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## Research Article

# VALIDATION OF COTTAM MODEL UNDER DIFFERENT SOWING DATES, ORIENTATION AND METHOD OF PLANTING CUM IRRIGATION APPLICATION

**YADAV R.P. AND MATHAUDA S.S. ***
Department of Agronomy and Agro Meteorology Punjab Agricultural University, Ludhiana 141 004, Punjab, India
*Corresponding Author: Email- raghu_mam@rediffmail.com

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**Abstract:** A field experiment was conducted on cotton (F-846) with two sowing dates (April 26 and May 20) in main plot and combinations of two orientations (66.5cm x 30cm and 100cm x 20cm) and two methods of planting cum irrigation application (ridge-furrow and flat) in sub-plot during kharif 2000 at Punjab Agricultural University, Ludhiana. The ancillary and yield parameters were compared with the simulated output of COTTAM model for validation. The COTTAM model underestimated the maximum LAI by 2 to 8 percent under April 26 sowing and overestimated by 8 to 12 percent under May 20 sowing. The model estimated number of open bolls per plant within 69 to 86 percent of field observed values. The model predicted maximum boll size very close (97 to 100 percent) to that of field observed maximum boll size under all treatments. The model simulated seed cotton and lint yield within 100 to 121 percent of the actual seed cotton and lint yield observed in the field. The COTTAM model showed 100 percent agreement in predicting the seed cotton yield under May 20 sowing with wider row spacing and ridge-furrow method of planting cum irrigation application under Punjab conditions.

**Keywords:** Model, COTTAM, Validation, Sowing date, Orientation, Planting method

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## Introduction

The yield of a crop is the end product of a continuous interaction of a genetic variable with its environment under good management conditions. The quantification of such interaction of weather in terms of growth and yield of a crop is called a crop model which can help in estimating crop growth and yield. The use of these models is becoming increasingly necessary, indeed an essential tool in our quest to develop an understanding of the processes of plant growth and functions. Simulation models also can help in better understanding of crop micronutrient interaction and interactions amongst soil, crop, insect, disease and weather. Though number of models are available to simulate crop growth and development dynamically but before any model is selected for commercial use, model testing, sensitivity analysis and validation of the model (*i.e.* comparison of model output data with real field data) are the pre-requisite steps which must be undertaken. A validated model with good accuracy can be used for to assist the growers making farm management decision, to improve the important genetic traits of a crop variety and to forecast of regional yields in advance of maturity or harvest. The timely and fairly accurate estimation of production, of a crop like cotton, will result in the price stability and will help the decision makers to regulate the domestic market and lead to optimal utilization of storage, transport and processing facilities. So the crop model will serve as an important tool for policy planning in the field of agriculture. Keeping this in view a cotton plant simulation model COTTAM was selected to validate under Punjab state conditions.

## Materials and Method

### Field Experiment

A field experiment was conducted during *Kharif* season 2000 on a sandy loam soil of research farm, Punjab Agricultural University, Ludhiana. The experiment was laid out in split plot design with four replications. The main plot treatments comprised of two sowing date ($D_1$ = April 26 and $D_2$ = May 20) and the sub- plot treatments had combinations of orientation ($S_1$ = 66.5 cm x 30 cm and $S_2$ = 100 cm x 20 cm) and methods of planting cum irrigation application (R = ridge – furrow and F = flat). Cotton variety F-846 (mid season) was sown on flat surface on April 26 and May 20 with 100 and 66.5 cm row spacing by dibbling. Ridges, with respect to particular treatment, were made after first irrigation. A depth of 50 mm irrigation on plot area basis was kept in ridge – furrow method while under flat method it was 75 mm. The crop was fertilized with 75 Kg N/ha and 30 Kg P2O5 /ha at the time of sowings by drilling. After emergence of seedlings, gaps were filled to maintain the required plant population in each plot. Pre-emergence spray of Pendimethalin 30 EC @ 2.5 lit/ha was done to control broad leaf and grassy weeds. Two hand weeding's at 40 and 75 days after sowing were done to keep the field free from weeds. Crop was irrigated as and when required as per treatment. Plant protection measures were adopted as per recommendation to control insect pests. The maximum leaf area index was observed at 120 DAS and recorded by portable leaf area meter. Treatment wise ancillary character *i.e.* squares, green bolls including flowers, open bolls and boll weight were recorded weekly from five representative plants. Retention rate was calculated by the following formula [4].

$$Retention\ rate\ (\%) = \frac{No\ of\ Squares\ per\ plant\ at\ the\ appearance\ of\ the\ first\ flower}{Total\ no\ of\ squares\ per\ plant\ upto\ the\ appearance\ of\ the\ first\ flower}$$

### The COTTAM Model

COTTAM is a daily incrementing simulation model of cotton growth, development and yield which was developed by Jackson, *et al* (1988) at Blackland Research Centre, Texas A & M University, Temple, Texas (USA)[3]. The model was validated under non-limiting nutrient conditions. The model used readily available weather, soil and genetic inputs, written in a familiar and widely used computer language (FORTRAN), requires minimal computation time to predict growth, development and yield of cotton crop [Table-1]. The COTTAM model uses two data input files.

