Crop Weather Relationship of Summer Irrigated Black Gram
(*Vigna Mungo*) at Coastal Areas of Karaikal

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Abstract

Field Experiment was conducted with five dates of sowing viz., March 7th, March14th, March 21st, March 28th and April 4th, 2012 summer season to studies on Crop weather relationship of summer irrigated black gram at coastal areas of Karaikal at different phases growth and grain yield of summer irrigated black gram. The variety VBN gave highest grain yield when compared to T 9, which was sown on March 7th, closely followed by the crops sown on March 14th. As compared to other dates, the crop sown on March 7th and March14th experienced the highest values of RH, optimum rainfall and lower evaporation during vegetative and maturity phase. The optimum agro climatic requirements for the entire growth phase of black gram crop during the highest yield are Maximum temperature 34.7 °C, Minimum temperature 24.7°C, Mean temperature 29.7°C, BSSH 535.7 hrs, RH1 88.6, RH2 56.5, evaporation 335 mm, total rainfall 15.5 mm. AGDD 1224.3 °Cd, AHTU 10604.5°Chr, APTU 14962.1 °Chr, ARTD 1772.3 %, ARHD 2235.8 5%, AHUE 0.559 gm -2 day -1 and DV 9.94 °C. Average values of RH, accumulated rainfall and accumulated HUE prevailing during vegetative and maturity phase exhibited significant positive correlation with grain yield. The sowing by first fortnight of March is adjusted to be the optimum time of sowing of summer irrigated black gram in the coastal areas of Karaikal at Pondicherry.

Key words: Black gram, weather parameters, phenological stage, grain yield, correlation

Introduction

The functional relationship between weather factors (like rainfall and temperature) and the crop yield remains the most elusive and mysterious till today and a matter of intense debate, though research in this area dates back to 1900s [8]. In spite of the daunting efforts being made by the research community to study the nature of relations existing between these two sets of variables, the problem continues to remain unresolved. The point that gives more impetus to initiate fresh research is that understanding of the precise linkage between weather and crop yield could provide potential implications of the effects of climate change on food security and consequently, it can facilitate some kind of institutions for securing crops from the vagaries of weather. In India, research in the area of crop-weather relations has been relatively very little. There will be an increasing demand for black gram in future and in order to achieve its increasing demand, efficient utilization of all the farming inputs as
well as adoption of sound agronomic practices are essential for enhancing the productivity of pulses particularly black gram, the chief pulse grown during the summer season in the Cauvery delta zone. So, characterization of weather conditions during growing season of black gram in relation to varietal performance and yield is necessary for determining optimum sowing time. Although several early research works done elsewhere outlined the importance of crop weather interaction in green gram \[^{[1, 4]}\]. The present paper aims to studies the crop weather relationship of summer irrigated black gram.

