# Effect of Agrometeorological Parameters at different Phenological Stages OfBlackgram(*Vigna mungo*) Under Different Sowing Dates during *rabi*in Sundargarh

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Abstract: A Field experiment was carried out during *rabi* 2018-2020 at the Regional Research and Technology Transfer Station, Kirei, Sundargarh district of Odisha to assess "Effect of Agrometeorological Parameters at different Phenological Stages Of Blackgram(Vigna mungo)Under Different Sowing Dates during rabi in Sundargarh".Three varieties(PU31, IPU 0243 and OBG41) were sown at spacing of 30 x 10 $cm^2$under 5 sowing dates viz., 8th November'19, 23rd November'19, 8th December'19, 23rd December'19 and 7thJanuary'20. Among all the dates and varieties, the mean highest Growing Degree Days was accumulated on $D_1$ (8th November) and by variety (IPU0243), whereas themean maximum Helio Thermal Units and Photo Thermal Units was attained by crop when sown on$D_5$ (7th January) andby IPU 0243. In the case of weather parameters, temperature requirement and relative humiditywere highest when sown on 8th November by IPU 0243whereas the lowest temperature and relative humidity was recorded on 7th January. When the crop was sown on all five dates,the maximum temperature was received by variety IPU 0243)followed byOBG 41 which was par withPU 31.

Key Words:Growing Degree Days, Helio Thermal Units, Photo Thermal Units

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## 1 Introduction

Blackgram (*Vigna mungo L.)*is grown as a principal pulse crop in India.Weather parameters play a very important role in deciding the success or failure of a crop as they strongly influence the physiological expression and genetic potential of the crop, winter crops are peculiarly vulnerable to high temperatures during maturity and show differential responses to changes in temperature under different environments. Karthick and Mani(2013) observed that climate change is a majorthreat tosustainable productivityand might remain so even in the future. Climate change affects Indian agriculture and has adverse impacts on climatic conditions in the long run. Higher temperature, low precipitation, and increased rainfall variability results in low crop yield and threaten food security in low-income and agriculture-based economies. There is a necessity to understand how farmers perceive and how they adapt to climate change. As per farmer's perception of temperature and precipitation shows that temperature increased considerably whereas precipitation decreased over the years. Hence, one of the major adaptation options of farmers included manipulating the sowing date and the harvesting date. Temperature is an important climatic factor that has immense effects on the yield of *rabi* crops. Temperature change affects the seed yield of crops mainly through the phenological development process. Winter crops are peculiarly vulnerable to high temperatures during reproductive stages and differential responses to temperature change to has been observed under different production surroundings. The effect of temperature on gram productivity can easily be seen in Northern India because of high inter-annual fluctuations in productivity due to fluctuations in temperature. Gram productivity is largely dependent on the magnitude of temperature change. Temperature-based agro-meteorological indices such as (Growing degree days, Heliothermal units, Photothermal units) were found to be helpful in predicting

the growth and yield of crops. Growing degree days (GDD) are based on the concept that real-time to attain phenological stage is linearly related to temperature in the range between base temperature and optimum temperature.By keeping all the factors in view an experiment was carried out during *rabi* season to study the major agrometeorological parameters at different phenological stages of blackgram under different sowing dates.

## 2. Materials and Methods

### Experimental Details

The Experiment was laid out in Factorial Randomized Block Design with fifteentreatments and three replications. The gross and net plot size was 4.80 x 3.40 $m^2$ and4.20 x 3 $m^2$, respectively.

### Meteorological Observations

### Computation Of Various agroclimatic and thermal indices

### Growing Degree Days (GDD)

al. 2000)

$$GDD= \{\Sigma (T_{max}+T_{min})/ 2\} - Tb$$

Where,

$T_{max}$= Daily maximum temperature ($^0$C)

$T_{min}$= Daily minimum temperature ($^0$C)

Tb= Base temperature

Table 1: Mean weekly weather data during the experimental period *rabi* 2019-2020 at Sundargarh.

