ANSF APPLIED AND NATURAL SCIENCE FOUNDATION

Journal of Applied and Natural Science
15(3), 1071 - 1079 (2023)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Evaluation of DSSAT CROPGRO model on growth and yield of pigeonpea cultivars under different fertigation levels

R. Jeyajothi*
SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Chengalpattu – 603201 (Tamil Nadu), India
S. Pazhanivelan
Department, Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore - 641003, Tamil Nadu, India
M. Saravana kumar
SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Chengalpattu – 603201 (Tamil Nadu), India
N. Vinothini
SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Chengalpattu – 603201 (Tamil Nadu), India
A. Indhushree
Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, India
S. Ramadass
SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Chengalpattu – 603201 (Tamil Nadu), India
S. Marimuthu
SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Chengalpattu – 603201 (Tamil Nadu), India

*Corresponding author. E-mail: jeyajotr@srmist.edu.in

Article Info
https://doi.org/10.31018/jans.v15i3.4740
Received: May 23, 2023
Revised: August 18, 2023
Accepted: August 25, 2023

How to Cite
Jeyajothi, R. *et al.* (2023). Evaluation of DSSAT CROPGRO model on growth and yield of pigeonpea cultivars under different fertigation levels. *Journal of Applied and Natural Science*, 15(3), 1071 - 1079. https://doi.org/10.31018/jans.v15i3.4740

Abstract
Crop modelling can make it easier for researchers to comprehend and describe experimental results and pinpoint yield disparities. In this competition, the impact of pigeonpea growth and yield under various fertigation levels was examined using the Decision Support Systems for Agrotechnology Transfer 4.6 (DSSAT) and CROPGRO pigeonpea models. Under drip fertigated levels, the cultivars received various nutrient doses. The pigeonpea model developed by DSSAT-CROPGRO successfully simulated measured pigeonpea grain yield. The field trials took place in Coimbatore at the millet breeding facility of the Tamil Nadu Agricultural University. The study ran the GLUE coefficient estimator to estimate the cultivar coefficients until it had a good match between the predicted and observed seed yield. The accuracy of the model was measured by calculating its R-squared, RMSE, NRMSE, and Agreement percentage. According to model simulation and field measurements, drip fertigation at 125% RDF via WSF + Azophosmet and foliar spray of 1% PPFM resulted in the highest seed output of 1875 kg ha^{-1}(V1F5) over both years. The increase in seed yield with drip fertigation at 125% RDF via WSF + Azophosmet and foliar spray of 1% PPFM (V1F5) was 8.0 - 11.0% when compared to drip fertigation at 100% RDF via WSF + Azophosmet and foliar spray of 1% PPFM (V1F4)12.9 - 16.1 % compared to drip fertigation at 100% RDF through WSF; and 68.0 - 74.3 % compared to conventional fertilizer. It was indicated that the DSSAT v.4.6 can be a helpful tool for determining and forecasting pigeonpea growth yield if it is appropriately calibrated. Simulation models substantially facilitated maximizing crop growth and generating management advice.

Keywords: CROPGRO pigeon pea model, Drip fertigation , DSSAT, Genetic co-efficients

INTRODUCTION

The pigeonpea (*Cajanus cajan.* L.) is a multipurpose pulse crop used nationwide as food, animal feed, and fuel. Pigeonpeas are a staple for sustainable agricultural production under various agro-climatic settings thanks to their durability under rainfed conditions, nitrogen-fixing capabilities, high protein content, and compatibility as an intercrop with a wide range of crop species. Pulses are a staple in many people's diets worldwide and they can significantly boost people's health, preserve our soils, protect natural habitats, and contribute to global food security. Noort *et al.* (2022). The exceptional deep root system permits optimum moisture and nutrient consumption, allowing it can withstand drought. The deep root system also breaks up hard pans, earning the nickname "biological plough" (Kavitha and Hemavathy, 2022). As the population grows, so does the need for pulses. Pigeonpea productivity must be raised to keep up with demand. It is widely acknowledged as being an excellent source of dietary proteins. India makes up 20.87 % of the world's total production of pulses. India harvests roughly 90% of pigeonpea (Goyal *et al*., 2008). As the population grows, so does the need for pulses. The average consumption is only 31 g per day per person, despite the Indian Council of Medical Research's recommendation of roughly 60 g per day per person (Sharma *et al.*, 2020).

The main water user is agriculture. The flood irrigation system's total effectiveness ranges from 25% to 40%, highlighting the need for water conservation and increased water use efficiency to produce "more crop per drop" of water. By 2050, India's food production will need to nearly double in order to meet the projected population's dietary, income, and food security needs. Adoption of micro irrigation may boost the quality and quantity of produce while saving a substantial amount of water Zafari *et al.* (2019). The ability to use water effectively will be key to expanding the area that can be irrigated. Micro irrigation is crucial in this situation to achieve increased production and water consumption efficiency and sustainability with productive use of resources (Rasul, 2016)

The most crucial steps to be performed for boosting pigeonpea productivity are micro irrigation with fertigation and their economy by adhering to the 4 R principles (right quantity, right site, right stage, and right time) Mikkelsen *et al.* (2015). One of the irrigated agriculture methods with the quickest rate of growth is drip irrigation. It has a huge potential to increase agricultural productivity due to its high water usage efficiency. By increasing crop output per volume of water and nutrients, the drip fertigation method is one way to use water and nutrients more effectively (Patel and Rajput 2011). According to Bhaskaran and Subrahmanyam (2012), fertigation reduces applied nutrient and water losses.

