Int.J.Curr.Microbiol.App.Sci (2019) *8*(8): 798-803

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 8 Number 08 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.808.090

Evaluation of Sowing Time for *Kharif* Pigeonpea and Validation by Infocrop

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Keywords

Pigeon pea, Kharif, Validation, Infocrop

Article Info

Accepted:
07 July 2019
Available Online:
10 August 2019

A B S T R A C T

A field experiment was conducted during *kharif* season of 2016-17to identify optimum meteorological week for sowing of pigeonpea. The treatments were four sowing dates (26th MW-30 June, 28th MW-15 June, 31th MW-30 July and 33th MW-15 August and three varieties (Asha (ICPL-87119), PKV-TARA, BSMR-736) with three replications and twelve treatment combinations were tested in Factorial Randomized Block Design. The results revealed that the Pigeonpea variety PKV-TARA recorded significantly higher grain (2182 kg ha^{-1}). Yield contributing characters such as number of pods plant^{-1} (184), straw yield (6356 kg ha^{-1}) and biological yield (8537 kg ha^{-1}) were higher in variety PKV-TARA than followed by Asha and BSMR-736. The performance of Crop simulation model (InfoCrop model v beta) in respect of phenological events (Days to flowering, days to maturity) was found to be highly reliable. Day to flowering and biological yield was well matched with model. Grain yield and straw yield were found to be slightly overestimated by model.

Introduction

Pigeonpea [*Cajanus cajan* (L.) *Millsp*] exploited leguminous crop belongs to family Fabaceae. It is also known as arhar, tur or red gram. The pigeonpea is a perennial legume, fast growing, deep extensive rooted system with large food reserves helps the plants to survive under unfavorable condition such as drought. Pigeonpea is an annual or a perennial shrub cultivated throughout India and it's normally grown in India as rainfed crop in rainy season. India is deficit both in pulses and oilseeds production. In India this crop is grown for dal purpose. Pigeonpea is grown in India both a food crop (dried peas or green vegetables peas) and a forage/cover crop.

Maharashtra is the largest producer of pigeonpea, accounting for over 30% of total production in the country followed by Karnataka, Madhya Pradesh and Andhra

Pradesh with 17%, 13% and 8% respectively. The total Indian pulses production is 17.5 million tonns in 2015-16. The average annual consumption of pulses in India is estimated to be 23-24 million tonns. Pigeonpea is grown in some of the African countries owing to their suitable climatic condition. The total production pigeonpea in India accounts for about 65% of the total global output. (Source: FAO statistics 2015). The pigeonpea crop suffers more in the condition of delayed sowing (Padhi, 1995).

The crop growth models can be used to predict crop performance in a given region, where the crop has not been grown before or not grown under optimal conditions. It can be developed at various levels of complexity. The level of complexity required depends on the objective of the modeling exercise.

The InfoCrop is generic crop growth model that can simulate the effects of weather, soil, agronomic management practices (including planting, nitrogen, residue and irrigation) and major pests on crop growth and yield. The InfoCrop are considered different crop development and growth process, which influence the crop yield. It performs well in tropical agro environments. The InfoCrop requires weather data, edaphic data, varietal data, crop data, insect and pest data output from the InfoCrop is like yield, total dry matter, crop duration, evapotranspiration, N uptake, greenhouse gas emissions and soil C, N and water dynamics.(Mote *et. al.*2016). The InfoCrop consider the process like crop growth, crop pest interactions, soil water balance, soil nitrogen balance, soil organic carbon dynamics and emission of greenhouse gases.

The study will be helpful to weather parameters plays an important role at different phenophase of the pigeonpea influencing the growth and final yield performance. Sowing at different times create a different set of environment conditions, which results in variation in yield of the same varieties. It will be beneficial for farmer and also the research worker to carry out the research on pigeonpea under adverse environmental conditions.