| SMW | Date &Month | Temp $^o$C | | R.F (mm) | RH (%) | | Wind Velocity (km/hr) | BSS (hrs) | EVP (mm) |
|---|---|---|---|---|---|---|---|---|---|
| | | Max | Min | | RH-I | RH-II | | | |
| 45 | 5-11 Nov | 29.5 | 15.6 | 0 | 72 | 58 | 32.85 | 5.1 | 3.1 |
| 46 | 12-18 Nov | 29.3 | 13.2 | 0 | 63 | 42 | 5 | 8.6 | 3.4 |
| 47 | 19-25 Nov | 28.4 | 13.5 | 0 | 65 | 40 | 1 | 7.3 | 2.5 |
| 48 | 26 Nov- 2 Dec | 29.1 | 14.3 | 0 | 82 | 47 | 33.7 | 4.7 | 2.3 |
| 49 | 3-9 Dec | 27.1 | 11.7 | 0 | 73 | 36 | 8.4 | 3.7 | 1.5 |
| 50 | 10-16 Dec | 28.1 | 14.6 | 0 | 79 | 45 | 2.7 | 2.9 | 2 |
| 51 | 17- 23 Dec | 26.5 | 11.9 | 0 | 67 | 43 | 9 | 5.3 | 1.8 |
| 52 | 24– 30 Dec | 25.5 | 9.3 | 0.34 | 72 | 37 | 10.8 | 3.5 | 2.1 |
| 53 | 31Dec- 6 Jan | 23.1 | 10.7 | 17.6 | 74 | 54 | 31.2 | 3.1 | 1.9 |
| 1 | 7- 13 Jan | 25.4 | 9.1 | 0.45 | 70 | 44 | 7.1 | 5.7 | 1.9 |
| 2 | 14-20 Jan | 28.1 | 11.6 | 0 | 70 | 42 | 4.1 | 7.7 | 2.9 |
| 3 | 21- 27 Jan | 27.8 | 9.2 | 0.5 | 66 | 41 | 8.1 | 0.5 | 2.7 |
| 4 | 28 Jan-3 Feb | 27.3 | 11.4 | 68.57 | 33 | 15 | 6.9 | 2.7 | 2.6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 4-10 Feb | 23.4 | 11.7 | 3.9 | 79 | 54 | 5.5 | 4.2 | 3.7 |
| 6 | 11- 17 Feb | 30 | 10.1 | 0 | 54 | 29 | 27 | 9.3 | 4.9 |
| 7 | 18-24 Feb | 30.7 | 12 | 0.77 | 60 | 47 | 11.2 | 8.8 | 4.3 |
| 8 | 25 Feb- 2 March | 28.3 | 13.6 | 1.7 | 61 | 46 | 6.5 | 5.6 | 4.8 |
| 9 | 3- 9March | 28.9 | 13.2 | 12.7 | 75 | 57 | 25.5 | 2.3 | |
| 10 | 10-16 March | 29.7 | 13.4 | 6.3 | 79 | 60 | 66.8 | 3.8 | 5.1 |
| Total/ Mean | | 27.6 | 12.1 | 112.8 | 68.1 | 44 | 15.9 | 4.9 | 2.9 |