Crop models are very helpful for simulating crop growth, soil processes, and yield in response to climatic and management changes. The fundamental idea of modelling crop development and production incorporating real-time crop modeling will generate outcomes representing how a real crop would grow in a particular environment and under a particular set of management settings. The DSSAT is a programme that helps users input experimental data by combining crop models with field trial observations. Analyzing the economic risk and uncertainty of different management options, estimating cultivar-specific parameters, doing sensitivity analysis, and displaying simulated and observed results visually (Hoogenboom *et al.,* 2003). The DSSATv.6 crop models replicate the expansion, maturation, and fruition of crops cultivated on a certain amount of land under specific management conditions. Unique to this system are the databases linked to the crop models and used to evaluate the models' efficacy and derive data on individual cultivars. In order to choose the optimal practice, DSSAT assists users in evaluating strategies modelled in terms of yield, profit, water use, nitrogen uptake, leaching, etc. (Hoogenboom *et al.,* 2019). Therefore, extensive calibration and validation are needed to give these models legitimacy and to suggest them for usage locally. The present study aimed to calibrate and evaluate DSSAT model with field data using semi determinate cultivars growing in open field and, therefore, assumptions regarding the indeterminate behavior of the model in greenhouses cannot be made until an appropriate evaluation is performed.

MATERIALS AND METHODS

The millet breeding facility of the Tamil Nadu Agricultural University in Coimbatore played host to the field trials conducted there (11N, 77E), at a height of 426.7 m above mean sea level (Fig 1). The farm receives 720.8 mm of rain annually during the past three decades, spread out over 47 rainy days. The average high temperature at this site is 31.9 degrees Celsius, while the average low temperature is 21.4 degrees Celsius. At 07.22 UTC, the humidity was between 78.5 and 88.4 %, and at 14.22 UTC, it was between 42.3 and 53.1 %. A daily average of 7.5 hours of direct sunlight produced an average solar radiation of 429 cal cm^{-2} min^{-1}. Overall, 163 millimetres of precipitation fell during the growing season. A median of 6.4 mm was found for the pan's evaporation, with a range of 4.97 mm to 8.4 mm. The sun radiation was on average 364.5 cal cm^{-2} day^{-1}, with a range of 224.0-462.6 cal cm^{-2} day^{-1}. Treatments and layout were arranged for each in a strip plot design that was duplicated three times. On each plot, which had a 40 m^2 area, there were 8 rows and 28 lines (Fig. 2). With a 90/3030 cm gap between rows, paired row

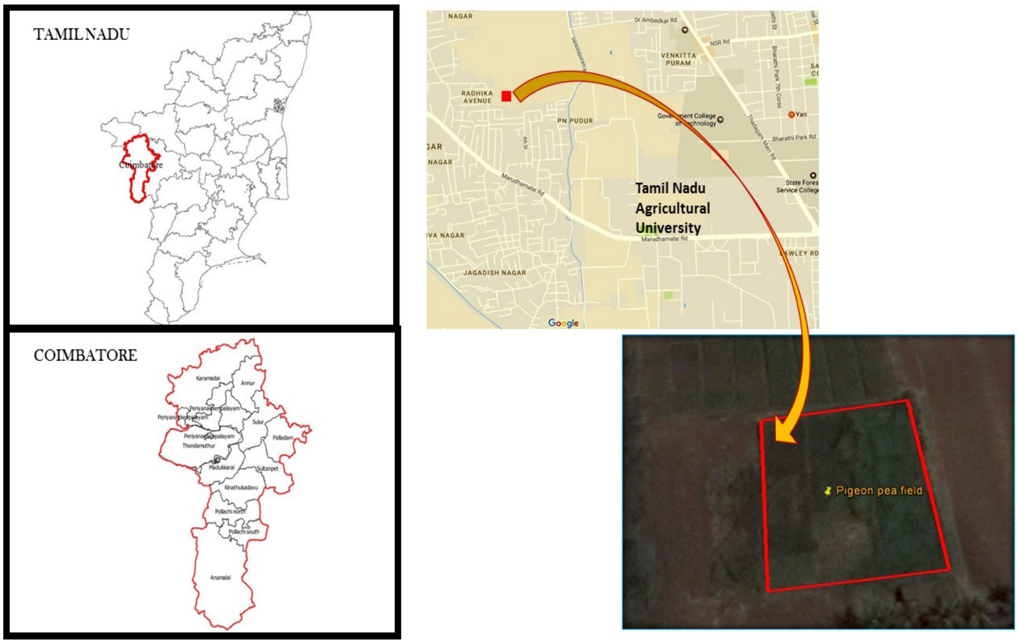


Fig. 1. *Location of the study area*

planting was used under drip irrigation. The raised bed's centre, measuring 60 cm wide by 25 m long, had one lateral with an inline dripper covering two rows of pigeonpea and discharging at a rate of 4 lph (Fig 3). Two raised flat beds were separated from one another by a 1.2 m furrow that was 30 cm wide and 15 cm deep. Every treatment received a separate fertigation system, which included drip tubes and controlled cassettes. To maintain fertigation water pressure of 1 kg/cm^2, water for fertigation was stored in a tank set about 1 m off the ground. Three photo-resistant pigeonpea varieties Co (Rg)7, APK 1, and VBN 3 as well as subplots in three fertigation levels 75%, 100%, and 125% RDF through WSF, were used in the treatment. When the cumulative pan evaporation (CPE) value reached 83 mm, irrigation was applied according to an IW/CPE ratio of 0.60.

