Original Research Article

CALIBRATIONANDVALIDATIONOFCROPGRO(DSSAT4.7)MODELFOR CHICKPEA CROP IN RAIPUR

Abstract

In agriculture aspect crop simulation models play key role in developing the decision making research, technology management and policy options. It acts as useful tool to predict the growth development and production of a crop under varying soil, crop input and climatic condition. The DSSAT CROPGRO model was calibrated and validated through fieldexperimentonchickpeacropduring*rabi*seasons*i.e.* 2020-21 and 2021-22 at instructional farm Indira Gandhi Krishi Vishwavidyalaya, Raipur Chhattisgarh. The experiment was laid out in randomized block design (factorial) considering 9 treatments of two factors 3 dates of sowing (D_1=Nov. 10, D_2=Nov. 25, D_3=Dec. 10) and 3 varieties (V_1=Vaibhav, V_2=JG-14 and V_3=JG-16). The results reported highest deviation percentage at anthesis days was (4.8 to 10 %) and physiological maturity was (1.7 to 5.5%) for JG-16 variety,whereas in seed yield the highest deviation percent was (6.2 to 9%) for Vaibhav variety. Similarly after validation the highest deviation percentage at anthesis days was (0 to 10.7%) for JG-16, at physiological maturity (1.8 to 3.6%) for Vaibhav and in seed yield (2.4 to 9.5%) for JG-16.

Keywords:DSSAT,CROPGROmodel,Chickpea,rabiseason,cultivar.

Introduction

Chickpea (*Cicerarietinum L.*) is a diploid species having16 chromosomes and belongs to the family Leguminoseae. It is the third most important pulse crop in the world after dry beanand peas whereas, in India it is first most important pulse crop. Chickpea is a cheap and important source ofprotein forthose people who cannot afford animal protein orwho arelargely vegetarian (Gul*et al.,* 2013; Hama, 2019). Crop growth models are computer software programs that can simulate daily growth and development of crops. These models have been developed by scientists worldwide over the last 40 years. They play an important role in scientific research and resource management and have been used to help students to understand, observe andexperiment with crop

systems (Graves *et al.,* 2002). The DSSAT is a software package integrating the effects of soil, crop phenotype, weather and management options that allowsusers to simulate results by conducting experiments in a minutes on a computer. The DSAAT wasutilizedtosimulatemulti-yearoutcomesofcropmanagementstrategiesfordifferentcrops atany location in the world. At present DSSAT v 4.7 contains models of 32 crops. Calibration is adjustment of the system parameters so that simulated results reach a predetermined level, usually that of an observation. It is necessary when adapting an existing application model to a new environment. Both the comprehensive and simplified crop models have technical problems, but they generally can provide reasonably good predictions, especially when the model is properly calibrated for a region (Jame and Cutforth, 1996).Validation is the comparison of the results against observed data; ideally, the observed data are not the same data used for model estimation or calibration. A practical model should be rigorously validated under widelydiffering environmental conditions to evaluate its accuracy on overall yield predictions, the results from the validation process are used to refine the model.

Dataandmethodology

To evaluate the model with field experiments were conducted on chickpea crop during *rabi* seasons of 2020-21 and 2021-22 at instructional farm Indira Gandhi KrishiVishwavidyalaya, Raipur Chhattisgarh which located at latitude of 21.16' N, longitudes 81.36' E and altitude 289.5 m above mean sea level. The experiment was laid out in randomized block design (factorial) considering 9 treatments of two factors 3 dates of sowing (D_1=Nov.10,D_2=Nov.25,D_3=Dec.10)and3varieties(V_1=Vaibhav,V_2=JG-14and V_3=JG-16). Yield and phonological stages like Days taken to anthesis, Days taken to physiological maturity andseed yield were used for calibration and validation of the DSSAT model. The daily weather data viz. maximum, minimum temperature, rainfall etc. were recorded from Agrometeorology observatory Raipur, C.G. The soil physical and chemical data were collected for the study area. The cultivar specific genetic coefficients of every chickpea cultivar (Vaibhav, JG-14 and JG-16) were derived with a close match between observed and simulated phenology,growth and yield. The model was calibrated for phenology, growth and between yield used experimental data during 2020-21 and validated from the data generated during 2021-22. For the evaluation of the model performance different statistical measure like R^2, RMSE and error % were used.