Table 2: Phenophase wise GDD required for different dates of sowing

| | $P_1$ | $P_2$ | $P_3$ | $P_4$ | $P_5$ | $P_6$ |
|---|---|---|---|---|---|---|
| $D_1$($8^{th}$ November) | | | | | | |
| $V_1$ | 51.5 | 236.75 | 50.75 | 144.5 | 110.25 | 51.75 |
| $V_2$ | 51.5 | 236.75 | 50.75 | 153 | 111 | 67 |
| $V_3$ | 51.5 | 236.75 | 50.75 | 144.5 | 110.25 | 59 |
| | | | | | | |
| $V_1$ | 43.75 | 217.25 | 46.5 | 111 | 117.75 | 55.75 |
| $V_2$ | 43.75 | 217.25 | 46.5 | 118.25 | 139 | 74 |
| $V_3$ | 43.75 | 217.25 | 38 | 110.25 | 127 | 65.5 |
| $D_3$($8^{th}$ December) | | | | | | |
| $V_1$ | 53.25 | 163.25 | 41.25 | 131.5 | 114.75 | 81.5 |
| $V_2$ | 53.25 | 158 | 46.5 | 131.5 | 133.5 | 85.15 |
| $V_3$ | 53.25 | 163.25 | 48.5 | 124.25 | 125.75 | 81.75 |
| $D_4$($23^{rd}$ December) | | | | | | |
| $V_1$ | 44.75 | 114.5 | 69.25 | 137.75 | 130.3 | 110.45 |
| $V_2$ | 44.75 | 106.25 | 77.5 | 137.75 | 142.05 | 111.7 |
| $V_3$ | 44.75 | 114.5 | 73.5 | 133.5 | 142.05 | 111.7 |
| $D_5$($7^{th}$January) | | | | | | |
| $V_1$ | 35.25 | 163 | 40.75 | 149.05 | 169.95 | 81.75 |
| $V_2$ | 35.25 | 163 | 40.75 | 160.8 | 168.45 | 101.5 |
| $V_3$ | 35.25 | 163 | 40.75 | 149.05 | 158.7 | 93 |

Table 3: Phenophase wise HTU required for different dates of sowing

| | $P_1$ | $P_2$ | $P_3$ | $P_4$ | $P_5$ | $P_6$ | Total |
|---|---|---|---|---|---|---|---|
| $D_1$($8^{th}$ November) | | | | | | | |
| $V_1$ | 242.4 | 1838.99 | 331.79 | 409.82 | 480.42 | 208.7 | 3512.12 |
| $V_2$ | 242.4 | 1838.99 | 331.79 | 476.12 | 432.62 | 401.67 | 3723.59 |
| $V_3$ | 242.4 | 1838.99 | 331.79 | 409.82 | 480.42 | 265.97 | 3569.39 |
| $D_2$($23^{rd}$ November) | | | | | | | |
| $V_1$ | 340.75 | 1045.38 | 187.42 | 432.62 | 871.17 | 339.13 | 3216.47 |
| $V_2$ | 340.75 | 1045.38 | 187.42 | 482.94 | 885.19 | 450.33 | 3392.01 |
| $V_3$ | 340.75 | 1045.38 | 121.12 | 480.42 | 889.67 | 431.75 | 3309.09 |
| $D_3$($8^{th}$ December) | | | | | | | |
| $V_1$ | 50.5 | 736.02 | 113.22 | 874.19 | 795.4 | 507.77 | 3077.1 |
| $V_2$ | 50.5 | 736.02 | 113.22 | 874.19 | 876.27 | 634.07 | 3284.27 |
| $V_3$ | 50.5 | 736.02 | 142.22 | 845.19 | 838.3 | 566.12 | 3178.35 |
| $D_4$($23^{rd}$ December) | | | | | | | |
| $V_1$ | 177.4 | 503.59 | 541.05 | 886.04 | 1066.15 | 769.32 | 3943.55 |
| $V_2$ | 177.4 | 427.69 | 616.95 | 886.04 | 1173.07 | 744.3 | 4025.45 |
| $V_3$ | 177.4 | 503.59 | 550.82 | 876.27 | 1173.07 | 744.3 | 4025.45 |
| $D_5$($7^{th}$January) | | | | | | | |
| $V_1$ | 161.2 | 1134.32 | 345.07 | 1147.02 | 965.19 | 254.49 | 4007.29 |
| $V_2$ | 161.2 | 1134.32 | 345.07 | 1253.94 | 883.89 | 488.32 | 4266.74 |
| $V_3$ | 161.2 | 1134.32 | 345.07 | 1147.02 | 914.57 | 305.11 | 4007.29 |