Water soluble fertilisers V1F3, V2F3, and V3F3 were applied at 75% of the recommended dose, 100% of the recommended dose, and using concentrations of 125% of the standard dose, V1F2, V2F2, V3F2, V1F4, V2F4, and V3F4 were administered respectively, using drip irrigation following the fertigation schedule. Through the use of water-soluble fertilizer applied through fertigation, the following nutrients were fed to the plants: mono ammonium phosphate (12:61:0 NPK), urea (46% nitrogen), poly feed (19:19:19), and sulphate of potash (0:0:50). These fertilisers also contained nitrogen, phosphorus, and potassium. The necessary amount of fertiliser was dissolved in water at a 1:5 ratio to create the fertiliser solution, which was then pumped into the irrigation system via a venturi assembly. Fertigation was set to occur once every seven days. The treatment surface-irrigated plot received the necessary doses of inorganic fertilisers directly (V1F1, V2 F1 and V2F3). Inorganic fertiliser dosages of 25:50:25 NPK kg ha^{-1} were administered at a basal rate. For irrigation on the surface, Urea (46% N), SSP (16% P_2O_5) and MOP (60%) were fertiliser sources employed to supply the NPK nutrients, respectively.

One of the unique features of DSSAT modeling is that it has databases that connect to the crop models and are used for evaluating model performance and estimating crop simulation programmes. The Crop Simulation Model simulates the growth, development and yield of a crop growing on a uniform area of land under specified management (Fig. 4). Repeated iterations of the GLUE coefficient estimator were used to estimate the cultivar coefficients until a high degree of agreement was found between the predicted and observed seed yield. Using test criteria such as R2, Root Mean Square Error (RMSE), Normalized Root Mean Square Error (NRMSE), and Agreement %, the performance of the model was assessed.

Root Mean Square Error (RMSE), Normalized Root Mean Square Error (NRMSE), and % Agreement were used to examine the correlation between predicted and measured values.

$$RMSE = \sqrt{1/N \sum(Oi - Pi)2} \qquad \text{Eq. 1}$$

NRMSE =100 x (RMSE / O*i*)

Agreement (%) =100 x (1- (RMSE / O*i*))

Where P*i* and O*i* are the predicted and observed values for the observation, and N is the count of individual observations for each treatment. The root-mean-square error (RMSE) is a positive metric used to evaluate how far the simulated values deviate from the actual values. Zero is the best possible score. As RMSE decreases, the accuracy of the model's prediction improves.

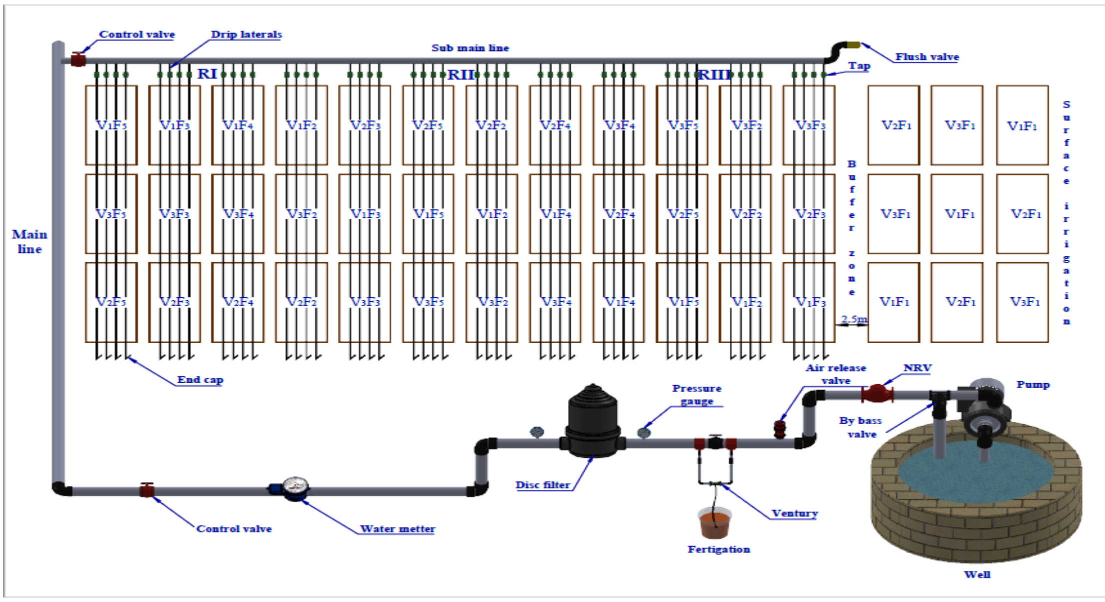


Fig. 2. *Experiment layout of the field with drip fertigation*

RESULTS

DSSAT – CROPGRO – Pigeopea Model Performance

The results revealed that the leaf area index, root dry weight, dry Matter production, pods per plant^{-1}, pod weight and grain yield of three varieties under the different nutrient doses closely matched the observed values. While growth parameters (LAI) were higher (2.64) under 125 % RDF through WSF + Azophosmet (V1 F5) and foliar spray of 1 % PPFM (Table 1) . The dry matter production was also highest 6638 kg ha^{-1} in the same treatment. Among the three cultivars the maximum gain yield was observed in Co(Rg)7 followed by APK1 variety. In case of variety Co (Rg)7 reached a higher yield under the higher dose of fertilizer treatment. Using WSF + Azophosmet and a foliar spray of 1% PPFM 1549 kg ha^{-1} over two years, the grain production was higher under 125% RDF (V1 F5).