Resultand Discussion

Calibrationof DSSAT4.7modelfordifferentvarieties ofchickpeacrop

DSSAT 4.7 model was calibrated for the Raipur center with the help of actual or measured data and simulated data of the year 2020-21 for the calibration of DSSAT CROPGRO model.

Daystakentoanthesis

The deviation between simulated and observed anthesis days were recorded 0 to +3 days by Vaibhav & JG-14 and +3 to +6 days by JG-16 respectively. The Root mean square error (RMSE) between the actual and predicted anthesis days was also found same for Vaibhav & JG-14 i.e. 0, 2 and 3 days while it was reported 6, 4 and 6 days for JG-16. Similarly, deviation % ranges between 0 to 5.2 %, 0 to 5.3 % and 4.8 to 10 % for Vaibhav, JG-14 and JG-16, respectively. R^2 value 0.52 was found for anthesis days.

DaysforPhysiological maturity

ThevariationofdeviationforPhysiologicalmaturitywas0to+5daysforVaibhav,0to +5 days for JG-14 and +2 to +6 days for JG-16. The RMSE was found 0, 2 and 5 for days for Vaibhav&JG-14 and 2, 4 and 6 days for JG-16.The deviation % of physiological maturity were found 0 to 4.7% for Vaibhav & JG-14 and 1.7 to 5.5% for JG-16. Coefficient of determination (R^2) of physiological maturity was observed 0.6219.

Seedyield(kgha^{-1})

Thegrainyieldsimulatedbythemodelandobservedyieldfromthefielddeviatedfrom +81 to +84 Kg/ha, for Vaibhav, +7 to +43 Kg/ha for JG-14 and +4 to +46 Kg/ha for JG-16. The RMSE for grain yield were obtained 81, 84 and 81 Kg/ha for Vaibhav, 43, 21 and 7 Kg/ha for JG-14 and 46, 34 and 4 Kg/ha for JG-16, respectively. The deviation % varied between 6.2 to9% for Vaibhav, 0.6 to 3.2% for JG-14 and 0.5 to 4.1% for JG-16.The $R^2$was found 0.9671.

