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Assessment of Effect of Sowing Dates and Genotypes on Chickpea Yield Using CROPGROW- Chickpea (DSSAT v 4.7) Model for Western Haryana

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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

The study was conducted at Department of Agricultural Meteorology, CCS Haryana Agricultural University to assess the effects of sowing dates and genotypes on chickpea yield using CROPGROW- chickpea (DSSAT v 4.7) model for western Haryana. Thus three varieties of chickpea i.e. HC 1(V1), HC 7(V2) and HC 5(V3) each sown at four different dates of sowing *i.e.* 13th October (D1), 1st November (D2), 15th November (D3) and 2nd December in split plot design was replicated thrice. Maximum accumulated PAR was recorded for the crop sown on D1 at physiological maturity stage and least accumulation was recorded in D4. Variety HC 7 recorded

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maximum value of intercepted PAR while lowest value was recorded in HC 1 Delay in sowing time resulted in decrease in seed yield. Maximum seed yield was shown by the crop sown on D1 followed by D2, D3 and D4. Significant variation was shown in seed yield by among the varieties. Maximum seed yield was recorded in variety HC 7 while least value was recorded in variety HC 1. Simulated seed yield was in good agreement with the observed values of seed yield. Mean observed seed yield varied between 1177 kg/ha (D4V1) and 2477 kg/ha (D1V2) while simulated values ranged from 1057 kg/ha (D4V1) and 2234 kg/ha (D1V2).

Keywords: CROPGROW- model; accumulated PAR; seed yield; crop; soil; weather data.

1. INTRODUCTION

Chickpea is a cool season legume crop. It requires cool and dry weather for good production. Temperature, moisture content and day length are three important abiotic factors affecting flowering in this crop. It is very sensitive to high maximum daily temperature and low minimum temperature at the reproductive stage of the crop. Low temperature at initial crop growth stage results in slow and poor vegetative growth, high temperature at the end of cropping season leads to forced maturity and poor biomass [1] Reproductive phase is the most important phase of chickpea life cycle which determines the final yield of the crop. Crop duration depends on the onset of flowering in the crop plants. Sowing time varies with the location depending on the temperature at different stages of the crop growth and development [2].

Crop simulation modelling has the ambition to improve the situation by quantifying the uncertainty in their results and reduce the various model uncertainties through model inter comparison, compiled data as required to fill knowledge gaps, eliminating model deficiencies and improve methods for scaling. The Decision Support System for Agro-technology Transfer (DSSAT) is most widely used decision support system which includes models for cereals, legumes, oilseed, vegetable crops [3] DSSAT was developed by an International Scientists network, cooperating in the International Benchmark Sites Network for Agrotechnology Transfer project, for facilitating the application of crop models in a systems approach to agronomic research. The systems provided a framework in which research is conducted to understand how the system and its components function. This understanding is then integrated into models that allow user to predict the behaviour of the system for given conditions. Once, it is validated that the models simulate the real world adequately, computer experiments can be performed hundreds or even thousands of times for given environments to determine how to best manage or control the system. DSSAT was developed to realize this approach and make it available for global applications [4].

2. MATERIALS AND METHODS

2.1 Study Area

The experiment was conducted in an open field during the Rabi season 2020-21 at the experimental farm, Department of Agricultural Meteorology, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The climate of the Hisar region is semi-arid subtropical monsoonal. During the summer, the maximum day time temperature ranges between 4^0 and 46^0C. During the winter, the minimum temperature can drop to 0°C. Except for small proportion of rains caused by western disturbances, the weather is mostly dry from October through the end of June the following year. The annual rainfall averages 460 mm.

2.2 Crop, Soil and Weather Data

Crop data was taken from the field experiments conducted at respective station in season 2020-21. Crop growth, yield and phenological observations taken according to date of sowings (D1, D2, D3 and D3) are used in the study for chickpea genotypes (HC 1, HC 7 and HC 5) in Hisar on different phenophases stages. Thermal time was calculated based on the stages of growth and duration of the varieties [1]. The soil was sandy loam at respective experiment site. Simulations were performed under condition different dates of sowing. Weather data for the period 2020-21 was compiled and taken as baseline to simulate the yield.