Materials and Methods

The experiment was carried out at farm in the field number 88, AICRP on Weed management. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* 2016-2017 in factorial randomized block design with twelve treatments replicated thrice. The treatments under study were sowing in different meteorological week's viz. D_1 (26 MW (30 June), D_2 28 MW (15 July), D_3 31 MW (30 July) and D_4 33 MW (15 August) with three varieties viz V_1 Asha (ICPL- 87119), V_2 PKV-TARA and V_3 BSMR-736.

The experimental field was laid out in thirty six unit plots each of 17.01 m^2 (4.20 x 4.05 m) gross and 11.25 m^2 (3.00 x 3.75 m) net size. A distance of 2 m was kept between the plots.

The soil of the experimental field was vertisols (medium black) clayey in texture. The recommended dose of fertilizer (25 kg N + 50 kg P + 00 kg K_2O/ha) and all the recommended agronomic practices were adapted during the experimental period.

The various phenological characters viz. Days to flowering, Days to maturity, Leaf area index were recorded. Grain yield, straw yield and biomass, were recorded at the time of harvest.

Results and Discussion

The observed and simulated days to flowering, day to maturity, leaf area index of pigeonpea varieties under four sowing times are presented in Table 1.

Days to flowering

The Asha variety took 117 days for flowering and the InfoCrop model simulated days to flowering are 123 days. Pigeonpea is a short day plant. The day length starts declining from July onwards in northern hemisphere with steeper fall from October onwards by Reddy *et al.,* (2015). With delay in sowing, flowering was induced earlier resulting in less vegetative growth and earliness in maturity resulting in low grain yield. The difference between the simulated and observed days for flowering is 6 days and the deviation from observed data shown as error % is 5.

The similar result was found by BSMR-736 variety took 111 days for flowering and the InfoCrop model simulated days to flowering is 121 days. The difference between the simulated and observed days for flowering is 10 days and the deviation from observed data shown as error % is 9.

Days to maturity

The observed and simulated days to maturity of pigeonpea variety under four dates of sowing are presented in Table 1.

Results showed that variety Asha took 175 days for maturity being early with delay in sowing. The InfoCrop model simulated days to maturity between 182 days under four sowing times. The difference between simulated and observed value was 7 days and the deviation indicated overestimation with mean value of 4 %.

Similar results showed that PKV-TARA took 170 days for maturity and the InfoCrop model also simulated days to maturity was 177 days. The difference between the simulated and observed days for maturity was 7 days and the deviation from observed data shown as error 4%.

Similar results were obtained for variety BSMR-736 model simulated days to maturity between 178 days against the observed values of 170 days under four dates of sowing. The difference between simulated and observed value was 8 days and the deviation indicated overestimation with mean value of 5 %.

The result revealed that model under estimated days to maturity under D_1 (26 MW), D_2 (28 MW) and D_3 (31 MW) and D_4 (33 MW). The difference between simulated and observed value was underestimation with mean value of 13 and the deviation indicated under estimation with mean value was 7 % which was less than 10%. Thus, simulated values were similar with observed value.

Leaf area index

The observed maximum leaf area index of pigeonpea for variety PKV-TARA varied between 3.26. InfoCrop model simulated values varied between 3.37. InfoCrop model simulated values were close to observed leaf area index with slightly underestimation the percent error of 3 states the suitability of model in simulating leaf area index.

In case of variety Asha the model simulated maximum leaf area index of 3.28 under four dates of sowing against the observed maximum leaf area index of 3.21. The InfoCrop model was found to underestimate the maximum leaf area index for variety Asha. The percent error of 2% states the suitability of model in simulating leaf area index.

Similar results were obtained for variety BSMR-736 the model simulated maximum leaf area index of 3.16 under four sowing times against the observed maximum leaf area index of 3.01. The InfoCrop model was found to underestimate the maximum leaf area index for variety BSMR-736. The percent error is 4%.

