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Agroclimatic Indices, Phenology and Growth Response of Clusterbean to Different Dates of Sowing and Varieties

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was performed to study the effect of different sowing times and varieties on agroclimatic indices, phenology and growth of clusterbean at CCS Haryana Agricultural University, Hisar (Haryana). Experiment was laid out in factorial randomized block design with three replications. Treatments consists of two factors *i.e.* sowing time and varieties. Three clusterbean varieties *i.e.* HG 365 (V1), HG 563 (V2) and HG 2-20 (V3) with each sown at three different dates of sowing *i.e* first (D1), third (D2) and fourth (D3) week of July. Clusterbean variety HG 563(V2), sown in first week of July (D1) resulted in significantly higher accumulation of agroclimatic indices *i.e.* growing degree days, photo thermal units, heliothermal units and heat use efficiency because the early sown crop had a fully developed normal reproductive phase and took longer time to attain maturity. Similarly, more number of days were taken for emergence, days to 50% flowering, days to 50% pod formation and days to maturity in variety HG 563, sown in first week of July. Significantly higher leaf area index and dry matter accumulation were observed in HG 563 sown on 1st week of July than rest of the varieties and date of sowings.

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Keywords: Clusterbean; HG 563; sowing time; agroclimatic indices; leaf area index.

1. INTRODUCTION

The cluster bean is a major vegetable crop belonging to the Fabaceae group. It has a lot of African wild relatives, which suggests that it was probably evolved in this region [1]. It is usually grown for its seed and green fodder purposes and also used in various industrial sectors such as textiles, paper, mining, and oil well drilling [2]. In India, the cluster bean is cultivated under a rain-fed condition since the ancient times. It is the largest producer of this crop in the world, accounting for over 80% of the global production. It is grown in regions with annual precipitation of 250 to 1,000 mm, and most of the seed production takes place in areas with less than 800 mm of rainfall. Although guar doesn't tolerate waterlogging, it can tolerate dry periods. High humidity can affect the development and fertilization of the pod, as well as the seed quality [3].

With a total seed output of 2.42 million tonnes and an average productivity of 567 kg/ha, cluster bean is grown on 4.26 million hectares in India. With a total harvest of 30293 tonnes and an average productivity of 4777 kg per hectare, cluster beans are grown on 6342 hectares in Haryana. Crop development is affected by a number of factors *i.e.* environmental factors (temperature, humidity, rainfall *etc*.), sowing time, seed rate, varieties, spacing, fertilizers, irrigation etc. Among these factors, time of sowing and varieties play a crucial role for the growth and development of crop [4]. Interaction of these factors with weather parameters decide the growth of the crop and ultimately yield. Hence the present investigation was carried out to find out the optimum sowing time and variety of clusterbean for better performance and growth.

2. MATERIALS AND METHODS

A field experiment was conducted during *Kharif* 2020 at CCS Haryana Agricultural University to study the effect of weather parameters on different varieties of clusterbean under different sowing time for accumulation of various agro-climatic indices The experiment consists of three varieties *i.e* HG - 365, HG – 563 and HG 2-20 of clusterbean with three dates of sowing *i.e.* 1st, 2nd and 4th week of July. Experiment was performed under factorial randomized blocked design with three replications. Different cultivars of clusterbean were sown as per the treatments with a seed rate of 15 kg/ha each and spacing of 45 X 10 cm [5]. Based on the weather parameters different agro climatic indices were calculated as follow:

Growing Degree Days (GDD): The daily mean temperature above base temperature was added to calculate the cumulative growing degree days/heat units, which are expressed in ^{0}C day. This was determined using the method below:

$$GDD = \sum \frac{(T_1 + T_2)}{2} - T_{base}$$

Where,

T_1 =Daily maximum temperature (^{0}C)
T_2 =Daily minimum temperature (^{0}C)
T_{base} = Minimum threshold or base temperature (10^{o}C, WMO, 1996)

Photothermal Unit (PTU): One of the fundamental elements regulating the duration of vegetative development in a photosensitive crop is the length of day and night. Photo-thermal units are expressed in ^{0}C day hours and are the cumulative value of GDD times the highest number of sunshine hours. The following formula was used to determine PTU:

PTU (^{0}C day hours) = Σ (GDD x N)

Where,

N = Day length or Maximum possible sunshine hours

Heliothermal Unit (HTU): For a given day, heliothermal units are stated in degrees Celsius (^{0}C) day hours and are the product of the global daily radiation (GDD) and the number of bright sunshine hours for that day. For a given phenophase of interest, the amounts of HTU were calculated using the following equation:

HTU (^{0}C day hours) = Σ (GDD x BSS)

Where,

BSS = Bright sunshine hours

Heat Use Efficiency (HUE): The ratio of dried matter (DM) and cumulative heat units (GDD) between any two successive phenophases of the crop was used to determine heat use efficiency (HUE).