Table-1 Different parameters used in the COT TAM model

**Crop management variables**

1. Sowing Dates (Julian day) $D_1$ = 116 Julian day (April 26), $D_2$ = 140 Julian day (May 20)
2. Row spacing (cm) $S_1$ = 66.5 cm, $S_2$ = 100 cm
3. Plant population/ha = 50125, 50000
4. Sowing depth = 5 cm

**Soil variables**

1. Soil albedo - 0.18
2. Air/Soil temperature ratio - 0.85

**Environmental parameters**

1. Stage 1 evaporation coefficient = 0.60 cm
2. Stage 2 evaporation coefficient = 0.33 cm/t^2
3. Latitude = 30° 54'
4. ETP coefficient = 0.87

**Variety parameters**

| Characteristics/ Treatment | $D_1RS_1$ | $D_1RS_2$ | $D_1FS_1$ | $D_1FS_2$ | $D_2RS_1$ | $D_2RS_2$ | $D_2FS_1$ | $D_2FS_2$ |
|---|---|---|---|---|---|---|---|---|
| 1st square Measured node | 7.1 | 7.6 | 8.2 | 8.2 | 7.5 | 7.7 | 8.2 | 7.9 |
| Retention Rate (%) | 43 | 44 | 43 | 44 | 45 | 46 | 45 | 46 |

**Soil profile information**

| No. of Layers | Soil Depth (cm) | Plant available water in soil (cm/cm) | Soil upper limit plant available water (cm/cm) | Bulk density (g/cc) | Clay (%) |
|---|---|---|---|---|---|
| 1 | 15 | 0.12 | 0.17 | 1.53 | 13 |
| 2 | 15 | 0.11 | 0.14 | 1.54 | 13 |
| 3 | 30 | 0.13 | 0.19 | 1.50 | 14 |
| 4 | 30 | 0.14 | 0.20 | 1.50 | 14 |
| 5 | 30 | 0.16 | 0.22 | 1.55 | 14 |
| 6 | 30 | 0.17 | 0.24 | 1.62 | 10 |

**Weather input file**

Includes daily values of solar radiation (ly day$^{-1}$), maximum and minimum air temperature (°C), precipitation (mmday$^{-1}$) wind speed (ms$^{-1}$) and relative humidity (%).

**Parameter input file**

It contains information regarding physical, hydraulic, surface runoff and water holding properties of the soil as well as initial soil water content. Information on irrigation is based on the Julian day and the amount of irrigation applied. It also utilizes crop management information as planting date, row spacing, plant population, sowing depth, latitude, ET coefficient, frequency in days of water balance, frequency in days of growth output *etc.* Genetic coefficients describing cultivar are presented as the first square node number, boll size and retention rate. Sensitivity analysis test was performed for the crop management, soil physical environment and genetic coefficients before validation.

**Results and Discussion**

Validation of COTTAM model was done on the basis of growth, yield contributing characters and yield of cotton.

**Maximum LAI**

Under April 26 sowing maximum LAI predicted by the model was slightly underestimated (2 to 8 percent) under both the orientations as well as both the methods of planting cum irrigation application while it was slightly overestimated (8-12 percent) under May 20 sowing. Under April 26 sowing the model underestimated the maximum LAI by the average values of 3 and 7.5 percent at $S_2$ and $S_1$ orientation under both the methods of planting cum irrigation application, respectively. The respective values under May 20 sowing were overestimated by 9 and 11.5 percent [Table-1]. During April 26 sowing, under ridge-furrow and flat method of planting cum irrigation application the model underestimated the maximum LAI by the average value of 6 and 4.5 percent.