2.3 Crop Model Description

DSSAT was developed by an International Scientists network, cooperating in the International Benchmark Sites Network for Agrotechnology Transfer project. CROPGROW is

Table 1. Generic coefficients for chickpea crop simulation

Coffs.	Model's Parameter	HC1	HC7	HC5
SD-PM	Time between first seed (R5) and physiological maturity (R7) (photothermal days)	37	42	40
LFMAX	Maximum leaf photosynthesis rate at 30 C, 350 vpm CO2, and high light (mg CO2/m2-s)	1.2	1.1	1.1
XFRT	Maximum fraction of daily growth that is partitioned to seed + shell	0.96	1.1	1
WTPSD	Maximum weight per seed (g)	0.17	0.15	0.16
SDPDV	Average seed per pod under standard growing conditions (#/pod)	1.3	1.5	1.4

a physiologically based crop growth simulation model that forecasts chickpea dry matter growth, LAI, crop phenology, and yield for specific soils based on daily meteorological data (maximum temperature, minimum temperature, rainfall, and sun radiation) [5] Based on run-off, percolation, and redistribution of water in the profile, soil characteristics indicate the ability of the soil to store water and supply water to plant roots. As a result, inputs such as soil parameters and weather data are necessary. Cultivar selection, planting date, row and plant spacing, and irrigation management are all factors that affect the model [6] (Table 1).

2.3.1 Calibration, validation and simulation for chickpea

The model has been validated by comparing the simulated yield with the observed yield for study year. The model was calibrated using genetic coefficients for the crop, soil parameters and adjusting the simulated yield with observed yield. Calibration in case of chickpea varieties HC 1, HC 7 and HC 5 for hisar location was done on the basis of data available from experimental records. The results of validation are presented in Table 2. Simulation was performed based on the calibration and validation. The coefficient of efficiency is calculated by the model (equation 1) [2].

$$E = 1.0 - \left(\frac{\sum_{i=1}^{N} (O_i - P_i)^2}{\sum_{i=1}^{N} (O_i - \bar{O})^2} \right) \quad (1)$$

3. RESULTS AND DISCUSSION

Analysis of weather data during the study period showed variation in weather variables. Mean maximum temperature was highest during sowing period and it decreased gradually till pod initiation stage. After that it increased till maturity of the crop. There was a gradual decrease in BSSh (Bright Sunshune Hours) from 41st SMW (Standard Meteorological Week) to 46th SMW after that it increased till 47th SMW. Highest value of BSSh was attained during 9th SMW showed in Graph 1. Highest weekly rainfall was received at 46th SMW with a value of 18mm. Average weekly rainfall values were 8mm during 1st and 5th SMW showed in Graph 2. Highest value of evening relative humidity was recorded at 1st SMW. It decreased gradually from 2nd SMW till 13th SMW as showed in Graph 3. There was a significant increase in the accumulated PAR from flowering stage till physiological maturity for all the treatments. Maximum accumulated PAR was recorded for the crop sown on D1 at physiological maturity stage and least accumulation was recorded in D4. There was a significant variation among the varieties for accumulated intercepted PAR (Photosynthetically Active Radiation). Variety HC 7 recorded maximum value of intercepted PAR while lowest value was recorded in HC 1 presented in Table 3. The increase in PAR values was probably due to more time interval for accumulation of PAR in early sown crops as compared to late sown crops. Mubvuma et al [7] Hussain et al., 1998.

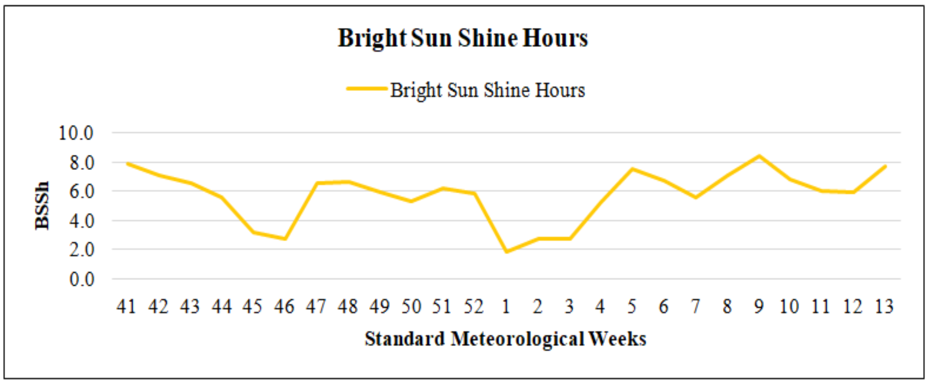
Delay in sowing time resulted in decrease in seed yield. Maximum seed yield was shown by the crop sown on D1 followed by D2, D3 and D4. Significant variation was shown in seed yield by among the varieties. Maximum seed yield was recorded in variety HC 7 while least value was recorded in variety HC 1. The high seed yield in early sowing of crop might be due to congenial environmental condition during crop growth thus resulting in good seed yield. Research findings are in tune with results of Kambale et al, [8] who reported maximum grain yield in crop sown on 49th SMW followed by 50th SMW and 51st SMW respectively. Nawab et al. [9] also reported that delay in sowing resulted in decline in seed yield of the crop. Dhote et al. [10] Pandey et al, [11] Prasad et al, [12] also found the same trend of decline of seed yield with delayed sowing date. Thombre et al, [13] and Dhote et al, [10] also concluded that biological yield decreased with delay in sowing time.

