</td>
<td>25</td>
</tr>
<tr>
<td>18-Jul</td>
<td>79</td>
<td>1281</td>
<td>6611</td>
<td>26</td>
</tr>
<tr>
<td>Mean</td>
<td>79</td>
<td>1286</td>
<td>6316</td>
<td>26</td>
</tr>
<tr>
<td>SD</td>
<td>1</td>
<td>23</td>
<td>662</td>
<td>1</td>
</tr>
<tr>
<td>CV%</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

**cv. Polasa Prabha**

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$_2$O$_5$ as single super phosphate and 40 kg K$_2$O as muriate of potash was applied. A basal dose of 1/3rd nitrogen, entire P$_2$O$_5$ and K$_2$O 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±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 al. (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°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

<table>
<thead>
<tr>
<th>Sowing Date</th>
<th>cv. Jagtiala Sannalu</th>
<th>cv. Polasa Prabha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Radiation (MJ m⁻² Day⁻¹)</td>
<td>Drymatter (kg ha⁻¹)</td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-Jun</td>
<td>2090</td>
<td>13120</td>
</tr>
<tr>
<td>26-Jun</td>
<td>2128</td>
<td>12510</td>
</tr>
<tr>
<td>7-Jul</td>
<td>2129</td>
<td>12277</td>
</tr>
<tr>
<td>18-Jul</td>
<td>2133</td>
<td>10843</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-Jun</td>
<td>2097</td>
<td>10730</td>
</tr>
<tr>
<td>26-Jun</td>
<td>2135</td>
<td>10697</td>
</tr>
<tr>
<td>7-Jul</td>
<td>2166</td>
<td>9093</td>
</tr>
<tr>
<td>18-Jul</td>
<td>2160</td>
<td>7110</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Phenophase</th>
<th>cv. Jagtiala Sannalu</th>
<th>cv. Polasa Prabha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergence to panicle initiation</td>
<td>0.9828**</td>
<td>0.9117**</td>
</tr>
<tr>
<td>Panicle initiation to flowering</td>
<td>0.6158</td>
<td>0.7361*</td>
</tr>
<tr>
<td>Flowering to physiological maturity</td>
<td>0.7896*</td>
<td>0.8076*</td>
</tr>
<tr>
<td>Emergence to physiological maturity</td>
<td>0.7497*</td>
<td>0.8133*</td>
</tr>
</tbody>
</table>

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 ±47 and heliothermal units of 5834±805 from emergence to panicle initiation (Table 1). Whereas medium duration (135 days) cultivar Polasa Prabha has accumulated 1286±23 mean growing degree days and heliothermal units of 6316±662 from emergence to panicle initiation stage. Jagtiala Sannalu has accumulated GDD and HTU of 405±20 and 2529±78 during panicle initiation to flowering and 428±24 and 3163 ± 94 from flowering to physiological maturity, respectively. While, Polasa Prabha has accumulated GDD and HTU of 399±9 and 2566±141 during panicle initiation to flowering and 417±19 and 3149 ± 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 growth 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: \[ Y = 63.99 + 0.019 \text{AGDD} + 0.002 \text{HTU} \quad R^2 = 0.84 \]

Polasa Prabha: \[ Y = 66.97 + 0.023 \text{AGDD} + 0.0015 \text{HTU} \quad R^2 = 0.86 \]

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.

REFERENCES


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