Table.1 Simulated and observed phenology, growth contributing characters of Pigeonpea

Treatments	Phenology								Growth			
	Days to flowering				Days to maturity				LAI			
	S	O	D	% E	S	O	D	% E	S	O	D	% E
Sowing times (D)												
D_1 (26 MW)	140	129	11	8	219	193	26	13	3.43	3.31	0.12	3
D_2 (28 MW)	138	126	12	9	206	192	14	7	2.97	3.20	-0.23	-7
D_3 (31 MW)	122	114	8	7	180	176	4	2	2.80	3.10	-0.30	-9
D_4 (33 MW)	113	108	5	4	177	168	9	5	2.73	3.04	-0.31	-10
Mean	**128**	**119**	**9**	**7**	**195**	**182**	**13**	**7**	**2.98**	**3.16**	**-0.18**	**-5**
Varieties (V)												
V_1 (Asha)	123	117	6	5	182	175	7	4	3.28	3.21	0.07	2
V_2(PKV-TARA)	116	109	7	6	177	170	7	4	3.37	3.26	0.11	3
V_3 (BSMR-736)	121	111	10	9	178	170	8	5	3.16	3.01	0.15	4
Mean	**120**	**112**	**8**	**7**	**179**	**171**	**7**	**4**	**3.27**	**3.16**	**0.11**	**3**

Table.2 Simulated and observed yield contributing characters of Pigeonpea

Treatments	Yield											
	Grain yield (kg ha^{-1})				Straw yield (kg ha^{-1})				Biomass (kg ha^{-1})			
	S	O	D	% E	S	O	D	% E	S	O	D	% E
Sowing times (D)												
D_1 (26 MW)	2531	2146	385	17	6043	6862	-819	-11	8974	9009	-35	-0.3
D_2 (28 MW)	2315	2114	201	9	5802	6469	-667	-10	8117	8583	-466	-5
D_3 (31 MW)	2117	2049	68	3	5626	5971	-345	-5	7743	8020	-277	-3
D_4 (33 MW)	2075	1969	106	5	5382	5354	28	0.5	7257	7324	-67	-0.8
Mean	**2259**	**2069**	**190**	**8**	**5713**	**6164**	**-451**	**-6**	**8023**	**8234**	**-211**	**-2.1**
Varieties (V)												
V_1 (Asha)	2271	2082	189	9	5547	6135	-588	-9	7818	8217	-399	-4
V_2 (PKV-TARA)	2405	2182	223	10	6275	6356	-81	-1	8980	8537	443	5
V_3 (BSMR -736)	1953	1945	8	0.5	5318	6002	-684	-11	7271	7947	-676	-8
Mean	**2209**	**2069**	**140**	**6**	**5713**	**6164**	**-451**	**-7**	**8023**	**8234**	**-211**	**-2.3**

S = Model Simulation O = Observed value % E – Error Per cent
D = (P-O) LAI- Leaf area index.

The result revealed that model under estimated of maximum leaf area index under D_1 (26 MW), D_2 (28 MW), D_3 (31 MW) and D_4 (33 MW). The difference between simulated and observed value was underestimation with mean value of -0.18 and the deviation indicated under estimation with mean value was -5% which was less than 10%. Thus, simulated values were well matching with observed value. The observed

and simulated grain yield, straw yield and biomass of pigeonpea varieties under four sowing times are presented in Table 1.

Grain yield (kg ha^{-1})

It may be seen that the observed grain yield for variety PKV-TARA was 2182 kg ha^{-1} and the simulated grain yield was 2405 kg ha^{-1}. The difference between the simulated and the observed value was 223 and the percent error was 10%.Similarly, for variety Asha the observed grain yield was 2082 ha^{-1} and the simulated grain yield was 2271 ha^{-1}. The difference between the simulated and the observed value was 189 and the percent error was 9%. Meanwhile the variety BSMR-736 the observed grain yield was 1945 ha^{-1} and the simulated grain yield was 1953 ha^{-1}. The difference between the simulated and the observed value was 8 and the percent error was 0.41% (Table 2).

