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Study of Agrometeorological Indices on Black Gram Cultivar under Varied Weather Condition

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A B S T R A C T

An investigation was carried out during *kharif* 2017 at Department of Agricultural Meteorology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, entitled "Crop Weather Relationship in Different Cultivars of Black Gram. (*Vigna mungo*)" The experiment was laid out in a FRBD where main plots were assigned to four sowing dates and sub-plots to three Cultivars of black gram, with twelve treatment combinations and replicated thrice**.** The treatment comprised the four date of sowing i.e. 24^{th} MW, 25^{th} MW, 26^{th} MW and 27^{th} MW and three cultivars, V_1 (BDU-1), V_2 (TAU-1) and V_3 (AKU-15). In the present investigation the biometric observations *viz*. plant height, number of leaves per plant, Number of branches per plant, Number of pods per plant was recorded from the different Cultivars and date of sowing. Treatment D_1 (24^{th} MW) and cultivar V_3 (AKU-15) was found significantly superior over all other treatments and Cultivars respectively. The grain yield and biomass yield were recorded highest in D_1 (24^{th} MW) and Cultivar V_3 (AKU-15). The treatment D_2 (25^{th} MW) and Cultivar V_1 (BDU-1) was found second in the order of merit. The highest total GDD was observed with D_4 (MW 27) sowing date and Cultivar V_2 (TAU-1) similarly the highest HTU was observed with D_1 (MW 24) sowing date and Cultivar V_2 (TAU-1). PTU observed during total crop growth period was highest in D_1 (MW 24) as compare to remaining treatments. In case of Cultivars PTU was highest in V_2 (TAU-1). The highest GDD, HTU and PTU was observed in V_2 (TAU-1) as compare to other three Cultivars. In case of date of sowing the highest GDD in D_4 (MW 27) and HTU, PTU was highest in D_1 (MW 24).

Keywords

Black gram, Cultivars, Sowing dates, Yield and Agrometeorological indices

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Introduction

Pulses have great importance in Indian agriculture as they are rich source of protein (17 to 25 percent) as compared to that of cereals (6 to 10 percent), their ability to fix atmospheric nitrogen and improve the soil fertility. The pulses are good source of protein which is cheaper than other protein rich food like meat and fish. They are most useful in solving the protein malnutrition and also used as fodder and concentrates in cattle feeds. Though India is the largest producer of pulses accounting 22 per cent of the world production, availability of pulses per capita per day in the country is much lesser (30-35 g) than the recommendations of WHO (80 g per capita) and thereby around 80 million children of the country are still protein energy under-nourished. Hence, there is a need for increasing average pulse productivity to fulfill protein requirement. Black gram has been distributed mainly in tropical to subtropical countries where it is grown in Kharif and Summer season. It is grown in India, Pakistan, Srilanka, Burma and some countries of East Asia. In India black gram is very popularly grown in Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Punjab, Haryana, Tamilnadu and Karnataka. In India Black Gram is grown on 2.89 million ha area with total production of 1.59 million tones and productivity of 532 kg ha-1. In Maharashtra, it occupies an area of 2.89 lakh ha with total production of 0.61 lakh tones and the productivity of 214 kg ha-1, while in Marathwada it is grown on an area of 1459 hundred ha with production of 189 hundred tones and productivity of 233 kg ha-1 (Anonymous, 2015-16).

Materials and Methods

A field investigation entitled "Crop weather relationship in different cultivars of black gram (*Vigna mungo* (L.) Hepper)" was conducted at experimental farm, Department of Agricultural Meteorology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2017. The experiment was laid out in a FRBD with four sowing dates and three cultivars of black gram in main plots and sub-plots respectively with twelve treatment combinations and replicated thrice.

The gross and net plot size of the experiment was 5.4 x 4.5 m^2 and 4.8 x 4.1 m^2, respectively. Sowing was done by adopting dibbling method on 17^{th} June, 24^{th} June, 01^{st} July and 08^{th}July 2017 (i.e. D_1, D_2, D_3 and D_4 respectively) on 30 cm x 10 cm spacing and the Cultivars used were BDU-1, TAU-1 and AKU-15. the periodical observations on growth, micrometeorological parameters and yield contributing characters were recorded to assess the treatment effects.