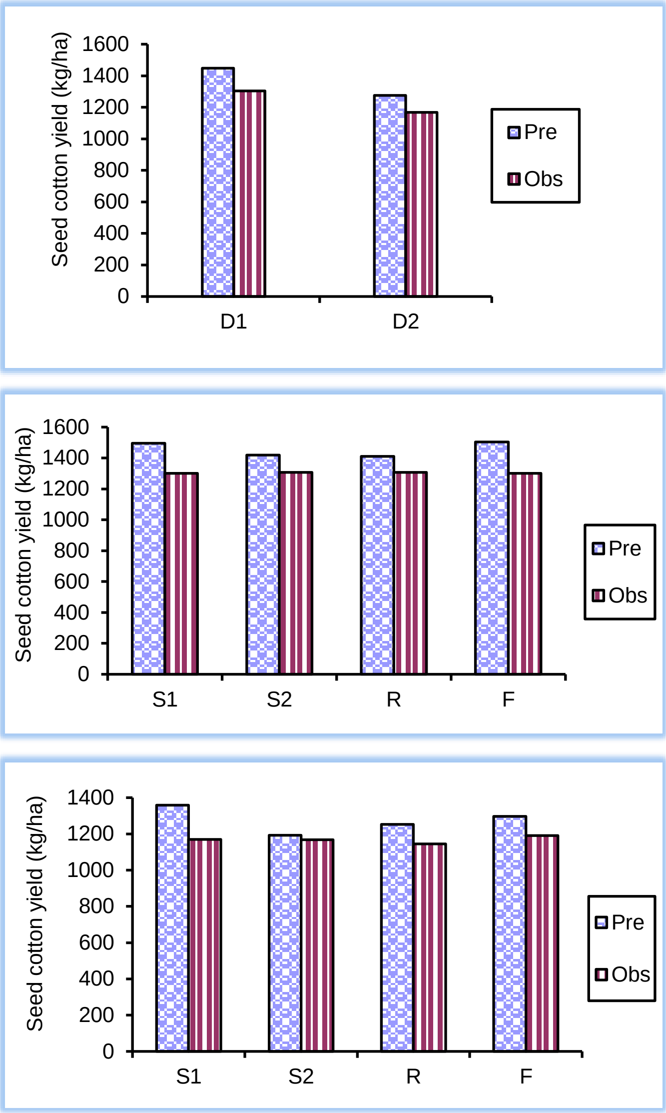


**Fig-1** Comparison of model-predicted and field observed seed cotton yield under different sowing dates, orientations and methods of planting cum irrigation application

The respective values under May 20 sowing were overestimated the maximum LAI by 9.5 and 11.0 percent. On an average the maximum LAI predicated by the model was more (4.11) under May 20 sowing as compared to April 20 sowing (4.04). It may be attributed to the prediction of LAI by the COTTAM model as a function of number of fruiting sites and soil moisture index. A value of 80 square cm per site is assumed to be unstressed leaf area increment. In COTTAM delay of 20 heat units is allowed between the appearance of fruiting site and the corresponding increase to 80 square cm leaf area. This short delay may be lengthened if water stress occurs [3]. Though the model did not predict any difference in soil moisture index between April 26 and May 20 sowing but a relatively more number of fruiting sites were estimated by the model under May 20 sowing (102.7) than April 26 sowing (97.07). This resulted in prediction of higher value of maximum LAI under May 20 sowing.

**Open bolls per Plant**

The performance of the model in predicting number of open bolls per plant under all the treatments showed that under April 26 sowing the model underestimated the number of open bolls per plant ranging from 26 to 31 percent while under May 20 sowing it ranged from 14 to 28 percent [Table-2]. Under April 26 sowing the model underestimated the open bolls per plant by 28.5 percent while under May 20 sowing by 20 and 26 percent under $S_1$ and $S_2$ orientations, respectively.

Table-2 Comparison of model-predicted and observed maximum LAI, yield contributing characters and seed cotton yield under different sowing dates, orientations and methods of planting cum irrigation application