Table 4:Phenophase wise PTU required for different dates of sowing

| | $P_1$ | $P_2$ | $P_3$ | $P_4$ | $P_5$ | $P_6$ | Total |
|---|---|---|---|---|---|---|---|
| $D_1$($8^{th}$ November) | | | | | | | |
| $V_1$ | 577.92 | 2618.79 | 553.16 | 1568.8 | 1191.75 | 560.36 | 7070.78 |
| $V_2$ | 577.92 | 2618.79 | 553.16 | 1660.68 | 1199.86 | 726.93 | 7337.34 |
| $V_3$ | 577.92 | 2618.79 | 553.16 | 1568.8 | 1191.75 | 639.24 | 7149.66 |
| $D_2$($23^{rd}$ November) | | | | | | | |
| $V_1$ | 481.68 | 2367.96 | 503.82 | 1199.86 | 1279.09 | 612.11 | 6444.52 |
| $V_2$ | 481.68 | 2367.96 | 503.82 | 1278.23 | 1351.69 | 812.49 | 6795.87 |
| $V_3$ | 481.68 | 2367.96 | 411.94 | 1199.86 | 1379.08 | 719.16 | 6559.68 |
| $D_3$($8^{th}$ December) | | | | | | | |
| $V_1$ | 548.82 | 1767.74 | 445.88 | 1430.06 | 1266.02 | 913.53 | 6372.05 |
| $V_2$ | 548.82 | 1710.99 | 502.63 | 1430.06 | 1474.7 | 957.52 | 6624.72 |
| $V_3$ | 548.82 | 1710.99 | 524.25 | 1351.69 | 1388.45 | 918 | 6442.2 |
| $D_4$($23^{rd}$ December) | | | | | | | |
| $V_1$ | 483.74 | 1239.74 | 754.39 | 1521.36 | 1468.68 | 1253.15 | 6721.06 |
| $V_2$ | 483.74 | 1149.98 | 844.15 | 1521.36 | 1603.21 | 1269.81 | 6872.25 |
| $V_3$ | 483.74 | 1239.74 | 801.05 | 1474.7 | 1603.21 | 1269.81 | 6872.25 |
| $D_5$($7^{th}$January) | | | | | | | |
| $V_1$ | 382 | 1782.18 | 453.53 | 1677.36 | 1937.11 | 960.93 | 7193.11 |
| $V_2$ | 382 | 1782.18 | 453.53 | 1811.89 | 1921.78 | 1196.62 | 7548 |
| $V_3$ | 382 | 1782.18 | 453.53 | 1677.36 | 1806.28 | 1091.76 | 7193.11 |

**Heliothermal Unit (HTU)**

The sum of HTU for each phenophase was worked out by the following equation Pal et al,(2013):

**Accumulated HTU = $\sum$ (T- Tb) D**

Where,

HTU = Helio-Thermal Units

$\bar{T}$ = Mean daily temperature ($^0$C)

Tb = Base temperature ($10^0$C)

D = Hours of bright sun shine

**Photothermal Unit(PTU)**

PTU was calculated by using the formula proposed by Amrawat et al. (2013):

**PTU = GDD X Day length**

**Results and Discussions**

**Phenophase wise weather parametersat different sowing dates**

The phenophase wise weather parameters data observed on8th Novembersowing among 3 varieties are presented in Table 5.

**Effects of sowing dates**

Table 5:Phenophase wise weather parameters of varieties observed on8th November

| Varieties | Weather parameters | Sowing to Emergence | Emergence to Branching | Branching to Flowering | Flowering to Pod formation | Pod formation to Dough | Dough to Maturity | Mean |
|---|---|---|---|---|---|---|---|---|
| **PU 31** | $T_{max}(^0C)$ | 28.5 | 28.05 | 26.5 | 24.6 | 26.7 | 27.6 | 26.99 |
| | $T_{min}(^0C)$ | 13.4 | 13.7 | 12.1 | 10.2 | 10.1 | 9.7 | 11.53 |
| | R.H-I (%) | 68.25 | 77.75 | 69.2 | 72 | 69 | 68 | 70.7 |
| | R.H-II (%) | 40.25 | 41.65 | 47.6 | 43.33 | 42.35 | 43 | 43.03 |
| **IPU 0243** | $T_{max}(^0C)$ | 28.5 | 28.05 | 26.5 | 24.6 | 26.8 | 27.9 | 27.05 |
| | $T_{min}(^0C)$ | 13.4 | 13.7 | 12.1 | 10.2 | 10.4 | 10.5 | 11.71 |
| | R.H-I (%) | 68.25 | 77.75 | 69.2 | 71.43 | 69.93 | 70.77 | 71.22 |
| | R.H-II (%) | 40.25 | 41.65 | 47.6 | 43.5 | 43.26 | 41.88 | 43.02 |
| **OBG 41** | $T_{max}(^0C)$ | 28.5 | 28.05 | 26.4 | 24.6 | 26.5 | 27.7 | 26.95 |
| | $T_{min}(^0C)$ | 13.4 | 13.7 | 12.6 | 10.2 | 10.4 | 9.9 | 11.7 |
| | R.H-I (%) | 68.25 | 77.75 | 72.5 | 72 | 69.46 | 68.44 | 71.4 |
| | R.H-II (%) | 40.25 | 41.65 | 49.75 | 43.33 | 42.73 | 43.11 | 43.47 |