**Materials and Methods**

A field Experiment was conducted with black gram during summer season of 2012, in the Eastern Farm of Department of Agronomy at PAJANCOA & RI, Karaikal, Union territory of Puducherry. (Latitude: 10\(^{\circ}\) 25' N; longitude: 79\(^{\circ}\) 49' E; altitude: 4 m above mean sea level) in sandy loam soil. Experimental treatments consisted of five dates of sowing viz., March 7\(^{th}\) (S\(_1\)), March14\(^{th}\) (S\(_2\)), March 21\(^{th}\) (S\(_3\)), March 28\(^{th}\) (S\(_4\)) and April 4\(^{th}\) (S\(_5\)) replicated thrice and designed in randomized complete block design (Factorial concept) two varieties (T 9 and VBN 3) of black gram was sown, using seed rate of 20 kg ha\(^{-1}\), with a spacing of 30 x 10 cm. all the crops which received 4 irrigations (pre-sowing, vegetative, reproductive and maturity stages) were fertilized uniformly as basal with 25 kg ha\(^{-1}\) N, 50 kg ha\(^{-1}\) P\(_2\)O\(_5\) and 25 kg ha\(^{-1}\) K\(_2\)O, Grain yield was recorded from grains of pods picked up 3 times at 80 % maturity. Phonological events like sowing to flower bud initiation (vegetative stage), flower bud initiation to 50% flowering (reproductive stage), 50% flowering to maturity (maturity stage) and total duration were recorded on the dates of occurrence of these events in 50 % of plants from which average dates were computed. average and accumulated values of weather parameters during these phenophases worked out and correlated with grain yield using the method of Gomez and Gomez \[^{[4]}\] to set up the best-fit regression equation for prediction of yields step wise regression equation for prediction of yield, step wise regression method as described by (Draper and Smith \[^{[2]}\] was followed. weather parameters are considered correlations are Maximum temperature, Minimum temperature, BSSH, Morning (RH1), Evening(RH2), Evaporation, accumulated rainfall, accumulated growing degree days(AGDD), accumulated photo thermal units (APTU), accumulated helio thermal units (AHTU), accumulated heat use efficiency (AHUE) and mean diurnal variation (DV). Daily weather data during the period of investigation were collected from the nearby meteorological observatory. The GDD which is the temperature above 10.8°C as the base temperature and PTU which is the product of GDD and maximum possible sunshine hours (mean day length) were calculated following the procedures suggested earlier \[^{[5]}\], the HTU which is the product of GDD and actual bright sunshine hours calculated by Campbell- stokes sunshine recorder was recorded following method suggested by Sastry and Chakravarty \[^{[7]}\]. The HUE which is the ratio of DMP (gm\(^{-2}\)) GDD (°Cday) following the method suggested
by Rajput [6]. The DV which is the product of difference between the daily maximum and minimum temperature were calculated. RTD is a linear direct relationship between temperature and RHD is a direct relationship between RH and growth of plants. RTD for the cropping period was calculated and expressed in percentage.

**Results and Discussion**

**Crop weather relationship of summer**

**Black gram**

Due to changes in sowing dates from March 7th to April 4th weather conditions at different phases of growth were found to be influenced greatly. The weekly average of daily maximum and minimum temperatures, RH1, RH2, accumulated RF, evaporation and BSSH have been illustrated in (Fig1,2) where in the periods of vegetative, reproductive and maturity phases overall dates of sowing have also been superimposed. Results revealed that with passage of time after sowing, weekly average maximum temperatures increased and reached its peak in 16 (MSW) and there after it decreased. During vegetative phase (sowing to flower bud initiation), mean maximum temperature varied from 34.7 °C in March 7th sown crop to 37.1 °C in April 4th sown crop. On the contrary, weekly average minimum temperature increased consistently after sowing until maturity. the average of mean temperature during sowing to maturity of early sown crops (sown by March 7th) was lower than those recorded by late sown crops (sown after March 7th). the weekly total BSSH decreased consistently up to maturity after increasing gradually from sowing, weekly total rainfall received its peak in 10th and 11th MSW and thereafter it reduced. Evaporation decreased consistently up to 16th MSW, beyond which it increased gradually. As compared to other dates, the crop sown on March 7th received the highest values of RH1 (92.5) at vegetative stage, RH2 (57.1) at reproductive stage, RH1 and RH2 values decreased with delay in sowings. RF decreased with delay in sowing, ranging from 15.5 mm in March 7th sown crop to 6 mm in last sown crop (April 4th). Similarly RF during vegetative phase decreased with delay in sowing, ranging from 9.5 mm in March 7th sown crop to 0 mm and 5.5 mm in March 21st and April 4th sown crops respectively.

During vegetative stage (sowing to flower bud initiation), the highest evaporation (168.1mm) was recorded in the crop sown on March 21st as against the lowest value of (136.7 mm) recorded during corresponding period in March 7th sown crop. During reproductive stage (flower bud initiation to 50% flowering) the crop sown on April 4th recorded the highest evaporation (65.9 mm), as against the lowest value of (36.5 mm) recorded during the corresponding period by the crop sown on March 7th. The optimum agro climatic requirements for the entire growth phase of black gram crop during the highest yield are Maximum temperature 34.7 °C, Minimum temperature 24.7°C, Mean temperature 29.7°C, BSSH 535.7 hrs, RH1 88.6, RH2 56.5, evaporation 335 mm, total rainfall 15.5 mm. AGDD 1224.3 °Cd, AHTU 10604.5°Chr, APTU 14962.1 °Chr, ARTD
1772.3 %, ARHD 2235.8 5%, AHUE 0.559 gm$^2$ day$^{-1}$ and DV 9.94 °C.