Simulated seed yield was in good agreement with the observed values of seed yield. Mean observed seed yield varied between 1177 kg/ha (D4V1) and 2477 kg/ha (D1V2) while simulated values ranged from 1057 kg/ha (D4V1) and 2234 kg/ha (D1V2). Mean bias error value of -74.21 kg/ha indicated that model underestimated the seed yield than observed values. Model underestimated the seed yield production as compared to the observed seed yield values presented in Table 2. This means that simulated seed yield may be reduced by delayed sowing from the present date of sowing (D1).

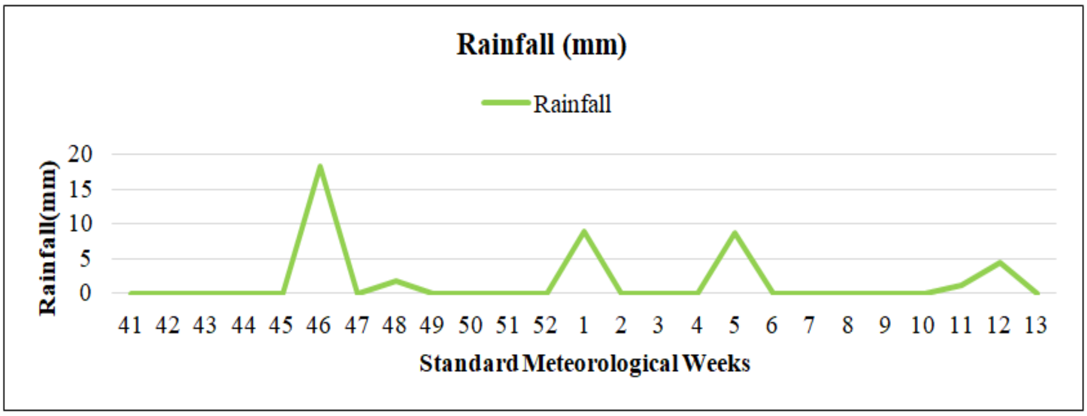
Table 2. Testing criteria for evaluation of grain yield

	Grain Yield (Kg/ha)		
Treatments	**Observed (O)**	**Simulated (P)**	**Deviation(P-O)**
D1V1	2338	2113	-225.00
D1V2	2477	2234	-243.00
D1V3	2416	2170	-246.00
D2V1	1788	1752	-36.00
D2V2	1900	1824	-76.00
D2V3	1866	1798	-68.00
D3V1	1433	1365	-68.00
D3V2	1572	1686	114.00
D3V3	1494	1614	120.00
D4V1	1177	1057	-120.00
D4V2	1311	1366	55.00
D4V3	1255	1226	-29.00
MEAN	1752.25	1683.75	-68.50
SDo	439.59		
SDs	361.78		
R^2	0.97		
MAE	116.67		
MBE	-74.21		
RMSE	139.09		
PE	7.93		
Observed Mean	1752.25		
Simulated Mean	1683.75		

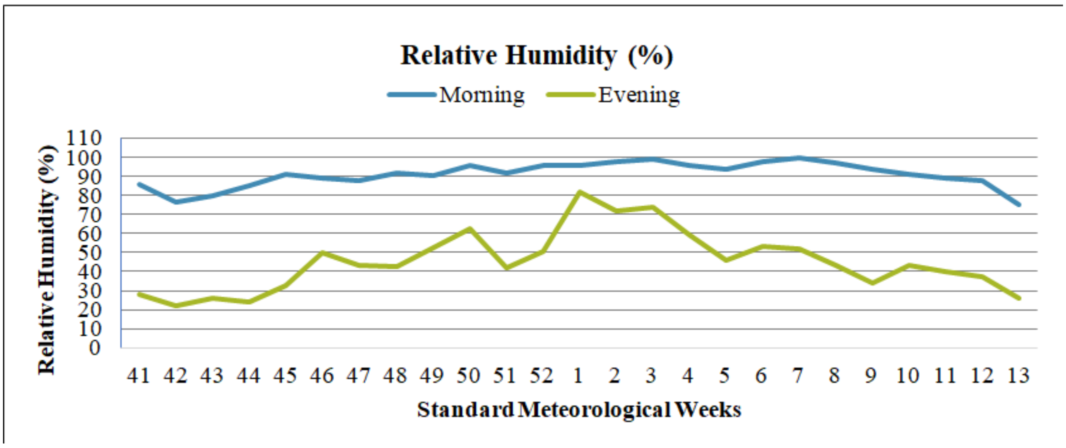
Where, O: Observed, P: Predicted, D: Deviation, MAE: Mean Absolute Error, MBE: Mean Bios Error, RMSE: Root Mean Square Error, R: Model's ability to produce the observed growth and development pattern, SDo: Standard Deviation Observed, SDs: Standard Deviation Simulated and PE: Percent Error