HUE ($g/m^2/{}^0C$ day) = DM (g/m^2)/GDD (^0C day)

By making visual observations in open fields every other day, the various phenological findings *i.e.* days to germination, days to 50% blooming, days to 50% pod formation and days to maturity were noted. The plant leaves that were removed from the samples used to measure the dry matter were used to calculate the leaf area index and the dry matter at intervals of 10 days beginning 20 days after the crop was sown. Utilizing a leaf area meter, the green leaf area (cm2) (LI-3000 Area meter, LI- COR Biosciences, Nebraska, USA). The leaf area index was calculated using the leaf area recorded with the aid of a leaf area meter using the following formula:

LAI= Leaf area /Ground area covered by plant (cm^2)

After 20 days of sowing, the five arbitrarily chosen plants from the destructive sampling were used to measure the amount of dry matter produced every 10 days. The examined vegetation were dried in the sun. Additionally, the samples were dried in an oven at 65 to 70 ^0C to a consistent weight.

The data was statistically analyzed using Statistical Software Package for Agricultural Research Workers by the Department of Mathematics Statistics, CCS HAU, Hisar.

3. RESULTS AND DISCUSSION

3.1 Agro-climatic Indices

Among the different varieties of clusterbean, variety HG 563 had accumulated significantly higher heliothermal units (14479.0), photo thermal units (26272.7) and while heat use efficiency (3.07) was higher in HG 365 as compared to rest of the varieties at maturity. Similarly, crop sown on first week of July accumulated higher heliothermal units (14494.3), photo thermal units (26295.0) and heat use efficiency (3.05) compared to sowing in the second and fourth week of July. Early sowings of a crop accumulated more heliothermal units (HTU) and photo thermal units (PTU) than seeded at later dates because they took longer time to maturity. When sowing is delayed, photo thermal unit (PTU) and heliothermal units (HTU) accumulation reduces because the delayed crop experienced an early reproductive phase, while, earlier-sown crop accumulated more PTU and HTU because the early crop had a fully developed normal reproductive phase. Similar findings were reported by Kumar et al*.,* [6] and Ram et al*.,* [7]. Early sown crops have higher heat use efficiency (HUE) than late sown crops, this could be because early-sown crops have higher biomass production and heat unit accumulation than late-sown crops. Among different planting dates, crops seeded in the first week of July had a higher HUE than crops sown in the second and fourth weeks of July. Among the several variations, HG 365 consistently outperforms HG 2-20 and HG 563 in terms of heat consumption efficiency. These findings are entirely consistent with those of Karunakar et al., [8].

3.2 Phenological Stages

Crop sown in the first week of July (99.1) had significantly longer growing season than crop that were sown in the second and fourth weeks of July. The clusterbean variety HG 563(100.2) had significantly longest overall crop duration in comparison to HG 2-20 and HG 365 at different phenophases (Table 2). This is because crops planted in the first week of July needed more hours of growing degree days to finish their reproductive cycles, whereas crops planted in the fourth week of July needed fewer days to reach maturity. Similar results were recorded by Shivaramu et al*.,* [9] and Singh et al., [10].

3.3 Growth Parameters

The highest LAI (5.50) was observed for crops sown in the first week of July (D1), significantly surpassing those sown in the second week of July (5.32) and fourth week of July (5.02). Among cluster bean varieties, HG 563 (V2) had the maximum LAI (5.85), significantly better than HG 2-20 (5.18) and HG 365 (4.81). LAI reduced as sowing time was extended. The timely sown crop produced more LAI than the late sown crop because the timely sown crop absorbed more PAR (Photosynthetically Active Radiation) due to a longer vegetative phase, whereas the delayed sowing crop's life cycle grew shorter due to an earlier reproductive stage. Maximum LAI and dry matter accumulation for different varieties and dates of sowing were observed at 60 DAS and at maturity, respectively. Maximum dry matter accumulation (31.38 g/plant) was observed for crops sown in the first fortnight of July (D1), significantly better than crops sown in the second

Table 1. Growing degree days (°C day) and Heliothermal units (HTU) requirement of cluster bean varieties at various phenophases under different growing environments