**Phenological development**

The number of days to reach different phenophases of black gram varied due to difference in sowing dates (Table 1 and Fig 3). Durations during vegetative phase (sowing to flower bud initiation) over different dates of sowing varied from 26 to 30 days with mean of 28.4 days. In case of reproductive stage durations under different dates of sowing ranged from 6 to 10 days with mean of 8.4 days. On the other hand, the total durations from sowing to maturity in crops sown on different dates extended from 30 days March 7$^{th}$ sown crop and 28 days in April 4$^{th}$ sown crop, with the mean of 29.2 days. As evidenced by mean values, the highest variation in duration was found to occur in durations in maturity stage followed by vegetative stage and reproductive stage. From the present investigation it could be observed that variety T 9 had taken a longer duration than VBN 3 by 4 days. However the variation in vegetative and reproductive phase was meager when compared to maturity phase for both the varieties.

The later sowings S$_4$ and S$_5$ (March 28$^{th}$ and April 4$^{th}$) had a longer vegetative and reproductive phase than the earlier sowings S$_1$ and S$_2$ (March 7$^{th}$ and March 14$^{th}$) for both the varieties because of lengthening in GDD due to occurrence of rainfall during respective stages which was not observed for earlier sowing. A similar result of extended vegetative phase in green gram due to increased GDD was reported earlier[4].

**Table 1. Duration (days) of major phenophase of black gram**

<table>
<thead>
<tr>
<th>Varieties &amp; phenophases</th>
<th>Date of Sowing (S)</th>
<th>S$_1$</th>
<th>S$_2$</th>
<th>S$_3$</th>
<th>S$_4$</th>
<th>S$_5$</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>T 9 (V$_1$)</td>
<td>S$_1$</td>
<td>26</td>
<td>27</td>
<td>29</td>
<td>30</td>
<td>30</td>
<td>28.4</td>
</tr>
<tr>
<td></td>
<td>S$_2$</td>
<td>06</td>
<td>06</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>08.4</td>
</tr>
<tr>
<td></td>
<td>S$_3$</td>
<td>31</td>
<td>32</td>
<td>30</td>
<td>30</td>
<td>32</td>
<td>31.0</td>
</tr>
<tr>
<td></td>
<td>S$_4$</td>
<td>63</td>
<td>65</td>
<td>69</td>
<td>70</td>
<td>72</td>
<td>67.8</td>
</tr>
<tr>
<td>VBN 3 (V$_2$)</td>
<td>S$_1$</td>
<td>26</td>
<td>27</td>
<td>28</td>
<td>29</td>
<td>29</td>
<td>27.8</td>
</tr>
<tr>
<td></td>
<td>S$_2$</td>
<td>06</td>
<td>06</td>
<td>06</td>
<td>09</td>
<td>10</td>
<td>07.4</td>
</tr>
<tr>
<td></td>
<td>S$_3$</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>28</td>
<td>28</td>
<td>29.2</td>
</tr>
<tr>
<td></td>
<td>S$_4$</td>
<td>62</td>
<td>63</td>
<td>64</td>
<td>66</td>
<td>67</td>
<td>64.4</td>
</tr>
</tbody>
</table>

1: Vegetative stage 2: Reproductive stage 3: Maturity stage 4: Total duration
## Table 2. Effect of varieties and dates of sowing on mean grain yield (kg ha\(^{-1}\)) on summer irrigated black gram

<table>
<thead>
<tr>
<th>Date of Sowing(S) / Varieties (V)</th>
<th>Varieties (V)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V(_1): T 9</td>
<td>V(_2): VBN 3</td>
</tr>
<tr>
<td>S(_1):March 7(^{th})</td>
<td>824</td>
<td>961</td>
</tr>
<tr>
<td>S(_2):March 14(^{th})</td>
<td>748</td>
<td>938</td>
</tr>
<tr>
<td>S(_3):March 21(^{st})</td>
<td>180</td>
<td>274</td>
</tr>
<tr>
<td>S(_4):March 28(^{th})</td>
<td>617</td>
<td>758</td>
</tr>
<tr>
<td>S(_5):April 4(^{th})</td>
<td>343</td>
<td>549</td>
</tr>
<tr>
<td>Mean</td>
<td>542</td>
<td>696</td>
</tr>
</tbody>
</table>

