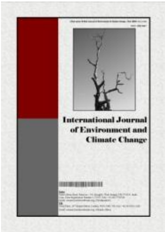

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An Evaluation of the Agrometeorological Heat Indices for Different Dates of Sowing and Varieties of Chickpeas

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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 conducted at the farmer area of "JOBNER, Jaipur" during *rabi* season 2020-21. The treatments consist of three growing dates viz. 25th October, 10th November, 25th November and three varieties of Chickpea viz. RGS 973 (Abha), CSJD-884 (Akash), RSG-991 (Arpana) were laid out in factorial randomized block design with three replication. The study revealed that 25th October dated chickpea crop performed better than rest two dates of sowing. In case of meteorological heat unit the second date of sowing I.e. 10th November out performed the rest two dates of sowing.

Keywords: Chickpea; sowing dates; pod length; test weight; growing degree days; heliothermal unit; photothermal unit.

1. INTRODUCTION

In world, Chickpea (*Cicer arietinum* L.) is the second most important pulse crop after French bean (*Phaseolus vulgaris* L.). It is an annual legume which belongs to family Fabaceae. Chickpea is an important winter season pulse crop of India and 68 per cent of total chickpea is mainly cultivated as rain fed crop. There is a growing demand for chickpea due to its

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nutritional value. India is the largest producer, importer and consumer of pulses in the world. Accounting for 25% of the global production 15% trade and 27% consumption, as sizeable population in the country still depends on vegetarian diets to meet its protein requirement [1]. Chickpea production is significantly affected by abiotic factors like temperature and rainfall etc, which generally helps in crop establishment. Changes in seasonal climate severely affects grain yield of chickpea mainly through physiological and developmental processes (Pandey, 2014). In north India, several factors like inappropriate production practices, viz; usage of low yielding, traditional and non-responsive genotypes, pest and disease problems, lack of stress-resistant high-yielding genotypes, lack of improved soil and crop management practices, poor agronomic practices like time of sowing, seed rate, fertilizer management, lack of appropriate institutional support etc, are responsible for untapped yield potential [2,3]. Among the various agronomic practices, sowing time is the most important non-monetary input which helps in the maximization of yield of any cultivar under favorable environmental conditions. Habitually delayed sowing decreases growing period, cause early maturity and reduces yield and yield components. Optimum sowing time of chickpea may vary from one variety to another and also from one region to another due to the variation in agro-ecological conditions [4-6]. Varying sowing dates subject to the differential vegetative and reproductive stages of the plant due to varying temperature, solar radiation and day length as chickpea is photo and thermo sensitive crop. Chickpea is grown during post monsoon in winter season as it requires cool and dry weather conditions for optimum growth and development [7]. Chickpea is usually sown between mid-Octobers to mid-November. However, sowings are often delayed when grown in sequence with Kharif crops. The exposure of crop to low temperatures during germination results in poor seedling establishment and also reduces plant vigor. Low temperature can also cause whole plant necrosis in some sensitive genotypes of chickpea thus ultimately reduces plant population. Low temperature during reproductive phase of chickpea can severely affect crop productivity by flower abortion. Whereas, high temperature during flowering can cause partial or complete pollen sterility and seed weight get drastically reduced due to forced maturity and poor biomass in chickpea [8-10]. Delay-sown chickpea results in drastic reduction in yield, 30-60% depending on genotype, sowing time, location, and climatic conditions (Pandey, 2014).

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted during the *rabi* season of 2020-21 in JOBNER, Rajasthan (India), which is situated at 26.97'N latitude, 75.37'E longitude and at an altitude of 400 m above mean sea level.

2.2 Climate

The area of Jobner comes under of south east Rajasthan, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 45°C – 48°C and seldom falls as low as -2°C – 01°C. The relative humidity ranged between 20 to 94 percent. The average rainfall in this area is around 536 mm annually.

Meteorological data viz. Maximum and minimum temperature, bright sun shine hours and day length during the experiment period was acquired from the agro-meteorological observatory of SKNAU, JOBNER.