Growing degree days (GDD)

Temperature is a major environmental factor that determines the rate of plant development. The temperature requirement and range of optimum temperature varied with species and genotype. The thermal response of genotype can be quantified by using the heat unit or thermal time concept. There is high probability of successfully predicting the development of black gram by heat unit. Thermal time or growing degree days were calculated according to the equation (Mali *et al.,* 2000).

$$G.D.D. = \sum_{i=1}^{n} [(Tmax. + Tmin.)/2 - Tb]$$

Where,

G.D.D. = Growing degree days

Tmax. = Daily maximum temperature of day i (^{0}C)

Tmin. = Daily minimum temperature of day i (^{0}C)

Tb = Base temperature

In present study, the base temperature of black gram was taken as 10 ^{0}C.

Helio-thermal units (HTU)

The Helio-thermal units was calculated by multiplying GDD with mean BSS at critical stages of crop.

Helio thermal units = GDD x Mean BSS

Helio-thermal units (HTU) and photo thermal units were determined by the equation proposed by Singh *et al.,* (1990).

Photo-thermal unit (^{0}C day hrs)

Photo-thermal unit was defined as the product of growing degree days and the day length. Photo-thermal unit is expressed in terms of ^{0}C day hrs.

Photo-thermal unit was computed by using following formula. This was proposed by Gudadhe *et al.,* (2013).

PTU = GDD x Day length (^{0}C day hrs).

Results and Discussion

Post-harvest studies

Grain yield and straw yield (kg/ha)

The data regarding grain yield and straw are presented in Table 1.

Date of sowing

The data on grain yield and straw yield indicated that the crop sown in D_1 (24 MW), i.e. (17th June) recorded higher grain yield (668.06 kg ha^{-1}) and straw yield (952.0 kg a^{-1}) found significantly superior over the other treatments whereas the lowest Grain and straw yield was recorded in treatment D_4 (27 MW), i.e. (8th July). The probable reason for this may be the suitable all the weather parameters and high test yield contributing characters of D_1 date of sowing.

Cultivars

Statistical analysis of Black Gram cultivars showed significant result. During this year, Cultivar AKU-15(V_3) produced higher grain yield (408.10 kg ha^{-1}) and straw yield (698.34 kg ha^{-1}) found significantly superior over the remaining treatments. Whereas, the Cultivar TAU-1(V_2) produced lowest grain (374.43 kg ha^{-1}) and straw yield (644.67 kg ha^{-1}).

Interaction

The interaction effect between date of sowing and different cultivars was found to be non-significant at all stages and the results to that effect are presented in Table 1.

Agro-meteorological indices

Growing degree days (GDD)

Growing degree days (GDD) for Black gram crop under different sowing dates from sowing to maturity are presented in Table 2. Data Revealed that the mean total heat requirement during crop life cycle *i.e.* emergence to maturity stage (P_1 to P6) was 1963.5^{0}C. The total heat load was reported during D_1 (MW 24) was 1998.8^{0}C day and it was followed by D_2 (MW 25) (1921.7^{0}C), D_3 (MW 26) (1920.4^{0}C) and D_4 (MW 27) (2013.3^{0}C) day. It indicated that the total heat load was decreased from D_1 to D_3 and again increased at D_4 (MW 27) it may be due to delayed sowing and due to dry spell occurred during crop life cycle. Whereas, Date of sowing D_4 (MW 27) indicated more heat load (i.e. 2013.3^{0}C day) than rest of the treatments it may be due to maximum air temperature prevailed at sowing time. Date of sowing D_3 (MW 26) lowest heat load (i.e. 1920.4^{0}C day). Heat unit required for attaining various phenophases in D_4 (MW 27) date of sowing due to effect of temperature and delayed sowing during the crop growing season. It is cleared that when the temperature of air was maximum then it will definitely affect GDD of Black gram crop.