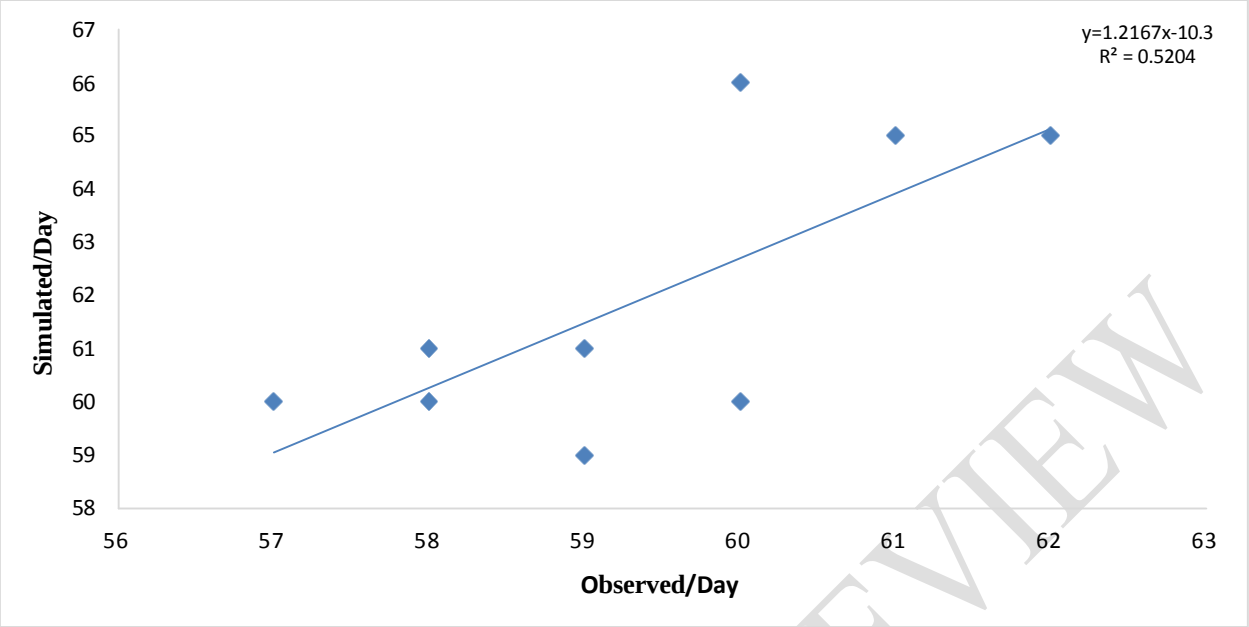

Fig:1Simulatedandobservedanthesisdays.

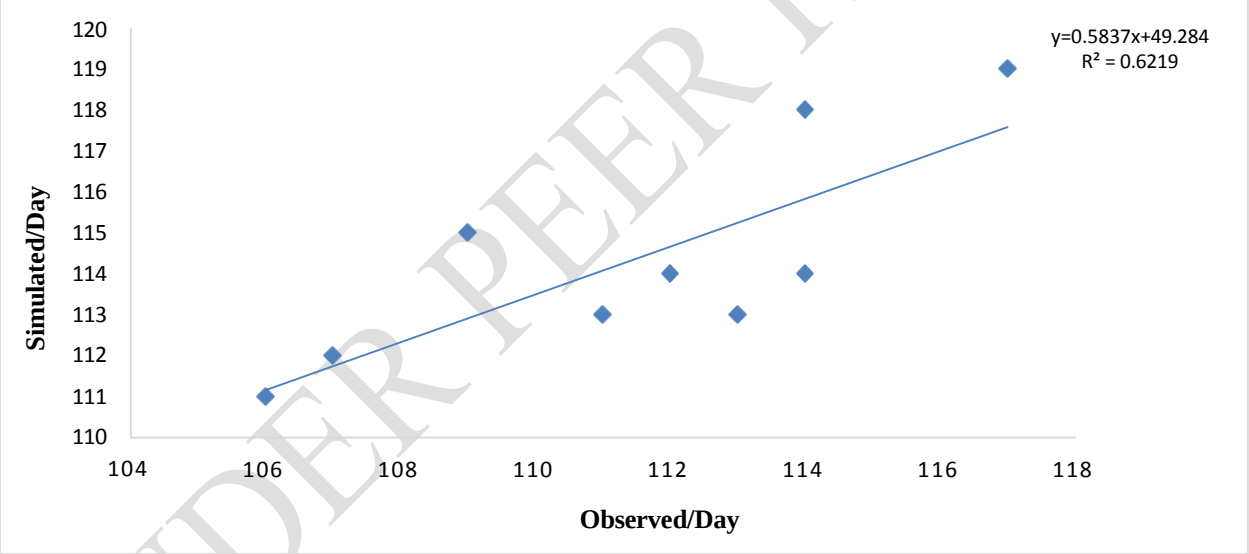

Fig:2Observedandsimulatedphysiological maturity days.