The chickpea crop was sown in farmer field in jobner with three different dates of sowing and three varieties during *Rabi* season of 2020-21. For the statistical analysis two factorial RBD design is used in OPSTAT.

Various intercultural operations were applied for better growth and development of the chickpea. The crop was harvested at full maturity on 7^{th} March, 9^{th} March and 11^{th} March 2021 respectively, harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of chickpea seed. Fresh weight of grain was recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%.the yields of grain per plot were recorded and converted to the per hac. Data were collected on plant height (cm), number of branches per plant, number of pods per plant, pod length, number of grains per pod, test weight (g), seed yield. The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment.

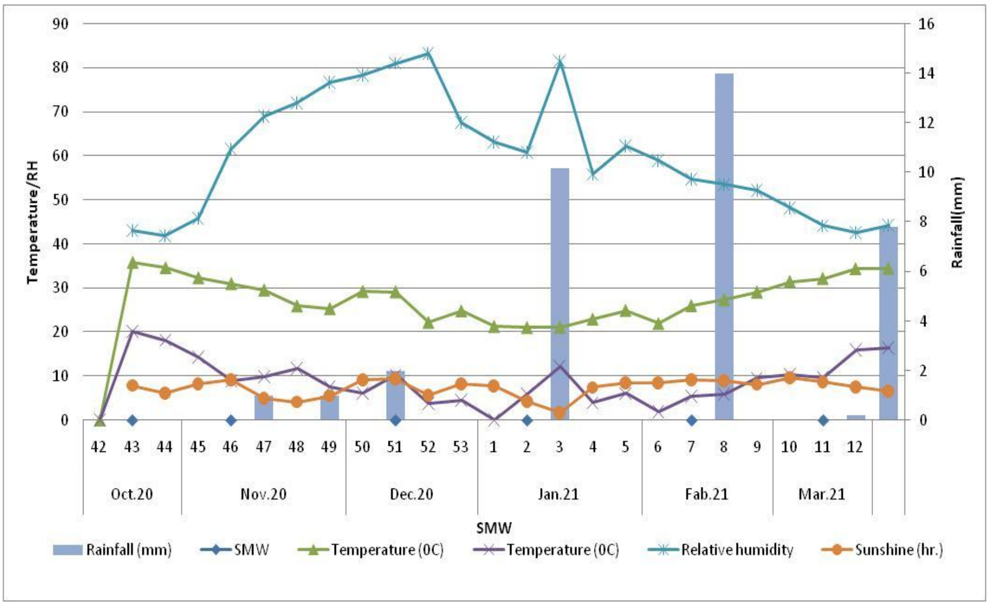

Fig. 1. Weekly weather parameters during *rabi* season 2020-21 at Jobner

Table 1. Physico-chemical properties of soil of the experimental field

S. no.	Particular	Value obtained	Methods
A.	**Mechanical analysis**		
(i)	Coarse sand (%)	20.6	International Pipette method (Piper, 1966)
(ii)	Fine sand (%)	62.3	International Pipette method (Piper, 1966)
(iii)	Silt (%)	9.8	International Pipette method (Piper, 1966)
(iv)	Clay (%)	7.3	International Pipette method (Piper, 1966)
(v)	Textural class	Loamy sand	USDA Triangle (Soil Survey Staff, 1975)

2.3 Calculation of Agrometeorological Indices

The agrometeorological indices such as heat units or growing degree days (GDD), Helio thermal units (HTU) and photo thermal units (PTU) were calculated.