Date of sowing - 8th November 2019

Among all varieties,the maximum temperature ($27.05^0C$) was received by IPU 0243 during the crop growing period, i.e., $P_1$ to $P_6$ (Sowing to harvest stage) which was similar to variety PU 31- ($26.99^0C$) and OBG 41-($26.95\ ^0C$). The minimum temperature ($11.71^0C$) wasinIPU 02 43 and OBG 41whereas RH-I (71.4%) and RH-II (43.47%) were maximum in OBG 41. The phenophase wise weather parameters data observed withsowing among 3 varieties is presented in Table 6. Among all varieties, the maximum temperature ($27.18^0C$) was received by IPU 02 43during the crop growing period, i.e., $P_1$ to $P_6$(Sowing to

harvest stage) followed by OBG 41 (27.06$^0$C) which was close to PU 31 (27.01 $^0$C). The highest minimum temperature (12.8$^0$C), RH-I (72.74%) and RH-II (45.33%) was observed by PU31.

Table 6:Phenophase wise weather parameters of varieties observed on23rd November

| Varieties | Weather parameters | Sowing to Emergence | Emergence to Branching | Branching to Flowering | Flowering to Pod formation | Pod formation to Dough | Dough to Maturity | Mean |
|---|---|---|---|---|---|---|---|---|
| **PU 31** | $T_{max}$($^0$C) | 29.1 | 29 | 27.3 | 27.4 | 24.8 | 24.5 | 27.01 |
| | $T_{min}$($^0$C) | 16.6 | 13.7 | 13 | 13.3 | 9.9 | 10.3 | 12.8 |
| | R.H-I (%) | 74.25 | 68.5 | 74.2 | 75.5 | 70.6 | 73.4 | 72.74 |
| | R.H-II (%) | 56.25 | 42.15 | 37.8 | 44.3 | 42.7 | 48.8 | 45.33 |
| **IPU 0243** | $T_{max}$($^0$C) | 29.1 | 29 | 27.3 | 27.4 | 24.6 | 25.7 | 27.18 |
| | $T_{min}$($^0$C) | 16.6 | 13.7 | 13 | 13 | 10.2 | 9.2 | 12.61 |
| | R.H-I (%) | 74.25 | 68.5 | 74.2 | 74.2 | 72 | 67.1 | 71.70 |
| | R.H-II (%) | 56.25 | 42.15 | 37.8 | 44 | 43.3 | 42.6 | 44.35 |
| **OBG 41** | $T_{max}$($^0$C) | 29.1 | 29 | 27.3 | 27.4 | 24.8 | 24.8 | 27.06 |
| | $T_{min}$($^0$C) | 16.6 | 13.7 | 13 | 13.3 | 9.9 | 9.9 | 12.73 |
| | R.H-I (%) | 74.25 | 68.5 | 74.2 | 75.5 | 70.6 | 72.5 | 72.59 |
| | R.H-II (%) | 56.25 | 42.15 | 37.8 | 44.3 | 42.7 | 45.7 | 44.81 |

Date of sowing - 23rd November 2019

The phenophase wise weather parameters data observed on 8th December among 3 varieties is presented in Table 7.Among all varieties, themaximum temperature (26.35$^0$C) was received by variety IPU 02 43 during the crop growing period, i.e., $P_1$ to $P_6$ (Sowing to harvest stage) followed by OBG 41 (26.25 $^0$C) and PU 31 (26.08$^0$C). The highest minimum temperature (11.1$^0$C) was found inOBG 41 whereas RH-I (72.27 %) and RH-II (43.65%) were highest in PU 31.