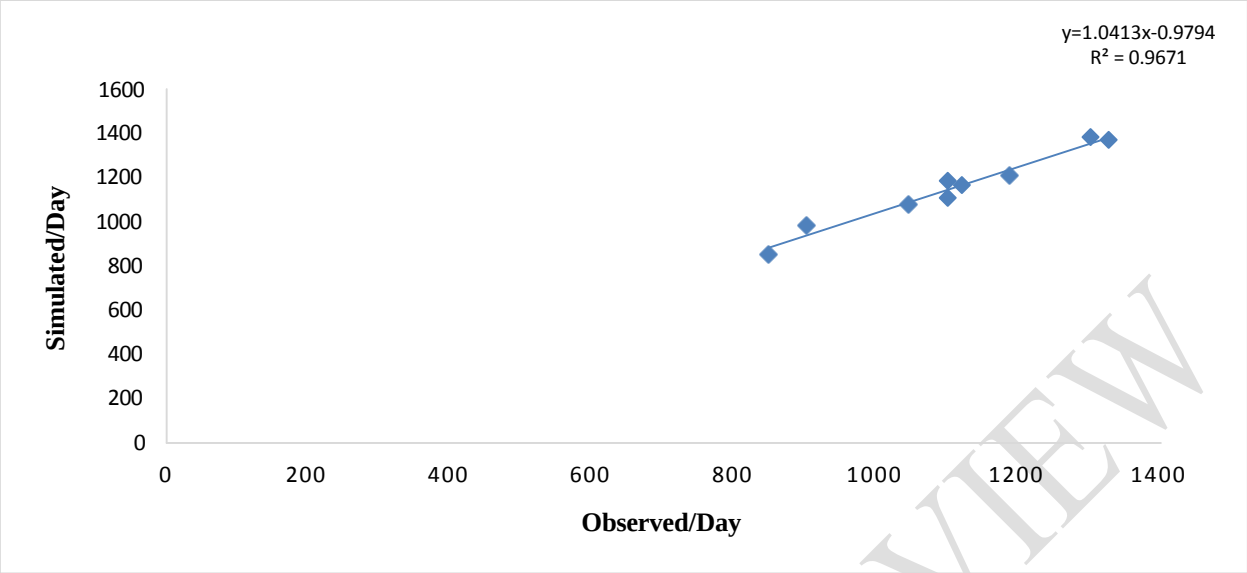

Fig.3Observedandsimulatedgrainyield(kg/h).

Validation of the DSSAT CROPGRO model for diffentcultiivarsof chickpea crop.

Daystakentoanthesis

Data pertaining to validation of simulated days taken to anthesis from observed in chickpea varieties sown under different dates of sowing for the year 2021-22 were presented in table no. 2 and error percentage and root mean square error was worked out between simulated &observed days taken to anthesis of chickpea. It is evident from the data presented in table no. 2deviation between simulated and observed anthesis days were recorded 0 to +6 days, 0 to +5 days and 0 to +6 days for Vaibhav, JG-14 and JG-16, respectively. The RMSE obtained between theactualandpredictedanthesisdayswasfound0,3and6daysforVaibhav,0,3and5days for JG-14 and 0, 4 and 6 days for JG16, respectively. Similarly, deviation % ranges between 0 to 10.5%, 0 to 8.8% and 0 to 10.7% for Vaibhav, JG-14 and JG-16, respectively. The R^2 value was found 0.6433.

Daystakentophysiologicalmaturity

Thedifferencebetweensimulatedandobservedphysiologicalmaturitydateswas+2to +4 days forVaibhav and 0 to +4 days for JG-14 & JG-16, respectively. The RMSEvaluesvaried from 2, 4 and 2 days for Vaibhav, 0, 4 and 4 days for JG-14 and 0, 2 and 4 days for JG-16 respectively.Thepercentoferrorbetweenobservedandsimulatedphysiologicalmaturitywas

observed1.8to3.6%forVaibhav,0to3.7%forJG-14&JG-16,respectively.Thecoefficientof determination $R^2$was recorded 0.5381.

Seedyield(kgha^{-1})

Simulated and observed grain yield of chickpea varieties were presented in Table 2. The difference between the simulated and observed grain yield ranges from +10 to +56 kg/ha for Vaibhav, +24 to +71 kg/ha for JG-14 and +35 to +95 Kg/ha for JG-16, respectively. The RMSE was 10, 56 and 18 Kg/ ha for Vaibhav, 75, 71 and 24 Kg/ ha for JG-14 and 35, 36 and 95 Kg/ha for JG-16, respectively. The percent of error between observed and simulated seed yield was observed 0.6 to 3.7% forVaibhav, 2.3 to 5.2% forJG-14 and 2.4 to 9.5% for JG-16 respectively. The R^2 value was found value of 0.9882. Fig 6 showed the relationship between observed and simulated grain yield. The calibration and validation of the crop growth model are integral to their development, evaluation and application. This process helps to ensure that the models are reliable, accurate and applicable across different conditions

The performance of model is acceptable because the error percentage between observed and simulated values of anthesis and physiological maturity are under the acceptable limit. Therefore model can predict phenological stages and yield of all cultivars with good accuracy.