The data presented in Table 2 revealed that the mean heat requirement of Cultivar during crop life cycle from 1998.5^{0}C. The total heat load reported in Cultivars during crop life cycle was 1998.8^{0}C, 2051.1^{0}C, and 1945.7^{0}C for BDU-1 (V_1), TAU-1(V_2) and AKU-15 (V_3) respectively. It may be occurred due to different crop duration, from emergence to maturity of such Cultivars Similar results were reported by Patil *et al* (2014).

Table.1 Mean seed yield, straw yield, biological yield (kg ha^{-1}) and harvest index as influenced by various treatments

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Sowing dates (D)				
D_1: MW 24	668.06	952.00	1620.06	41.23
D_2: MW 25	455.12	719.31	1174.43	38.75
D_3: MW 26	248.80	533.55	782.35	31.80
D_4: MW 27	193.63	480.00	673.63	28.74
SE ±	10.26	11.68	15.72	--
CD at 5 %	30.08	34.25	46.11	--
Cultivars				
V_1: BDU-1	391.68	670.64	1062.32	36.87
V_2: TAU-1	374.43	644.67	1019.10	36.72
V_3: AKU-15	408.10	698.34	1106.44	36.88
SE ±	8.88	10.11	13.62	--
CD at 5 %	26.05	29.66	39.93	--
Interaction (D x V)				
SE ±	17.76	20.22	27.22	--
CD at 5 %	NS	NS	NS	--
General Mean	391.40	608.36	1062.61	35.85

Table.2 Phenophase wise GDD required for different dates of sowing and Cultivars of black gram during *Kharif* 2017

Treatment	P_1	P_2	P_3	P_4	P_5	P_6	Total
Dates of sowing							
D_1: MW 24	167.8	559.2	254.6	206.6	323.8	486.8	1998.8
D_2: MW 25	217.7	485.1	287.4	186.8	285.5	459.2	1921.7
D_3: MW 26	275.4	444.1	268.3	209.0	246.0	477.6	1920.4
D_4: MW 27	183.6	391.2	269.6	207.7	271.5	689.7	2013.3
Mean	211.125	469.9	269.975	202.525	281.7	528.325	1963.5
Cultivars							
V_1: BDU-1	226.9	500.0	254.6	206.6	296.5	514.2	1998.8
V_2: TAU-1	285.8	467.0	255.9	207.1	296.2	539.1	2051.1
V_3: AKU-15	167.8	446.9	260.5	205.6	294.1	570.8	1945.7
Mean	226.8	471.3	257	206.4	295.6	541.36	1998.5

P_1: Sowing to Emergence P_2: Emergence to Branching P_3:Branching to Flowering
P_4:Flowering to Pod formation P_5:Pod formation to Dough stage P_6:Dough stage to Maturity

Table.3 Phenophase wise HTU required for different dates of sowing and Cultivars of black gram during *Kharif* season 2017

Treatment	P_1	P_2	P_3	P_4	P_5	P_6	Total
Dates of sowing							
D_1: MW 24	1493.4	3243.3	330.9	1074.3	1748.5	1995.8	9886.2
D_2: MW 25	1132.0	1891.8	1264.5	1513.0	1113.4	2296.0	9210.7
D_3: MW 26	1790.1	1243.4	1824.4	836.0	738.0	3056.6	9488.5
D_4: MW 27	954.7	1134.4	1860.2	872.3	950.2	4000.2	9772.0
Mean	1342.6	1878.2	1320.0	1073.9	1137.5	2837.2	9589.3
Cultivars							
V_1: BDU-1	1996.7	2750.0	330.9	1074.3	1630.7	2108.2	9890.8
V_2: TAU-1	2486.4	2335.0	435.0	1118.3	1510.6	2587.6	10472.9
V_3: AKU-15	1476.6	2592.0	807.5	842.9	1941.0	2111.9	9771.9
Mean	1986.6	2559.0	524.5	1011.8	1694.1	2269.2	10045.2

Table.4 Phenophase wise PTU required for different dates of sowing and Cultivars of black gram during *Kharif* 2017