Treatments	Growing Degree Days (GDD) (°C day)				Heliothermal Units (HTU) (°C day hour)			
	Days to emergence	Days to 50% flowering	Days to 50% Pod formation	Days to maturity stage	Days to emergence	Days to 50% flowering	Days to 50% Podformation	Days to maturity stage
D1	97.9	896.3	1187.1	2015.6	883.7	6180.9	8477.4	14494.3
D2	92.5	857.3	1170.1	2000.9	836.8	5979.4	8366.9	14375.5
D3	87.1	791.3	1155.1	1987.7	789.9	5617.5	8245.7	14266.9
CD at 5%	N/A	31.1	20.9	18.1	N/A	130.3	158.8	150.2
V1	81.1	780.8	1129.2	1965.2	737.8	5536.7	8029.0	14249.9
V2	106.3	940.7	1208.4	2034.4	956.6	6478.3	8634.1	14479.0
V3	90.1	823.4	1174.6	2004.7	816.0	5763.0	8426.9	14407.4
CD at 5%	12.7	31.1	20.9	18.1	122.6	130.3	158.8	150.2

Table 2. Leaf area index and Dry matter (g/plant) of cluster bean varieties at various growth intervals under different growing environments

Treatments	Leaf Area Index (LAI)					Dry Matter Accumulation (g/plant)				
	20 DAS	40 DAS	60 DAS	80 DAS	Maturity	20 DAS	40 DAS	60 DAS	80 DAS	Maturity
D1	1.74	2.04	5.50	2.54	0.14	4.64	9.40	22.94	25.70	31.38
D2	1.73	2.03	5.32	2.52	0.12	4.37	9.31	22.54	25.23	31.15
D3	1.71	1.98	5.02	2.31	0.11	3.89	8.98	22.32	24.60	30.84
CD at 5%	0.014	0.051	0.087	0.124	0.004	0.101	0.103	0.220	0.512	0.12
V1	1.70	1.92	4.81	2.16	0.11	4.04	9.13	21.95	24.81	30.90
V2	1.77	2.06	5.85	2.77	0.14	4.55	9.39	22.78	25.72	31.40
V3	1.72	2.01	5.18	2.43	0.12	4.31	9.16	22.07	25.01	31.07
CD at 5%	0.014	0.051	0.087	0.124	0.004	0.101	0.103	0.220	0.512	0.122

Table 3. Photothermal units (°C day hour) requirement, heat use efficiency (g/m²/ºC day) requirement and days taken for occurrences of different phenophase of cluster bean varieties under different growing environments

Treatments	Photothermal Units (°C day hour)				Heat Use Efficiency (g/m²/ºC day)				Days taken for occurrences of different phenophase			
	Days to emergence	Days to 50% flowering	Days to 50% Pod formation	Days to maturity stage	Days to emergence	Days to 50% flowering	Days to 50% Pod formation	Days to maturity Stage	Days to Germination	Days to 50% Flowering	Days to 50% Pod formation	Days to Maturity
D1	342.4	11417.2	16085.6	26295.0	0.85	5.06	2.84	3.05	5.1	39.7	57.1	99.1
D2	332.1	11057.8	15866.0	26123.3	0.83	4.99	2.74	2.98	4.8	38.4	56.2	98.2
D3	321.9	10337.0	15672.0	25968.6	0.70	4.80	2.67	2.94	4.5	36.0	55.4	97.4
CD at 5%	N/A	234.8	270.5	212.5	0.11	0.17	0.06	0.02	N/A	0.80	1.09	1.09
V1	303.0	10241.0	15337.1	25945.8	0.87	5.36	2.78	3.07	4.3	35.6	54.1	96.1
V2	359.2	11935.1	16361.3	26272.7	0.73	4.65	2.69	2.91	5.2	41.4	58.2	100.2
V3	334.0	10635.9	15925.3	26168.3	0.78	4.84	2.77	3.00	5.0	37.0	56.4	98.4
CD at 5%	37.0	234.8	270.5	212.5	0.11	0.17	0.06	0.02	0.49	0.80	1.09	1.09

week of July (31.15 g/plant) and fourth week of July (30.84 g/plant). Among the varieties, HG 563 (V2) accumulated the highest dry matter (31.40 g/plant), superior to HG 2-20 (31.07 g/plant) and HG 365 (30.90 g/plant). High dry matter accumulation by crop sown on first fortnight of July (D1) and variety HG 563 (V2) was due to their highest LAI and PAR interception. These results are in line with Choudhary et al*.,* [11] and Singla et al*.,* [12].

4. CONCLUSION

The clusterbean variety HG-563 sown on 1st week of July had accumulated higher agro-climatic indices and resulted in better growth in comparison to late sowing and remaining varieties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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