Calibration and validation

Results on simulated values of several growth and yield characteristics for three cultivars of pigeopea under various nutrient doses reveal a very similar association with the observed values, as shown by statistical parameters RMSE and NRMSE. The Agreement % for DSSAT-CROPGRO Pigeopea model underestimated the biomass for all nutrient dosages and types. The model even overestimated the grain yield of cultivar VBN3. The observed and predicted pigeon pea cultivar seed yields for the calibration (2019–21). Metrics like the root-mean-square error were used to evaluate the model's efficacy (RMSE) for leaf area index, root dry weight, dry matter production, pods per m^2, pod weight, and grain yield (0.69,855,1.90 and 19.21), the NRMSE (28,22,14,17,20 and 15), R^2 (0.97,0.96,0.88.0.91,0.89 and 0.72), and agreement% (72,78,86,83,80 and 85),

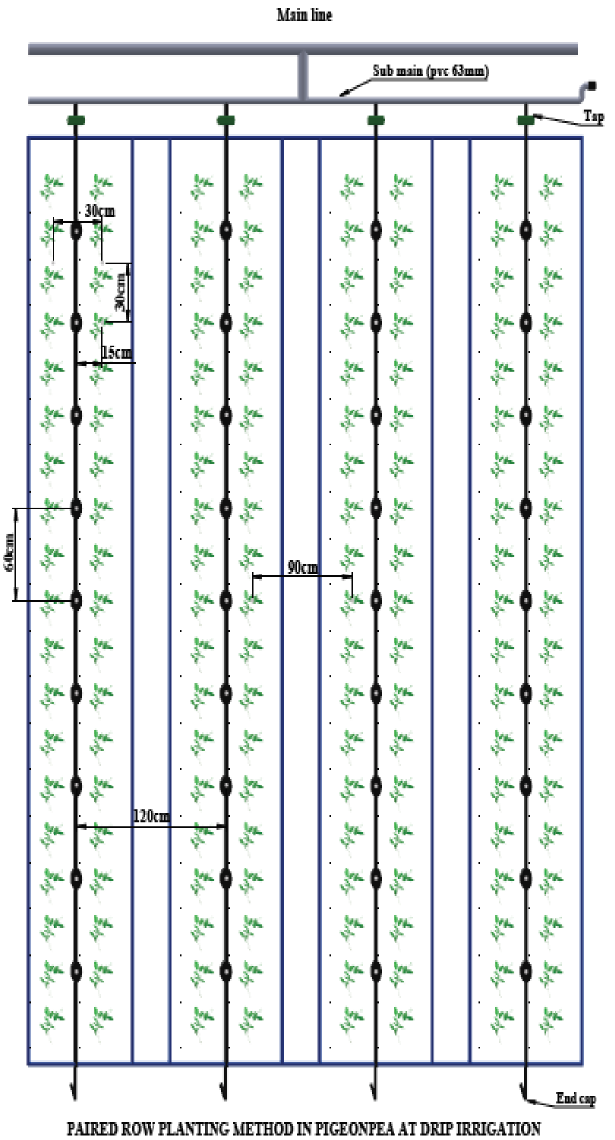


Fig. 3. *Paired row planting method in pigeonpea at drip irrigation*

Table 1. Comparison of mean values of field observations and their simulation for leaf area index and dry matter production

LAI				DMP (kg ha^{-1})		
Treatment	**Observed**	**Simulated**	**Agreement (%)**	**Observed**	**Simulated**	**Agreement (%)**
V_1F_1	1.94	1.42	73	3351	2547	76
V_1F_2	2.79	2.08	75	5029	4124	82
V_1F_3	2.35	2.25	96	4537	3584	79
V_1F_4	2.88	1.96	68	5294	4288	81
V_1F_5	2.92	2.34	80	5692	4383	77
V_2F_1	1.90	1.22	64	2643	1982	75
V_2F_2	2.56	1.86	73	4101	2953	72
V_2F_3	2.21	1.6	72	3475	2815	81
V_2F_4	2.69	1.75	65	4241	3647	86
V_2F_5	2.82	2.04	72	4596	3631	79
V_3F_1	1.79	1.22	68	2319	1693	73
V_3F_2	2.53	1.46	58	3267	2418	74
V_3F_3	2.44	1.74	71	2860	2402	84
V_3F_4	2.54	2.15	85	3405	2690	79
V_3F_5	2.76	2.23	81	3985	3228	81
RMSE kg ha^{-1}	0.69			855		
NRMSE (%)	28			22		
R^2	0.97			0.96		
Agreement (%)	72			78		

Main plot: V_1 – Co (Rg)7; V_2 – APK 1;V_3 – VBN 3 and **Subplot:** F_1 - 100% RDF with CF under surface irrigation; F_2 - 100% RDF with WSF under drip fertigation; F_3 - 75% RDF with WSF under drip fertigation + Azophosmet + 1% PPFM; F_4 - 100% RDF with WSF under drip fertigation + Azophosmet + 1% PPFM; F_5 - 125% RDF with WSF under drip fertigation + Azophosmet + 1% PPFM

Table 2. Comparison of mean values of field observations and their simulation for root dry weight and number of pods per plant