Treatment	P_1	P_2	P_3	P_4	P_5	P_6	Total
Dates of sowing							
D_1: MW 24	2219.9	7387.0	3350.5	2745.7	4293.5	6075.2	26071.8
D_2: MW 25	2877.9	6398.4	3808.0	2525.5	3625.8	5707.8	24943.4
D_3: MW 26	3638.0	5839.9	3635.4	2668.9	3075.0	5898.3	24755.5
D_4: MW 27	2421.6	5159.9	3634.2	2619.0	3388.3	8469.5	25692.5
Mean	2789.4	6196.3	3607.0	2639.8	3595.7	6537.7	25365.8
Cultivars							
V_1: BDU-1	3001.8	6605.0	3350.5	2745.7	3949.3	6422.3	26074.6
V_2: TAU-1	3781.1	6169.0	3365.0	2750.2	3912.8	6722.5	26700.6
V_3: AKU-15	2219.9	5908.0	3433.3	2699.5	3970.3	7180.6	25411.6
Mean	3000.9	6227.3	3382.9	2731.8	3944.1	6775.1	26062.2

Accumulated Helio-thermal units (HTU)

The Helio-thermal units (HTU) for Black gram crop under different sowing dates from sowing to maturity are presented in Table 3. revealed that the mean total helio-thermal units (HTU) observed during crop life cycle i.e. emergence to maturity stage (P1 to P6) in date of sowing (D1 to D4) 9589.3^{0}C day hour. The helio-thermal units were higher in first date of sowing D1 (MW 24) i.e. 9886.2^{0}C day hour. The lowest HTU were observed in D2 (MW 25) i.e. 9210.7^{0}C day hour than rest of the treatments due to variation of temperature and bright sunshine hours during the crop growing season. The data depicted in Table 3 revealed that the total mean helio-thermal unit (HTU) requirement for all the Cultivars during crop life cycle was 10045.2^{0}C day hour. The helio-thermal units (HTU) were higher in TAU-1(V2) i.e.10472.9^{0}C day hour and the lowest HTU were observed in AKU-15 (V3) i.e. 9771.9^{0}C day hour. It may be due to the different crop duration in above Cultivars. The data presented in Table 3 showed that total HTU required during total crop growth period was highest in D1 (MW 24) i.e. 9886.2^{0}C day hour as compare to remaining treatments. In case of Cultivars V2 (TAU-1) required highest total HTU i.e.

10472.9^{0}C day hour as compare to other two Cultivars. It might be due to different growth period. Similar results were reported by Neog *et al.,* (2008) and Singh *et al.,* (2013).

Photo-thermal Units (PTU)

The data presented in Table 4 revealed that mean total Photo-thermal Units (PTU) required in the life cycle i.e. emergence to maturity stage (P_1 to P_6) stage was 25365.8 and 26062.2 ^{0}C day hrs for sowing date and cultivars respectively. Date of sowing D_1 (MW 24) required more PTU i.e. 26071.8 ^{0}C day hrs than rest of the treatments, it may be due to maximum air temperature prevailed at sowing time. Date of sowing D_3 (MW 26) required lowest heat load i.e. 24755.5 ^{0}C day hrs heat unit for attaining various phenophases due to effect of temperature during the crop growing season. The total PTU were higher in TAU-1(V_2) i.e. 26700.6 ^{0}C day hour and the lowest in AKU-15 (V_3) i.e. 25411.6^{0}C day hour. It might be due to the different crop duration in above Cultivars. Similar results were reported by Chavan *et al.,* (2018).

Based on the above findings, it may be concluded that sowing date of black gram D_1 (668.06 kg/ha) and cultivar AKU-15 (408.1 kg/ha) produced higher grain yield as compare to other treatments. On an average, timely sown cultivars produced the maximum grain yield. The total growing degree days, helio-thermal units and phenothermal units for entire crop growing period required of TAU-1 cultivar was more as compare to other cultivars and D_1 sowing date was highest except HTU. This study also indicated that change in microclimate due to different sowing time is reflected in individual phonological stage. Differences in agro-meteorological indices for various phonological stages indicated that accumulated temperature can be utilized for dry biomass and crop yield.

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