Graph 1. Weekly bright Sun shine hours during crop season



Graph 2. Weekly rainfall during crop season



Graph 3. Weekly relative humidity during crop growth

Table 3. Accumulated intercepted photosynthetically active radiation during important phenophases

	Accumulated Intercepted Photosynthetically Active Radiation (MJm^{-2})		
	FLOWERING	**POD INITIATION**	**MATURITY**
D1	338.5	510.2	703.5
D2	322.8	475.7	665.6
D3	286.8	459.8	636.0
D4	265.9	425.6	615.0
Sem ±	7.4	8.7	12.3
CD	25.8	30.4	42.5
V1	291.7	451.5	629.6
V2	316.5	483.7	683.7
V3	302.3	468.3	651.8
Sem ±	5.3	7.1	6.8
CD	16.0	21.3	20.4

Studies concluded that seed yield increased with increase in maximum and minimum temperature and it was in positive correlation with evening relative humidity as well. Biological yield increased with minimum temperature while it decreased with increase in evening relative humidity.

DSSAT model underestimated most of the crop parameters viz., phenology yield and its attributes with the error within acceptable range. So, CROPGROW- chickpea (DSSAT) model proved to be valuable tool for predicting chickpea yield for western Haryana region.

4. CONCLUSION

Simulated seed yield was in good agreement with the observed values of seed yield. Maximum intercepted PAR was recorded in early sown crop (D1 = 13th October) and in variety HC 7.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Chaturvedi SK, Dua RP. Breeding chickpea for late sown conditions in northern India. International Chickpea Conference, Raipur, India. 2003;11.
2. Hatfield JL, Prueger JH. Temperature extremes: Effect on plant growth and development. Weather and Climate Extremes, 2015;10: 4-10.
3. Hoogenboom G. Contribution of agrometeorology to the simulation of crop production and its application. Agricultural Forest Meteorology. 2000;103(1-2):137-157.
4. Jones JW, Hoogenboom G, Poeter CH, Boote KJ, Batchelor WD, Hunt LA, Wilkens PW, Singh U, Gijsman AJ, Ritchie JT. The DSSAT cropping system model. *European.* Journal of Agronomy. 2003;18: 235-235.
5. Sivakumar MV, Glinni AF. Applications of crop growth models in the semiarid regions. In Agricultural System Models In Field Research And Technology Transfer 2016;177-205.
6. Rahman MH, Ahmad A, Wajid A, Hussain M, Rasul F, Ishaque, W., and Nasim, W. Application of CSM-CROPGRO-Cotton model for cultivars and optimum planting dates: Evaluation in changing semi-arid climate. Field Crops Research. 2019;238: 139-152.
7. Mubvuma MT, Ogola JB, Mhizha T. Effect of planting date and genotype on intercepted radiation and radiation use efficiency in chickpea crop (*Cicer arietinum* L.). Cogent Food & Agriculture. 2021;7(1): 1899422.
8. Kambale RD, Andhale RP, Jadhav JD. and Pawar PB. Effect of sowing dates on potash levels in chickpea. Asian Journal of Soil Science. 2012;7(2): 367-373.
9. Nawab K, Kamal T, Rahmatullah Rab A Iqbal M. Effect of irrigation on chickpea varieties sown on different dates on irrigated fields of Bannu, Khyber Pakhtunkhwa, Pakistan. Journal of Biology, Agriculture and Healthcare. 2015;5(11): 37-41.
10. Dhote PP, Thaokar A, Gawali KA, Sarda A, Nagmote A. Effect of different sowing dates on growth and yield of chickpea (*Cicer arietinum* L.) under irrigated condition. Journal of Pharmacognosy and Phytochemistry. 2019;8(5): 1864-1867.
11. Pandey RK, Tyagi PK. Shukla KC. Effect of sowing dates and varieties on yield attributes and yield of chickpea (*Cicer arietinum* L.). The Journal of Rural and Agricultural Research. 2014;14(2): 37-39.
12. Prasad D, Bangarwa AS, Kumar S, Ram A. Effect of sowing dates and plant population on chickpea (*Cicer arietinum*) genotypes. Indian Journal of Agronomy, 2012;57(2): 206-208.
13. Thombre SV, Goud VV, Jaybhaye JN, Hodole SS, Tupe AR. Effect of sowing dates and varieties on nutrient uptake and yield of chickpea. Journal of Pharmacognosy and Phytochemistry. 2019;8(5): 806-808.

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