Table 7:Phenophase wise weather parameters of varieties observed on8th December

| Varieties | Weather parameters | Sowing to Emergence | Emergence to Branching | Branching to Flowering | Flowering to Pod formation | Pod formation to Dough | Dough to Maturity | Mean |
|---|---|---|---|---|---|---|---|---|
| **PU 31** | **$T_{max}$($^0$C)** | 27.7 | 26.4 | 22.8 | 26.7 | 27.3 | 25.6 | 26.08 |
| | **$T_{min}$($^0$C)** | 12.5 | 11.7 | 10.9 | 10.3 | 10.4 | 10.7 | 11.08 |
| | **R.H-I (%)** | 76.8 | 71.5 | 75.83 | 69.5 | 67.42 | 72.6 | 72.27 |
| | **R.H-II (%)** | 41 | 41.16 | 55.33 | 43.43 | 38.42 | 42.6 | 43.65 |
| **IPU 0243** | **$T_{max}$($^0$C)** | 27.7 | 26.6 | 23.1 | 26.7 | 27.2 | 26.8 | 26.35 |
| | **$T_{min}$($^0$C)** | 12.5 | 12 | 10.2 | 10.3 | 10.7 | 10.2 | 10.98 |
| | **R.H-I (%)** | 76.8 | 72.11 | 73.71 | 69.5 | 68.93 | 65.8 | 71.14 |
| | **R.H-II (%)** | 41 | 40.76 | 54.28 | 43.43 | 38.66 | 38.1 | 42.70 |
| **OBG 41** | **$T_{max}$($^0$C)** | 27.7 | 26.6 | 23.1 | 26.8 | 27.2 | 26.1 | 26.25 |
| | **$T_{min}$($^0$C)** | 12.5 | 12 | 10.7 | 10.4 | 10.7 | 10.3 | 11.1 |
| | **R.H-I (%)** | 76.8 | 72.11 | 74 | 69.93 | 68.93 | 68.1 | 71.64 |
| | **R.H-II (%)** | 41 | 40.76 | 54 | 43.26 | 38.66 | 42.2 | 43.31 |

Date of sowing - 8th December2019

The data on phenophase wise weather parameters observed on23rd Decemberis presented in Table 8.Among all varieties, the maximum temperature (27.1$^0$C) was received by variety PU 31during the crop growing period, i.e., $P_1$ to $P_6$ (Sowing to harvest stage) followed by OBG 41 (26.48$^0$C) which was similartoIPU 0243(26.4$^0$C). The highest minimum temperature (11.16$^0$C) was found in PU 31whereas RH-I (68.54%) and RH-II (43.37%) were highest in IPU 0243.

Table 8:Phenophase wise weather parameters of varieties observed on 23rd December

| Varieties | Weather parameters | Sowing to Emergence | Emergence to Branching | Branching to Flowering | Flowering to Pod formation | Pod formation to Dough | Dough to Maturity | Mean |
|---|---|---|---|---|---|---|---|---|
| **PU 31** | **$T_{max}$($^0$C)** | 26.2 | 24.3 | 28.1 | 27 | 28.2 | 28.8 | 27.1 |
| | **$T_{min}$($^0$C)** | 11.7 | 9.2 | 11.6 | 10.8 | 10.4 | 13.3 | 11.16 |
| | **R.H-I (%)** | 73.6 | 70.82 | 70 | 68.94 | 61.14 | 64.1 | 68.1 |
| | **R.H-II (%)** | 37.2 | 46.35 | 41.71 | 40.82 | 37 | 50.1 | 42.19 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **IPU0243** | **$T_{max}$($^0$C)** | 26.2 | 24 | 24 | 27 | 28.5 | 28.7 | 26.4 |
| | **$T_{min}$($^0$C)** | 11.7 | 9.3 | 9.3 | 10.8 | 10.5 | 13.7 | 10.88 |
| | **R.H-I (%)** | 73.6 | 72 | 72 | 68.94 | 60.8 | 63.9 | 68.54 |
| | **R.H-II (%)** | 37.2 | 46.87 | 46.87 | 40.82 | 36.8 | 51.7 | 43.37 |
| **OBG 41** | **$T_{max}$($^0$C)** | 26.2 | 24.3 | 24.2 | 27 | 28.5 | 28.7 | 26.48 |
| | **$T_{min}$($^0$C)** | 11.7 | 9.2 | 9.3 | 10.8 | 10.5 | 13.7 | 10.86 |
| | **R.H-I (%)** | 73.6 | 70.82 | 71.64 | 69.12 | 60.8 | 63.9 | 68.31 |
| | **R.H-II (%)** | 37.2 | 46.35 | 46.88 | 40.43 | 36.8 | 51.7 | 43.22 |