Interaction

- SE: 25.32
- CD(P=0.05): 53.19

## Table 3. Correlation coefficients between direct weather parameters and Black gram grain yield during different phenophases of Black gram

<table>
<thead>
<tr>
<th>S.No</th>
<th>Direct weather parameters</th>
<th>Vegetative Stage</th>
<th>Reproductive Stage</th>
<th>Maturity Stage</th>
<th>Total Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean Maximum Temperature</td>
<td>-0.506**</td>
<td>-0.389*</td>
<td>-0.593**</td>
<td>-0.567**</td>
</tr>
<tr>
<td>2</td>
<td>Mean Minimum Temperature</td>
<td>-0.446*</td>
<td>-0.612**</td>
<td>-0.509**</td>
<td>-0.500**</td>
</tr>
<tr>
<td>3</td>
<td>Mean Morning relative humidity</td>
<td>0.604**</td>
<td>0.337NS</td>
<td>0.457*</td>
<td>0.499**</td>
</tr>
<tr>
<td>4</td>
<td>Mean Evening relative humidity</td>
<td>0.063NS</td>
<td>-0.117NS</td>
<td>0.547**</td>
<td>0.563**</td>
</tr>
<tr>
<td>5</td>
<td>Total Evaporation</td>
<td>-0.630**</td>
<td>-0.339NS</td>
<td>-0.519**</td>
<td>-0.561**</td>
</tr>
<tr>
<td>6</td>
<td>Total Bright Sunshine hours</td>
<td>-0.674**</td>
<td>-0.229NS</td>
<td>-0.233NS</td>
<td>-0.706**</td>
</tr>
<tr>
<td>7</td>
<td>Total Rainfall</td>
<td>0.603**</td>
<td>-0.112NS</td>
<td>0.275NS</td>
<td>0.672**</td>
</tr>
</tbody>
</table>

*Significant at 5% level, **Significant at 1% level, NS: Non Significant

## Table 4. Correlation coefficients between derived weather parameters and Black gram grain yield during different phenophases of Black gram

<table>
<thead>
<tr>
<th>S.No</th>
<th>Derived weather parameters</th>
<th>Vegetative Stage</th>
<th>Reproductive Stage</th>
<th>Maturity Stage</th>
<th>Total Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total Growing degree days</td>
<td>-0.544**</td>
<td>-0.501**</td>
<td>-0.544**</td>
<td>-0.584**</td>
</tr>
<tr>
<td>2</td>
<td>Total Helio thermal units</td>
<td>-0.671**</td>
<td>-0.290NS</td>
<td>-0.737**</td>
<td>-0.669**</td>
</tr>
<tr>
<td>3</td>
<td>Mean Diurnal variation</td>
<td>0.279NS</td>
<td>0.131NS</td>
<td>-0.662**</td>
<td>-0.816**</td>
</tr>
<tr>
<td>4</td>
<td>Total Relative temperature disparity</td>
<td>-0.377*</td>
<td>-0.375*</td>
<td>-0.398*</td>
<td>-0.651**</td>
</tr>
<tr>
<td>5</td>
<td>Total Relative humidity disparity</td>
<td>-0.179NS</td>
<td>-0.316NS</td>
<td>-0.199NS</td>
<td>-0.650**</td>
</tr>
<tr>
<td>6</td>
<td>Total Heat unit efficiency</td>
<td>0.848**</td>
<td>0.869**</td>
<td>0.572**</td>
<td>0.575**</td>
</tr>
<tr>
<td>7</td>
<td>Total Photo thermal units</td>
<td>-0.543**</td>
<td>-0.494**</td>
<td>-0.581**</td>
<td>-0.582**</td>
</tr>
</tbody>
</table>

*Significant at 5% level, **Significant at 1% level, NS: Non Significant
Fig. 1 Duration of major phenophase of summer irrigated black gram