Patil and Patel, 2017 calibrated and validated the DSSAT CROPGRO model by using field experimental data of two consecutive *rabi* seasons 2014-15 and 2015-16 at Anand, Gujarat. They found that the error % between measured and observed for all the parameters was found below ±10 % error. The model could be used to predict the seed yield accurately under different management conditions. Hence, the CROPGRO model can be used to simulate the phenology and yield of chickpea.

Conclusion

The validatin outcome of DSSAT CROPGRO model revealed that the model satisfactorily simulated the yield attributes of observed data and can be adopted for prediction of crop growth phenology and grain yield of chickpea crop Raipur district. Result can be used for farmers at regional level and for agro-advisory program.

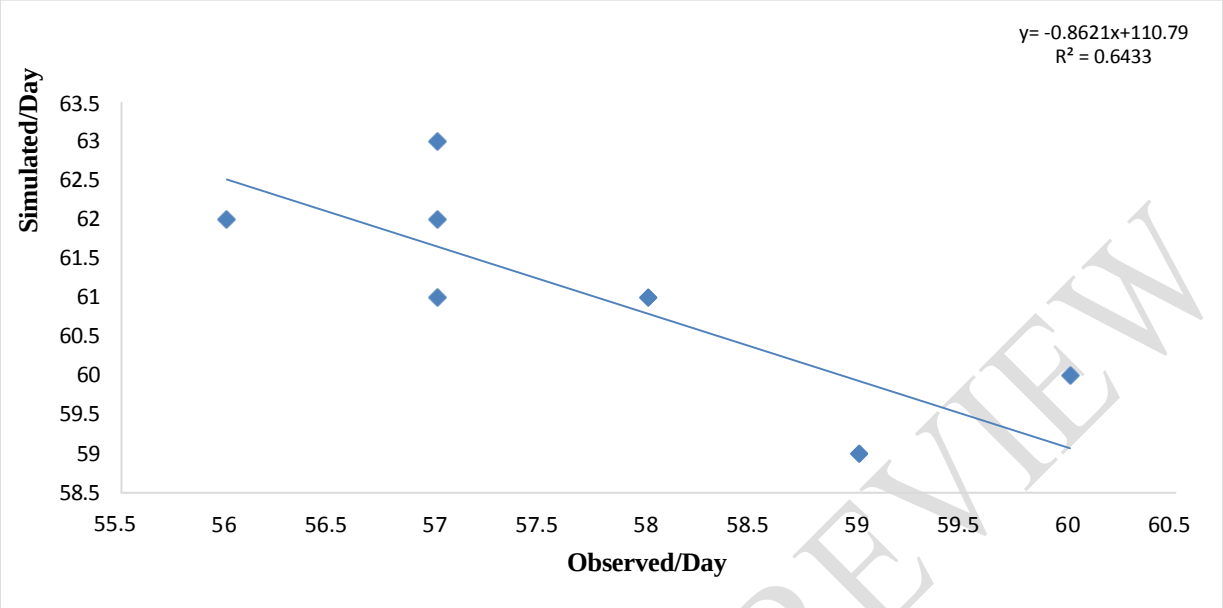

Fig:4Observedandsimulatedanthesisdays.