Date of sowing - 23rd December2019

The phenophase wise weather parameters data observed on 7th January, 2020among 3 varietiesare presented in Table 9. Among all varieties, the maximum temperature (27.35$^0$C) was received by variety IPU 0243during the crop growing period, i.e., $P_1$ to $P_6$ (Sowing to harvest stage) which was similar toOBG 41 and PU 31(27.3 $^0$C). The highest minimum temperature (11.23$^0$C) was observed in IPU 0243whereas RH-I (69.16%) and RH-II (45.83%) was highest in PU 31.

Table 9:Phenophase wise weather parameters of varieties observed on 7th January

| Varieties | Weather parameters | Sowing to Emergence | Emergence to Branching | Branching to Flowering | Flowering to Pod formation | Pod formation to Dough | Dough to Maturity | Mean |
|---|---|---|---|---|---|---|---|---|
| **PU 31** | **$T_{max}$($^0$C)** | 24.5 | 27.9 | 26.1 | 27.8 | 29.1 | 28.4 | 27.3 |
| | **$T_{min}$($^0$C)** | 9.6 | 10.6 | 10.2 | 10.8 | 13.5 | 12.1 | 11.13 |
| | **R.H-I (%)** | 75 | 69 | 61.4 | 63.62 | 64.86 | 81.12 | 69.16 |
| | **R.H-II (%)** | 49.6 | 40.94 | 32.2 | 39.18 | 51.6 | 61.5 | 45.83 |
| **IPU 0243** | **$T_{max}$($^0$C)** | 24.5 | 27.9 | 26.1 | 27.8 | 28.9 | 28.9 | 27.35 |
| | **$T_{min}$($^0$C)** | 9.6 | 10.6 | 10.2 | 10.8 | 13.6 | 12.6 | 11.23 |
| | **R.H-I (%)** | 75 | 69 | 61.4 | 63.62 | 67.07 | 76.75 | 68.80 |
| | **R.H-II (%)** | 49.6 | 40.94 | 32.2 | 39.18 | 53.85 | 58 | 45.62 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **OBG 41** | **$T_{max}$($^0$C)** | 24.5 | 27.9 | 26.1 | 27.8 | 29.1 | 28.4 | 27.3 |
| | **$T_{min}$($^0$C)** | 9.6 | 10.6 | 10.2 | 10.8 | 13.5 | 12.1 | 11.13 |
| | **R.H-I (%)** | 75 | 69 | 61.4 | 63.62 | 64.28 | 81.12 | 69.07 |
| | **R.H-II (%)** | 49.6 | 40.94 | 32.2 | 39.18 | 50.78 | 61.5 | 45.7 |

Date of sowing - 7th January2020

**Thermal Indices**- The data recorded on these aspects is presented in Table 6.

**Growingdegree days**

The highest GDD (656$^0$C day) was accumulated when the crop was sown on $D_1$(8th November) and the lowest GDD (596.7$^0$C day)was received when the crop was sown on $D_3$(8th December).It implies that the total heat load was decreased from $D_1$ to $D_3$, slightly increased at $D_4$ but abruptly increased at $D_5$. This might be due to delayed sowing, due to dry spell that occurred during the crop life cycle and differences in maximum and minimum temperature.It is clear that when the air temperature was maximum, then definitely it affects GDD of the crop.