	Root dry weight (g $plant^{-1}$)			Number of pods per plant		
Treatment	**Observed**	**Simulated**	**Agreement (%)**	**Observed**	**Simulated**	**Agreement (%)**
V_1F_1	10.21	11.58	86.58	514.6	561.25	90.93
V_1F_2	16.34	17.598	92.30	660.85	796.75	79.44
V_1F_3	13.12	15.24	83.84	629.75	721.1	85.49
V_1F_4	16.86	17.22	97.86	689.2	776.15	87.38
V_1F_5	17.71	20.27	85.54	691.1	793.1	85.24
V_2F_1	9.86	10.24	96.15	357.9	461.77	70.98
V_2F_2	13.98	14.58	98.01	533.95	598.1	87.99
V_2F_3	12.01	13.44	88.09	446.1	524.25	82.48
V_2F_4	14.11	15.98	86.75	525.9	621.15	81.89
V_2F_5	15.48	17.965	83.95	538.1	679.4	73.74
V_3F_1	10.01	12.325	87.57	469.9	563.25	80.13
V_3F_2	15.25	16.54	91.54	584.75	651.6	88.57
V_3F_3	12.64	14.52	85.13	522.5	641.75	77.18
V_3F_4	15.81	17.58	84.69	592.05	661.25	88.31
V_3F_5	16.41	18.93	80.99	672.25	768.25	85.72
RMSE kg ha^{-1}	1.90			19.21		
NRMSE (%)	14			17		
R^2	0.88			0.911		
Agreement (%)	86			83		

Main plot: V_1 – Co (Rg)7; V_2 – APK 1;V_3 – VBN 3 and **Subplot:** F_1 - 100% RDF with CF under surface irrigation; F_2 - 100% RDF with WSF under drip fertigation; F_3 - 75% RDF with WSF under drip fertigation + Azophosmet + 1% PPFM; F_4 - 100% RDF with WSF under drip fertigation + Azophosmet + 1% PPFM; F_5 - 125% RDF with WSF under drip fertigation + Azophosmet + 1% PPFM

Table 3. Comparison of mean values of field observations and their simulation for pod weight and yield

	Pod weight			Yield		
Treatment	**Observed**	**Simulated**	**Agreement (%)**	**Observed**	**Simulated**	**Agreement (%)**
V_1F_1	9.725	8.564	88	1145	939	82
V_1F_2	14.56	11.245	77	1731	1575	91
V_1F_3	12.759	9.653	76	1556	1354	87
V_1F_4	15.247	11.68	77	1827	2028	89
V_1F_5	14.935	12.05	81	1992	2171	91
V_2F_1	7.58	6.589	87	898	781	87
V_2F_2	12.598	9.6532	77	1399	1063	76
V_2F_3	9.963	7.2152	72	1184	935	79
V_2F_4	12.47	11.0548	89	1451	1320	91
V_2F_5	12.68	10.285	81	1574	1464	93
V_3F_1	7.985	6.3598	80	783	947	79
V_3F_2	9.321	9.124	98	1111	1211	91
V_3F_3	8.522	8.0124	94	966	1072	89
V_3F_4	6.654	5.21	78	1158	1459	74
V_3F_5	11.245	9.5621	85	1360	1659.2	78
RMSE kg ha^{-1}	2.25			204		
NRMSE (%)	20			15		
R^2	0.89			0.72		
Agreement (%)	80			85		

Main plot: V_1 – Co (Rg)7; V_2 – APK 1;V_3 – VBN 3 and **Subplot:** F_1 - 100% RDF with CF under surface irrigation; F_2 - 100% RDF with WSF under drip fertigation; F_3 - 75% RDF with WSF under drip fertigation + Azophosmet + 1% PPFM; F_4 - 100% RDF with WSF under drip fertigation + Azophosmet + 1% PPFM; F_5 - 125% RDF with WSF under drip fertigation + Azophosmet + 1% PPFM

which showed (Fig 8). The model's performance was also fairly good over the validation period, as shown by the RMSE test criteria. As a result, using this model, one can replicate the seed production of three pigeon pea cultivars grown in various settings.

Growth parameters

Pigeonpea's leaf area index was strongly influenced by the interaction effect of fertigation levels and cultivars in both growing seasons. After receiving 125% of the recommended dose of RDF via WSF + Azophosmet biofertigation + 1% PPFM foliar spray, Co(Rg)7 showed the greatest leaf area index (2.39). (V1F5). Pigeonpea LAI was found to be lowest in VBN3 while using 100% of the recommended dose of conventional fertiliser alone with surface watering (V3F1). However, under drip fertigation with 125% RDF through WSF + Azophosmet and foliar spray of 1% PPFM (V1F5), the variety Co(Rg)7 significantly reported greater dry matter yield of 6638 kg ha^{-1} in two years. Following this was the variety Co(Rg)7, which achieved a dry matter yield of 6125 kg ha^{-1} in both years when subjected to drip fertigation with 100% RDF via WSF + Azophosmet and a foliar spray of 1% PPFM (V1F4).