Fig. 2 Crop weather relationship of summer irrigated black gram
Fig. 3. Crop weather relationship of *summer* black gram

**Fig 4** Effect of varieties and dates of sowing on grain yield of black gram (kg ha⁻¹)
Grain yield
The average grain yield of black gram sown on different dates have been illustrated in (Table 2 and Fig 4) which indicated that the highest grain yield (892 kg ha\(^{-1}\)) was obtained from the crop sown on March 7\(^{th}\), closely followed by the crop sown on March 14\(^{th}\) (843 kg ha\(^{-1}\)), with a dip in March 21\(^{st}\) sowing. (227 kg ha\(^{-1}\)) significant reductions in grain yields were found to occur in crops sown beyond March 21\(^{st}\) sowing. So, it is evident that for achieving the higher grain yield of summer black gram the crop needs to be sown by first fortnight of March in the coastal deltaic region of Karaikal at Puducherry.

Relationships between grain yield and weather parameters
Production potential of a given crop in a region is strongly dependent upon the weather conditions prevailing during the growing season and hence to investigate the impact of weather on grain yield, correlation coefficients between mean and accumulated weather parameters occurring during different phenophases and grain yield were computed presented in (Table 3 and 4).

Air temperature
Mean maximum and mean minimum temperatures during almost all phases of growth demonstrated significant negative correlation with grain yield. Evidently, the increasing values of maximum and minimum temperatures with delay in sowing during maturity phase (3\(^{rd}\) stage) reduced the yield.

Bright sunshine hours
BSSH during all phases of growth demonstrated negative correlation with grain yield. Out of all phases of growth, BSSH during sowing to flower bud initiation (vegetative phase) and total duration of crop registered significant positive correlation with grain yield. Mean values of BSSH over different dates of sowing showed a consistent decreasing trend with yield and hence, evidenced by negative correlation values, higher temperatures were associated with lesser yields.

Rainfall
Total RF during vegetative phase showed significant positive correlation with grain yield, whereas during reproductive and maturity phases had not significantly affect the grain yield, the overall life span of the crop demonstrated significant positive correlation with grain yield, it is apparent that optimum RF during vegetative phase of growth of early sown crops favourable influence on grain yield.

Relative humidity
Both morning and evening RH during overall life span of crop had significant positive correlation with grain yield, Mean morning RH at vegetative phase of growth showed significant positive correlation with grain yield, whereas other phases are not significantly influence on the grain yield, both RH1 and RH2 decreased with delay in sowing dates and exerted adverse influence on grain yield.

Evaporation
Mean evaporation during different phases of growth except(reproductive phase) had significant negative correlation with grain yield and hence, it is inferred that lower values of evaporation during these phases of early sown crops were associated with greater yield of black gram.

Accumulated Agro meteorological indices
Mean DV and ARHD during vegetative phase did not influence the grain yield significantly, whereas at reproductive stage AGDD, ARTD, and APTU had significant negative impact on the grain yield, during maturity phase ARHD had not significantly effect the grain yield, AHUE during all the phases of growth exhibited positive correlation with grain yield, so, it is obvious that higher values of HUE exerted favourable influences on crop growth for higher grain yield in earlier sowings.

Conclusively, significant positive associations were exhibited by grain yield with mean morning relative humidity (RH1) (r = 0.60**) and total rainfall (r = 0.60**) at vegetative phase, whereas during the maturity
phase mean morning relative humidity (RH1) 
\( r = 0.46^* \) and mean evening relative 
humidity (RH2) \( r = 0.55^{**} \) were positive 
significant correlation with grain yield, 
whereas total duration of the crop RH1 \( r = 
50.** \), RH2 \( r = 0.56^{**} \), RF \( r = 0.67^{**} \), 
and AHUE\( (r = 0.58^{**}) \) were significant 
correlation with grain yield. As compared to 
other dates of sowing, the crop sown on March 
7th experienced the optimum values of RH1, 
RH2, RF and AHUE during vegetative and 
maturity phase and brought about favourable 
influences for higher grain yield production. 
The sowing of summer black gram by first 
fortnight of March is necessary for higher 
grain yield in the coastal deltaic region of 
karaikal at Pondicherry.

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