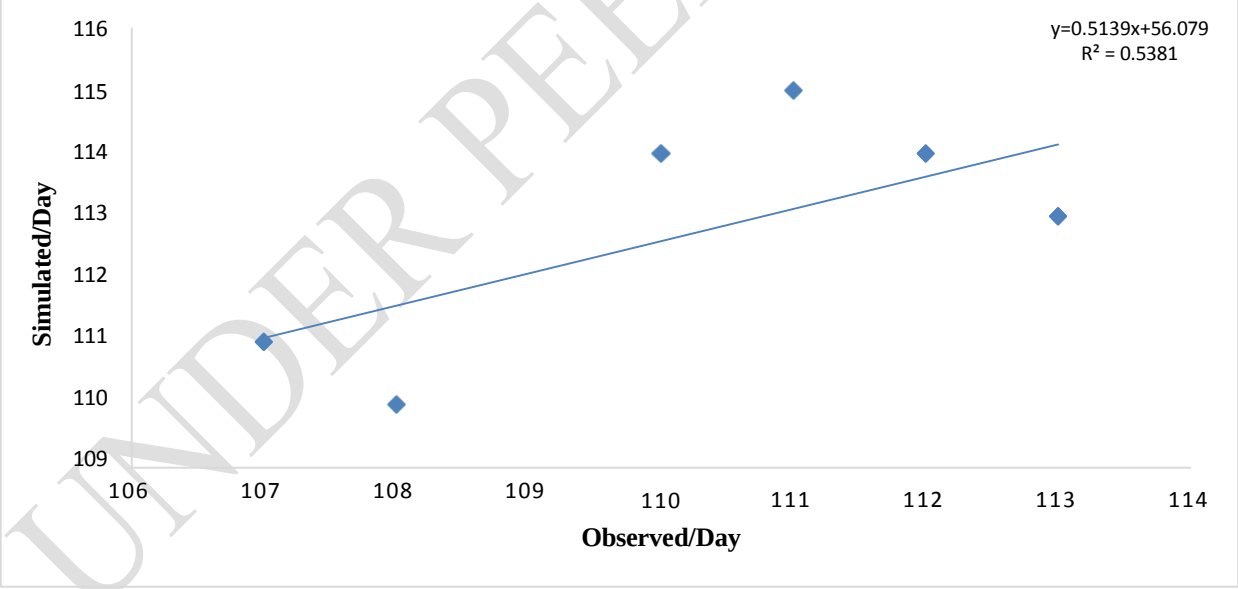

Fig:5Observedandsimulated valuesofphysiologicalmaturityday.

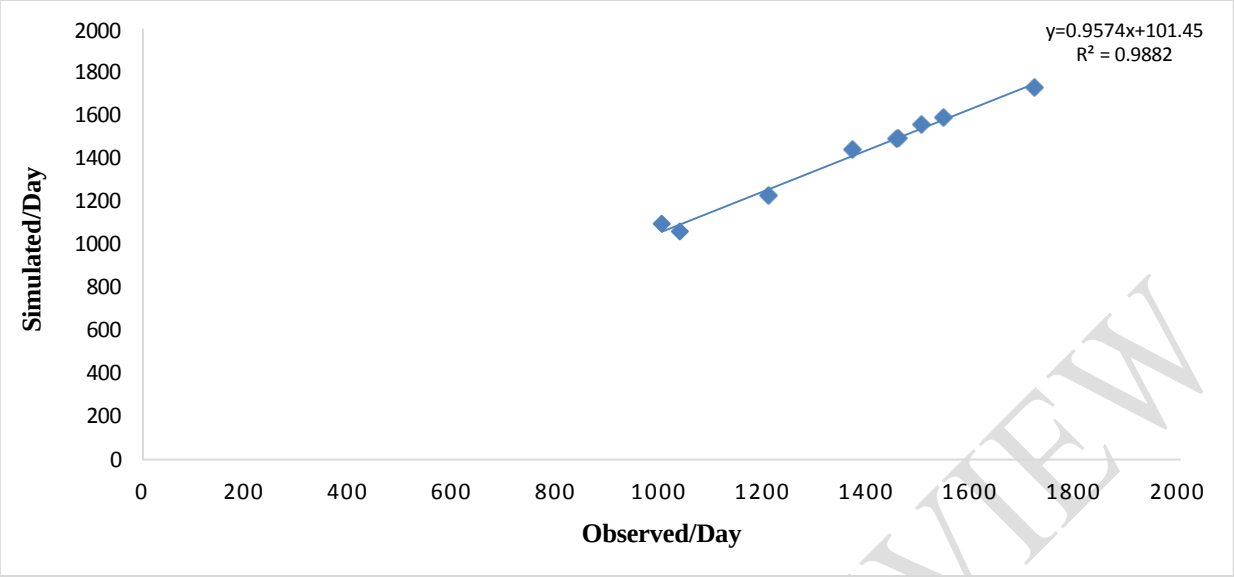

Fig:6Observedand simulatedgrainyield(kg/ha).