In both seasons, conventional fertiliser treatment with surface irrigation resulted in the lowest dry matter output (3169 kg ha^{-1}) . Higher irrigation frequency and more readily available soil moisture from drip irrigation may have facilitated greater root proliferation, improved nutrient uptake and utilisation, and quick canopy growth (Ayotamuno *et al*., 2007). The biggest increase in vegetative growth during drip fertigation may result from the soil's optimal amount of moisture availability (Pattanaik *et al.,* 2003)

Yield attributes

Co(Rg)7 variety with drip fertigation at 125 % RDF through WSF + Azophosmet + 1% PPFM foliar spray (V1F5) achieved the highest number of pods per m^2 131. Following this, in two years, fertigation at 100% RDF was performed using WSF + Azophosmet + 1% PPFM (V1F4) 130 pods per m^2 (Table 2). During both years, variety and fertigation had a strong interaction impact. Regardless of variety, foliar application of 1% PPFM in addition to drip fertigation at 125% RDF via WSF + Azophosmet (V1 F5) resulted in the highest ever seed yield of 1875 kg ha^{-1} over both years (Table 3). The increase in seed yield from drip fertigation at 125% RDF through WSF + Azophosmet and foliar spray of 1% PPFM was 8.0-11.0%, compared to drip fertigation at 100% RDF through WSF + Azophosmet and foliar spray of 1% PPFM, 12.9-16.1%, and 68.0-

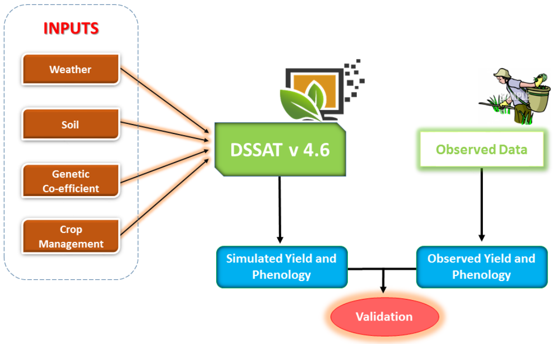


Fig. 4. *Schematic representation of DSSAT V 4.6 Modelling*

74.3% from conventional fertiliser application with surface irrigation (V1F1).

DISCUSSION

The predictability of the maximum leaf area was comparatively good, as evident from the low value of difference as the leaf area index was under predicted. Observed LAI varied between 1.79 to 2.92 compared with the 1.22 to 2.34 simulated LAI (Fig. 5). The R^2 value of the leaf area index was 0.97. Calibration of DSSAT CROPGRO model (V 4.6) was done by running the model repeatedly until simulated growth, indicating that yield parameters reached very close to the observed values Battisti et al. (2017).DSSAT model provided a good estimate of dry matter production (kg ha^{-1}) compared with measured values. In both the varieties and fertigation levels had close prediction over observed value. (RMSE = 855, R^2 = 0.96).

The simulation for pigeonpea was carried out to give the best fit to the simulated root dry weight, and the simulated root dry weight was over-predicted compared to the simulated data, it would be desirable to formulate the changing pattern of weight with observed root dry weight in all the treatments (Fig. 6). To better-fit soil depth and incorporate it into the model. The agreement on dry matter production of Pigeonpea DSSAT simulated value was 86 per cent. There was an underestimation of the root weight, particularly near the surface. It would be ideal to create and include in the model the changing pattern of length/weight ratio with soil depth to better fit the observed data Webster et al. (2020)

The simulation of grain yield was good in relation to observed values for pigeonpea at different fertigation levels and varieties. The simulation of grain yield was

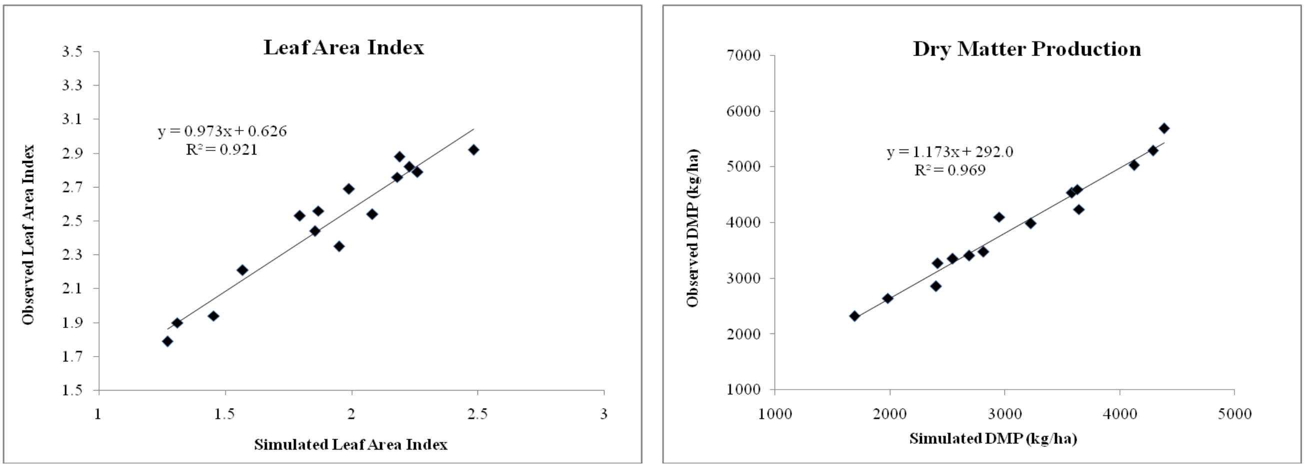


Fig. 5. *Comparison of observed and simulated LAI and Dry matter production of pigeonpea with DSSAT-CROPGRO model*