The observed grain yield varied between 2146 kg ha^{-1} (D_1), 2114 kg/ha (D_2), 2049 kg ha^{-1} (D_3) and 1969 kg ha^{-1} (D_4) against the simulated yield ranging from 2531, 2315, 2117, 2075 kg ha^{-1} and the difference between observed and the simulated value was 385, 201, 68, 106 and the percent error was 17%, 9%, 3% and 5% respectively. The mean deviation value was 8.5, which was less than 10%. Thus, simulated values were well matching with observed value but the (D_1) percent error was 17% higher than 10%, thus, simulated values were not matching with observed value.

Straw yield (kg ha^{-1})

The observed straw yield for variety PKV-TARA was 6356 kg ha^{-1}and the simulated straw yield was 6275 kg ha^{-1} the difference between the simulated and the observed value was -81 and the percent error was -1%. Similarly for variety Asha the observed straw yield was 6135 kg ha^{-1} and the simulated straw yield was 5547 kg ha^{-1}. The difference between the simulated and the observed value was -588 and the percent error was -9%. More over the variety BSMR-736 the observed straw yield was 6002 kg ha^{-1} and the simulated straw yield was 5318 kg ha^{-1}. The difference between the simulated and the observed value was -684 and the percent error was -11%.

The observed straw yield varied between 6862 kg ha^{-1} (D_1), 6469 kg ha^{-1} (D_2), 5971 kg ha^{-1} (D_3) and 5354 kg ha^{-1} (D_4) against the simulated yield ranging from 6043, 5802, 5626, 5382 kg ha^{-1} and the difference between observed and the simulated value was -819, -667, -345, 28 and the percent error was -11%, -10%, -5%, 0.52% respectively. The mean deviation value was -6.37% which was less than 10%. Thus, simulated values were well matching with observed value.

Biomass yield kg ha^{-1}

The observed biomass yield for variety PKV-TARA was 8537 and the simulated biomass yield was 8980. The difference between the simulated and the observed value was 443 and the percent error was 5.Similarly for variety Asha the observed biomass yield was 8217 kg ha^{-1} and the simulated biomass yield was 7818 kg ha^{-1}. The difference between the simulated and the observed value was -399 and the percent error was -4.Similarly for variety BSMR-736 the observed biomass yield was 7947 kg ha^{-1} and the simulated biomass yield was 7271 kg ha^{-1}.The difference between the simulated and the observed value was -676 and the percent error was -8.

The observed biomass yield varied between 9009 kg ha^{-1} (D_1), 8583 kg ha^{-1} (D_2), 8020 kg ha^{-1} (D_3) and 7324 kg ha^{-1} (D_4) against the simulated yield ranging from 8974, 8117,

7743, 7257 kg ha^{-1} and the difference between observed and the simulated value was -35, -466, -277, -67 and the percent error was -0.38%, -5%, -3%, -0.83% respectively. The mean deviation value was -2.19, which was less than 10%. Thus, simulated values were well matching with observed value.

Crop simulation modeling

Crop simulation model (InfoCrop v beta) performance in respect of phenological phases was found to be highly reliable. Day to flowering, days to maturity, Leaf area index, seed yield and biological yield was found to be underestimated by model for all three varieties except straw yield that is overestimated.

The pigeonpea variety PKV-TARA found most suitable for higher grain yield where sowing at D_1 (26 MW) as compare to other varieties.

Grain yield, straw yield, biomass, days to flowering, days to maturity, leaf area index were satisfactory simulated by InfoCrop model, however straw yield was overestimated for all three varieties and rest at the parameters was underestimated by the model with reasonable agreement. This shows the robustness at InfoCrop model: proper calibration at InfoCrop model works well for yield simulation during projected period. By and large the model performance was found good during *kharif* season for pigeonpea crop at Akola location.

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How to cite this article:

Deepak Kumar, A.R. Tupe, Subhradip Bhattacharjee, Pramod Kumar and Sheilendra Kumar. 2019. Evaluation of Sowing Time for *Kharif* Pigeonpea and Validation by Infocrop. *Int.J.Curr.Microbiol.App.Sci.* 8(08): 798-803. doi: https://doi.org/10.20546/ijcmas.2019.808.090