Growing degree days (GDD): Growing degree days defined as the total amount of heat required between the lower and upper thresholds, for crop to develop from one point to another in it's life cycle is calculated in units. The growing degree days (GDD) were worked out by considering the base temperature. For chickpea the base temperature considered was 5^0C.

$$GDD = (Tmax + Tmin)/2 - Tb \qquad (1)$$

Where,

Tmax= daily maximum temperature(°C)
Tmin= daily minimum temperature (°C)
Tb= base temperature

2.3.1 Helio-thermal units (HTU)

HTU may be defined as the accumulated product of GDD and bright sunshine hours between the developmental thresholds for each day. The HTU is the product of GDD and the mean daily hours of bright sunshine

$$HTU = \Sigma \{GDD \times BSS\,(n)\} \qquad (2)$$

Where,

GDD = growing degree days,
BSS (n) = bright sun shine hours (hrs)

2.3.2 Photo-thermal Unit (PTU)

Were computed by taking the product of GDD and corresponding day length for that day (Nuttonson, 1955). This can be mathematically represented using the following formula:

$$PTU = \Sigma\,(GDD \times N) \qquad (3)$$

Where,

GDD = Growing degree days,
N = Maximum possible sunshine hours or day length (hrs)

3. RESULTS AND DISCUSSION

Significantly higher grain yield (22.65 q/ha) was recorded under first date of sowing (D1) followed by the second date of sowing (20.81 q/ha) (Table 1), and significantly lower yield under third date (18.21 q/ha). Among the varieties significantly higher yield was recorded by CSJD-884 (Akash), (23.10 q/ha), followed by RGS-973 (Abha) (21.07 q/ha). The yield attributing character were also significantly influenced by the date of sowing (Table 1). The first date of sowing recorded significantly higher Plant height, number of branch per plant, Pod length, Pod per plant, number of grains per pod, Test weight. Among varieties CSJD-884 (Akash) recorded higher Plant height, number branch per plant, Pod length, Pod per plant, No of grains per pod, Test weight.

3.1 Duration of Phenophase

Date of sowing significantly influenced the duration of crop growing period. Normally it is observed that with delay in sowing the maturity period is reduced. However from Table 2 it is observed that in case of second date of sowing (10th November) the growing length was maximum in comparison to the rest dates of sowing. It may be concluded that the normal sowing date has longest crop duration while shortest crop duration in case of late sown chickpea. Among the varieties the longest period of maturity was recorded in case of RSG-991(126 days) and the shortest in case of RGS-973(113 days).

On the basis of date of sowing, variations in total maturity periods as well as the number of days in attaining different phonological stages of chickpea indicated that successive delay in sowing reduced the duration to maturity. The duration of emergence for all sowing dates was not influenced but subsequently the Flower initiation pod initiation, grain formation, physiological maturity periods were considerably influenced by the sowing date [11].

Table 2. Effect of sowing dates on growth and yield attributes of chickpea

Treatments	Plant height (cm) at maturity	No. of branches per plant	Pod length (cm)	Pods per plant	No. of grains per pod	Test weight (g)	Grain yield (q/ha.)
Date of sowing							
D1	42.84	20.76	3.42	39.56	1.29	22.08	22.65
D2	41.97	17.48	2.88	37.62	1.18	22.01	20.81
D3	41.14	16.44	2.22	36.75	1.09	21.08	18.21
SE m	0.75	0.31	0.06	0.89	0.03	0.51	0.47
CD (p=0.05)	2.17	0.90	0.18	2.57	0.08	1.48	1.35
Varieties							
V1	41.73	17.93	3.04	38.04	1.16	21.03	21.07
V2	42.54	19.25	3.40	40.81	1.34	24.72	23.10
V3	41.68	17.51	2.07	35.07	1.06	19.42	17.50
SE m	0.75	0.31	0.06	0.89	0.03	0.51	0.47
CD (p=0.05)	2.17	0.90	0.18	2.57	0.08	1.48	1.35

Table 3. Physiological Days taken from sowing to maturity

Treatments	Emergence	Flower initiation	Pod initiation	Grain formation	Physiological maturity	Total
Date of sowing						
D1	8	40	27	18	27	120
D2	7	42	28	17	29	123
D3	8	35	26	20	24	113
Varieties						
V1	7	37	25	17	27	113
V2	8	39	27	19	24	117
V3	8	41	29	19	29	126