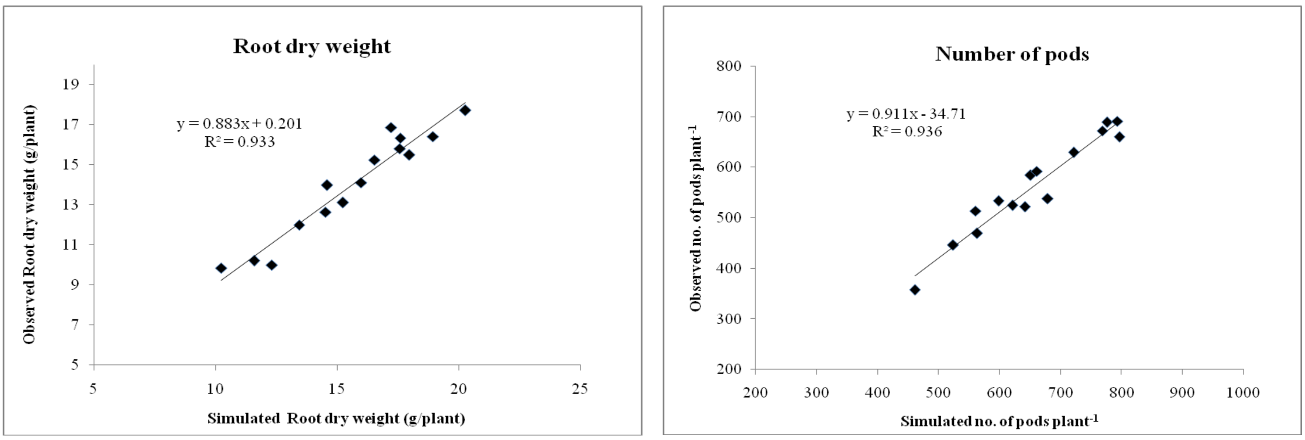
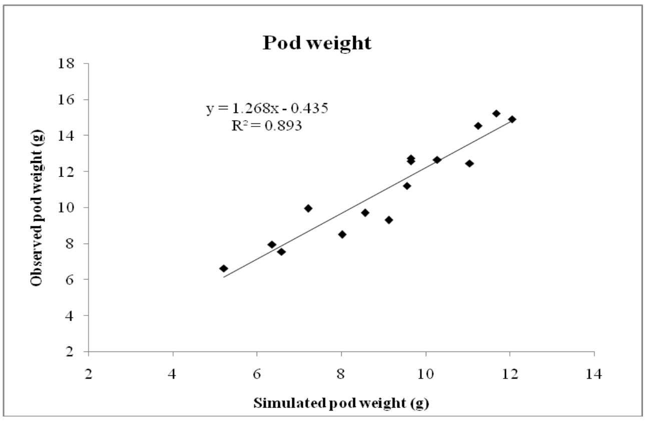


Fig. 6. *Comparison of observed and simulated Root dry weight and number of pods plant^{-1} of pigeonpea with DSSAT-CROPGRO model*



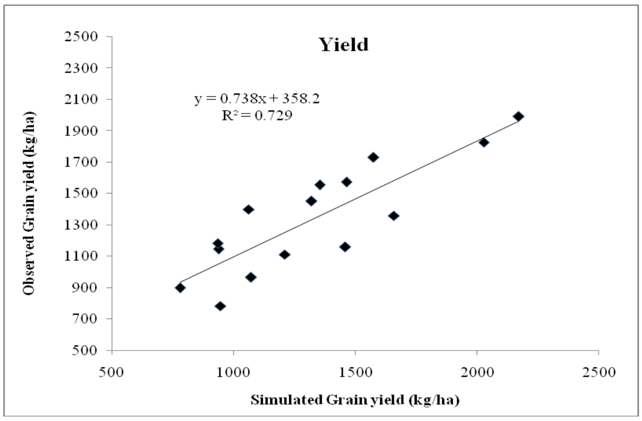


Fig. 7. *Comparison of observed and simulated pod weight and yield of pigeonpea with DSSAT-CROPGRO model*

less in relation to values. Simulated grain yield kg ha^{-1} for pigeonpea at different varieties and fertigation levels were found to have close predictions during the year (RMSE = 204, R^2 = 0.72. The 125 % RDF through WSF with Azophosmet and 1% PPFM foliar spray (V1F5) was found to be reliable based on agreement with simulated yield under drip fertigation observed values as compared to other treatments. The results showed that the model could reasonably simulate grain yield for all the treatments. Crop modelling systems can forecast how environmental changes will affect growth and yield by helping to analyse how crops grow and develop in response to environmental factors (Raza *et al* ., 2019). The number of pods per m² ranged between 691.1 to 793.1 and for observed and simulated data, respectively. The studies showed close prediction over observed values followed (RMSE 19.21 and R^2 = 0.911) during the year. The agreement of number of pods per m² is 83 per cent (Fig 7).

The observed yield of pigeonpea varied between 1584 to 1878 kg ha^{-1} compared to the simulated data of 1577 to 1984 kg ha^{-1}. Simulated yield (kg ha^{-1}) for wheat found to have close predictions through CROPGRO in 2008. Da silva *et al.* (2022) (2002) reported that the CROPGRO model reasonably simulated legume grain yield. CROPGRO models were able to simulate the phenological events and wheat grain yield (Rahman et al., 2019)). The model provides insights about the response mechanism to different varieties and fertigation levels and there were least differences between observed and predicted values. All agricultural production systems aim to get higher crop yield per unit of land area with optimal resource use. Crop yield is a function of crop growth and development and yield components under different irrigation and management practices (Rai et al*.,* 2020)