Table 10: GDD, HTU, PTU requirements as influenced by different dates of sowing and varieties of blackgram during *rabi* 2019-2020

| Treatment | GDD | HTU | PTU |
|---|---|---|---|
| SOWING DATES (D) | | | |
| $D_1$ | 656 | 3601.7 | 7185.9 |
| $D_2$ | 610.8 | 3305.8 | 6600 |
| $D_3$ | 596.7 | 3179.9 | 6479.6 |
| $D_4$ | 615.6 | 3998.1 | 6821.8 |
| $D_5$ | 649.7 | 4093.7 | 7311.4 |
| VARIETIES(V) | | | |
| $V_1$ | 613.9 | 3551.3 | 6760.3 |
| $V_2$ | 641.2 | 3738.4 | 7035.6 |
| $V_3$ | 622.2 | 3617.9 | 6843.3 |

**Heliothermal Unit**

The variation in mean daily temperature and bright sunshine hour within sowing dates resulted in varied accumulated helio-thermal units at different phenophases and life cycles of blackgram crop.The highest HTU(4093.7$^0$C day hr) was observed when the crop was planted on $D_5$ whereas the lowest HTU wasrecorded(3179.9$^0$C day hr) on $D_3$(8$^{th}$ December)due to variation of BSS and temperature during the crop growth period.

Among three varieties, maximum heliothermal units (3738.4$^0$C day hr) was accumulated by variety $V_2$ (IPU 0243),followed by $V_3$ (OBG 41) and $V_1$( PU 31)

**Photothermal Unit**

Photothermal unit is the agro meteorological indices that indicated how much quantity of heat energy is utilized by the crop during the day. It is calculated by multiplying GDD bythe length of the day.

The maximum photo thermal units reported during $D_5$(7$^{th}$ January) was 7311.4$^0$C day hours and theminimum PTU (6479.6$^0$C day hours) was observed on $D_3$(8$^{th}$ December). Date of sowing $D_5$(7$^{th}$ January) reported more heat load 7311.4$^0$C day hours as compared to other sowing dates. The reason for this might be due to the fact that the crop took a longer duration to reach phenological stages. The planting date $D_3$(8$^{th}$ December) was reported with lowest heat load (6479.6$^0$C day hours) due to the effect of temperature during the crop growing season.Among all varieties, maximum photothermal units (7035.6$^0$C day hr) were accumulated by variety $V_2$ (IPU-0243) andthe lowest PTU was accumulated by $V_1$( PU 31) (6760.3$^0$C day hr).

## 3. Conclusion

The crop when sown on 8$^{th}$ Novemberat initial vegetative growth from sowing to the flowering stage, maximum temperature, minimum temperature, RH-I, RH-IIremains the same in all 3 varieties but in the reproductive growth stage, variations of weather parameters were observed.

Temperature and relative humidity in all the 3 varieties started decreasing from 8$^{th}$ Novemberto 8$^{th}$ December and further started increasing up to 7$^{th}$ January. Relative humidity showed decreasing rate from 8$^{th}$ to23$^{rd}$ December and then slightly increased on7$^{th}$ January.

When the crop was sown on all five dates of sowing, the maximumtemperature was received highest by IPU 0243 followed by OBG 41 which was par with PU 31. Sowing crop on the first date, the highest minimum temperature, RH-I and RH-II was attained by PU 31 and the lowest was attained by OBG-41during the crop growing period. On 23$^{rd}$ November, the highest mean temperature was found in IPU 0243 andOBG 41, whereas RH-I and RH-II werethe maximum in OBG 41. When sown on the third date, the highest mean temperature was found in OBG 41 whereas RH-I and RH-II were highest in PU 31. Sowing crop on the fourth and fifth date, the highest minimum temperature was found in PU 31 whereas RH-I and RH-II were highest in IPU 0243. Therefore, due to the influence of weather conditions, varieties that were sown early took minimum days to attain maturity whereas varieties that were sown late took maximum days to attain maturity stage.

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