Table 4. Growing degree days sowing to maturity (^{0}C per day)

Treatments	Emergence	Flower initiation	Pod initiation	Grain formation	Physiological maturity	Total
Date of sowing						
D1	143.8	547.25	245.3	167.8	303.05	1407.20
D2	106.85	474.35	259.25	162.9	473.3	1476.65
D3	97.25	364.65	228.4	251.35	430.5	1372.15
Varieties						
V1	128.45	502.8	232.65	172.75	270.9	1339.75
V2	143.8	531.65	252	176.7	262.4	1398.75
V3	122.3	561.65	261.15	163.1	377.1	1517.50

Table 5. Heliothermal units sowing to maturity (^{0}C per day)

Treatments	Emergence	Flower initiation	Pod initiation	Grain formation	Physiological maturity	Total
Date of sowing						
D1	1211.745	3865.085	1357.88	1210.39	2659.92	10305.02
D2	409.52	3499.605	1442.48	1510.83	4072.545	10934.98
D3	610.085	2528.29	1735.58	2182.79	3639.57	10696.32
Varieties						
V1	1072.06	3440.8	1845.99	725.325	2352.255	9436.43
V2	1211.745	3713.765	1855	1399.2	2271.88	10451.59
V3	1035.445	4004.765	1864.7	1395.85	3413.715	11714.48

Table 6. Photothermal units sowing to maturity (^{0}C per day)

Treatments	Emergence	Flower initiation	Pod initiation	Grain formation	Physiological maturity	Total
Date of sowing						
D1	1657.33	5918.61	2608.08	1795.46	3399.83	15379.33
D2	1164.66	5077.85	2772.73	1816.14	5500.43	16331.83
D3	1052.09	3872.30	2450.27	2840.25	5084.94	15299.86
Varieties						
V1	1490.02	5452.05	2466.75	1848.425	2996.04	14253.29
V2	1657.33	5753.25	2678.21	1890.69	2940.49	14919.99
V3	1407.935	6071.255	2779.12	1745.17	4251.93	16255.41

3.2 Sowing Time and Accumulated Thermal Units

The second date of sowing (D2) accumulated the highest thermal units as compared to subsequent sowing periods, followed by first date of sowing i.e on 25th October. Hence the optimum thermal unit requirement might be 147.20 GDD, 10305.02 HTU and 15379.33 PTU (Tables 2,3,4) for obtaining higher yield of chickpea at Jobner respectively.

Among the varieties the thermal units for maturity range from 1339.75 to 1517.50, HTU from 9436.43 to 11714.48 and PTU from 14253.29 to 16255.41 from sowing to maturity. The variety RSG-991 accumulated highest thermal units. Among sowing date D2 recorded highest thermal unit accumulation, but the highest yield was obtained from date of sowing D1.

Similar kind of study has been done in BCKV, West Bengal, India to study the effect of four sowing date and four varieties on phenology and yield of chickpea during *rabi* season of 2017-18. In this study it has been observed that mean cultivar days of chickpea crop from sowing to emergence, flower initiation, pod initiation and maturity were 6.7, 59.6, 80.5 and112.6 days, respectively. The duration of chickpea and summed growing degree days (GDD) were reduced successively with delay in sowing from 4th November (119.8 days and 1715) to 19 December (103.9 days and 1604). The average GDD, heliothermal units (HTU) and photothermal units (PTU) for entire life cycle of chickpea were recorded as1661, 11403 and 18766, respectively [12].

4. CONCLUSION

In the study we have taken three dates of sowing of chickpea where 25th October is early 10th November is normal date while 25th November is late sown. From the analysis it may be concluded that the late sown crop has reduced the growing length by 10 days. It is in line with the previously reported research work.

Though it was observed that the highest heat units or meteorological indices were in D2 (10th November) while the first date of sowing had highest grain yield. Since it is one year data of crop further work can be done in this field to confirm & correlate the above finding.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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