Conclusion

The results showed that the simulation produced good results with various cultivars and fertiliser doses; therefore, the DSSAT CROPGRO v 4.6 model should be utilised within the bounds of experiential error to simulate growth and yield over a wide variety of fertiliser doses and cultivars for adaptation methods. The findings supported the assertion that the DSSAT v.4.6 Pigeon Pea Model effectively replicates pigeon pea growth and yield produced in a semi-arid region of Tamil Nadu. CROPGRO models were able to simulate the phenological events and grain yield. The model provides insights into the response mechanism to different varieties and fertigation levels, and there were the least differences between observed and predicted values. In the future, calibrated and validated CROPGRO-pigeonpea model may be used as a management tool to determine an optimum planting date or cultivar choice, considering the variability of weather and the associated yield loss risks. It may also be used to predict crop performance in regions where the crop has not been grown before by predicting probabilities of grain yield levels for a given soil type and rainfall distribution.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Ayotamuno, J.M., Zuofa, K., Sunday, O.A. & Kogbara., B.R. (2007). Response of maize and cucumber intercrop to soil moisture control through irrigation and mulching during the dry season in Nigeria. *African Journal of Biotechnology*. **6,** 509-515.
2. Battisti, Rafael, Paulo C. Sentelhas & Kenneth J. Boote. (2017)"Inter-comparison of performance of soybean crop simulation models and their ensemble in southern Brazil." *Field Crops Research* 200 : 28-37. Doi.org/10.1016/j.fcr.2016.10.004
3. Bhaskaran, M.N & Subrahmanyam, S.V.S. (2012). Water soluble fertilizers-NFCL experience. *Indian Journal of Fertilizer*. **8:** 56-61.
4. Da Silva, Evandro H. & Figueiredo M, (2022)"Predicting soybean evapotranspiration and crop water productivity

for a tropical environment using the CSM-CROPGRO-Soybean model." *Agricultural and Forest Meteorology* 323 (2022): 109075. Doi/.org /10.1016/agr for-met.2022.109075.

5. Goyal, R.K., R.K Vishwakarma. & O.D.(Wanjari., 2008). Optimisation of pigeonpea dehulling processing Biosystems Engineering. **99:** 56-61.
6. Hoogenboom, G., Jones, J.W., Porter, C.H.,. Wilkens, P. W, Boote, K.J., Batchelor W.D.Hunt & L.A Tsuji, G. Y. (2003). Vol. 1: Overview. **In** Decision Support System for Agrotechnology Transfer. Version 4.0. Honolulu, Hawaii: University of Hawaii.
7. Hoogenboom, Gerrit, (2019)."The DSSAT crop modeling ecosystem." *Advances in crop modelling for a sustainable agriculture*. Burleigh Dodds Science Publishing,. 173-216.
8. Kavitha, S., & Hemavathy, A. T. (2022). Enrichment of soil eminence by pulses farming. *Biological plough-pigeonpea is a drought tolerant*.
9. Mikkelsen, Robert L., Timothy K. Hartz, & MJ Mohammad Rusan.(2015) "Challenges of increasing water and nutrient efficiency in irrigated agriculture." *Managing water and fertilizer for sustainable agricultural intensification* : 168.
10. Noort, M. W., Renzetti, S., Linderhof, V., du Rand, G. E., Marx-Pienaar, N. J., de Kock, H. L., ... & Taylor, J. R. (2022). Towards sustainable shifts to healthy diets and food security in sub-saharan Africa with climate-resilient crops in bread-type products: a food system analysis. *Foods*, *11*(2), 135. Doi:10.3390/foods11020135.
11. Patel, N. &T.B.S. Rajput. 2011. Simulation and modeling of water movement in potato (*Solanum tuberosum*). *Indian Journal of Agricultural Sciences.* 81:25-32.
12. Pattanaik, S.K., Sahu, N.N., Pradhan, P.C, & Mohanty, M.K.,.(2003). Response of Banana to drip irrigation under different irrigation designs. Journal of Agricultutal Engineering. 40 : 29-34.
13. Rahman, M. H., Ahmad, A., Wajid, A., Hussain, M., Rasul, F., Ishaque, W., ... & Nasim, W. (2019). Application of CSM-CROPGRO-Cotton model for cultivars and optimum planting dates: Evaluation in changing semi-arid climate. *Field Crops Research*, *238*, 139-152. Doi.org/10.1016/j.fcr.2017.07.007.
14. Rai, A., Sharma, V., & Heitholt, J. (2020). Dry bean [phaseolus vulgaris L.] growth and yield response to variable irrigation in the arid to semi-arid climate. *Sustainability*, *12*(9), 3851. Doi: 10.3390/ SO1209385.
15. Rasul, G. (2016). Managing the food, water, and energy nexus for achieving the Sustainable Development Goals in South Asia. *Environmental development*, *18*, 14-25. Doi: 10.1016/JJ.envdev.2013.12.001.
16. Raza, A., Razzaq, A., Mehmood, S. S., Zou, X., Zhang, X., Lv, Y., & Xu, J. (2019). Impact of climate change on crops adaptation and strategies to tackle its outcome: A review. *Plants*, *8*(2), 34. doi:10.3390/plants8020034
17. Sharma, M., Kishore, A., Roy, D., & Joshi, K. (2020). A comparison of the Indian diet with the EAT-Lancet reference diet. *BMC Public Health*, *20*(1), 1-13.
18. Webster, R. A., Soderlund, E., Dykstra, C. L., & Stewart, I. J. (2020). Monitoring change in a dynamic environment: spatiotemporal modelling of calibrated data from different types of fisheries surveys of Pacific halibut. *Canadian Journal of Fisheries and Aquatic Sciences*, *77*(8), 1421-1432.doi.org/10.1139/cjfas-2019-0240
19. Zafari, Janbaz Khan, & Nazir Khan Mohammadi.(2019) "A review on drip fertigation on field crops." *International Journal of Engineering Science and Technology* 8.11 : 722-29