Table1.CalibrationofDSSATCROPGROmodelfor3varieties(V1-Vaibhav,V2-JG-14andV3-JG-16)ofchickpeacrop under different growing environment, during*rabi* season 2020-21.

	Daysto anthesis				Daystomaturity				Grainyield(Kg/ha)			
Variety	**O**	**S**	**E (%)**	**RMSE**	**O**	**S**	**E (%)**	**RMSE**	**O**	**S**	**E (%)**	**RMSE**
V1	60	60	0.0	0	114	114	0.0	0	1301	1382	6.2	81
	59	61	3.4	2	112	114	1.8	2	1100	1184	7.6	84
	58	61	5.2	3	107	112	4.7	5	901	982	9.0	81
V2	59	59	0.0	0	113	113	0.0	0	1327	1370	3.2	43
	58	60	3.4	2	111	113	1.8	2	1187	1208	1.8	21
	57	60	5.3	3	106	111	4.7	5	1100	1107	0.6	7
V3	62	65	4.8	3	117	119	1.7	2	1120	1166	4.1	46
	61	65	6.6	4	114	118	3.5	4	1045	1079	3.3	34
	60	66	10.0	6	109	115	5.5	6	848	852	0.5	4

Table2.Validationof3chickpeavarieties(V1-Vaibhav,V2-JG-14andV3-JG-16)fordaystoanthesis,daystofirstpod formation, days to maturity and grain yield under different growing environment, based on *rabi*season 2021-22.

	Daysto anthesis				Daystomaturity				Grainyield(Kg/ha)			
Variety	**O**	**S**	**E (%)**	**RMSE**	**O**	**S**	**E (%)**	**RMSE**	**O**	**S**	**E (%)**	**RMSE**
V1	60	60	0	0	112	114	1.8	2	1719	1729	0.6	10
	58	61	5.2	3	111	115	3.6	4	1502	1558	3.7	56
	57	63	10.5	6	108	110	1.9	2	1207	1225	1.5	18
V2	59	59	0.0	0	113	113	0.0	0	1545	1590	2.9	45
	58	61	5.2	3	110	114	3.6	4	1369	1440	5.2	71
	57	62	8.8	5	107	111	3.7	4	1036	1060	2.3	24
V3	59	59	0.0	0	113	113	0.0	0	1457	1492	2.4	35
	57	61	7.0	4	112	114	1.8	2	1454	1490	2.5	36
	56	62	10.7	6	107	111	3.7	4	1001	1096	9.5	95

References

Gul, R.,H., Khan, M., Bibi, Q. and Imran, B., 2013. Genetic analysis and interrelationship of yield attributing traits in chickpea.*Journal of Animal Plant Science*, 23(2):521-526.

Hama, S.J., 2019. Correlation and path coefficient analysis for seed yield and yield components in chickpea under rainfed condition. *Journal Kerbala Agriculture Science*, 6(1):26-35.

Graves, A.R., Hess, T., Matthews, R.B., Stephens, W. and Middleton, T., 2002. Crop simulation models as tools in computer laboratory and classroom-based education. *Journal of Natural Resources and Life Sciences Education*, 31:48-54.

Jame,Y.W.andCutforth,H.W.,1996.Cropgrowthmodelsfordecisionsupportsystems. *CanadianJournalofPlantScience*,76:9-19.

Patil, D.D. and Patel, H.R., 2017. Calibration and validation of CROPGRO (DSSAT 4.6) model for chickpea under middle Gujrat agroclimatic region. *International Journal of Agriculture Sciences*, 9(27):4342-4344.