| | $D_1$ | | | | | | | | $D_2$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R | | | | F | | | | R | | | | F | | | |
| Characters | $S_1$ | | $S_2$ | | $S_1$ | | $S_2$ | | $S_1$ | | $S_2$ | | $S_1$ | | $S_2$ | |
| | Pre | Obs | *Pre* | Obs | Pre | Obs | Pre | Obs | Pre | Obs | Pre | Obs | Pre | Obs | Pre | Obs |
| Maximum LAI | 3.97 | 4.30 | 4.08 | 4.26 | 3.96 | 4.25 | 4.16 | 4.25 | 4.11 | 3.71 | 4.03 | 3.73 | 4.19 | 3.73 | 4.11 | 3.72 |
| | (92) | | (96) | | (93) | | (98) | | (111) | | (108) | | (112) | | (110) | |
| Open bolls per plant | 9.2 | 13.3 | 9.8 | 13.4 | 10.1 | 13.6 | 9.6 | 13.7 | 8.7 | 10.1 | 7.8 | 10.9 | 8.8 | 11.9 | 8.2 | 10.8 |
| | (69) | | (73) | | (74) | | (70) | | (86) | | (72) | | (74) | | (76) | |
| Unopened bolls per plant | 0 | 1.9 | 0 | 1.8 | 0 | 1.8 | 0 | 1.9 | 0.1 | 1.8 | 0.1 | 1.9 | 0 | 1.8 | 0 | 1.9 |
| Maximum boll size(g/boll) | 3.11 | 3.10 | 2.90 | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.10 | 3.10 | 3.00 | 3.10 | 3.10 | 3.20 | 2.90 | 3.00 |
| | (100) | | (97) | | (97) | | (97) | | (100) | | (97) | | (97) | | (97) | |
| Seed cotton yield (kg/ha) | 1408 | 1293 | 1414 | 1319 | 1584 | 1307 | 1423 | 1296 | 1335 | 1114 | 1172 | 1177 | 1381 | 1224 | 1213 | 1158 |
| | (109) | | (107) | | (121) | | (110) | | (120) | | (100) | | (113) | | (105) | |
| Lint yield (kg/ha) | 485 | 445 | 487 | 450 | 546 | 450 | 489 | 444 | 460 | 381 | 403 | 401 | 476 | 416 | 418 | 391 |
| | (109) | | (108) | | (121) | | (110) | | (121) | | (100) | | (114) | | (107) | |

Pre-Predicted, Obs-Observed, Figures in parenthesis are per cent of the character predicted by the COTTAM model as compared to that observed in the field.

The model underestimated the number of open bolls per plant under ridge-furrow method of planting by 29 percent under April 26 sowing and by 21 percent under May 20 sowing. Under flat method of planting on April 26 sowing the model underestimated the number of open bolls per plant by 28 percent and on May 20 sowing by 25 percent. Number of open bolls per plant depends on two important factors *viz.* the genetic potential and partitioning pattern of dry matter among different plant organs under prevailing environmental conditions. The genetic potential of any variety depends on the retention rates of different plant characters and actual carrying capacity of plant in eventual development of boll opening [3]. In COTTAM model the actual carrying capacity (number of growing bolls that induce vegetative or fruit retention cutout) is the function of potential carrying capacity (constant upper limit of boll load for a given plant population), radiation interception (%) and soil moisture stress factor [4] The actual carrying capacity is dynamic and changes daily with the development of cotton plant and also with change in environmental conditions like solar radiation interception and soil after use. In COTTAM threshold value of soil moisture index below which plant response declined, is 0.5 for leaf growth, 0.4 for vegetative growth and 0.3 for carbon assimilation and hypocotyl elongation [3]. The underestimation of number of open bolls per plant under all treatments may be attributed to lower retention rate (43 to 46 percent) and model also predicted soil moisture stress during peak growth for nine days which might have reduced the actual carrying capacity leading to reduced number of open bolls per plant. Under May 20 sowing overall higher percentage of agreement between model predicated and field observed number of open bolls per plant may partly be due to higher retention rate (45 to 46 percent) as against April 26 sowing (43 to 44 percent).

**Unopened bolls per plant**

Under both the dates of sowing the model predicted number of unopened bolls per plant ranged 0 to 0.1 while under field conditions the number of unopened bolls per plant ranged 1.8 to 1.9 [Table-2]. Thus, in our conditions the model considered all the bolls as open bolls.

**Maximum boll size**

The model predicted the maximum boll size very well matched (97 to 100 percent) with that of field observed maximum boll size, under all treatments [Table-2]. It may be due to the fact that in COTTAM, the plant carbohydrate status is determined by the ratio of growing bolls to that carrying capacity. When the growing bolls are less than the carrying capacity then carbohydrate is allocated to the growing bolls at a constant rate [3]. In our conditions, carrying capacity was more than growing bolls under all the treatments. This resulted in proper allocation of carbohydrates into growing bolls and thus narrowed down the difference between model-predicated maximum boll size and field observed maximum boll size.

**Seed cotton yield and lint yield**

It is clear from the data that under April 26 planting the seed cotton yield predicted by the model ranged 107 to 121 percent of the actual field observed seed cotton yield while under May 20 planting it ranged 100 to 120 percent of the field observed seed cotton yield under both row spacing and method of planting [Table-2] and [Fig-1].

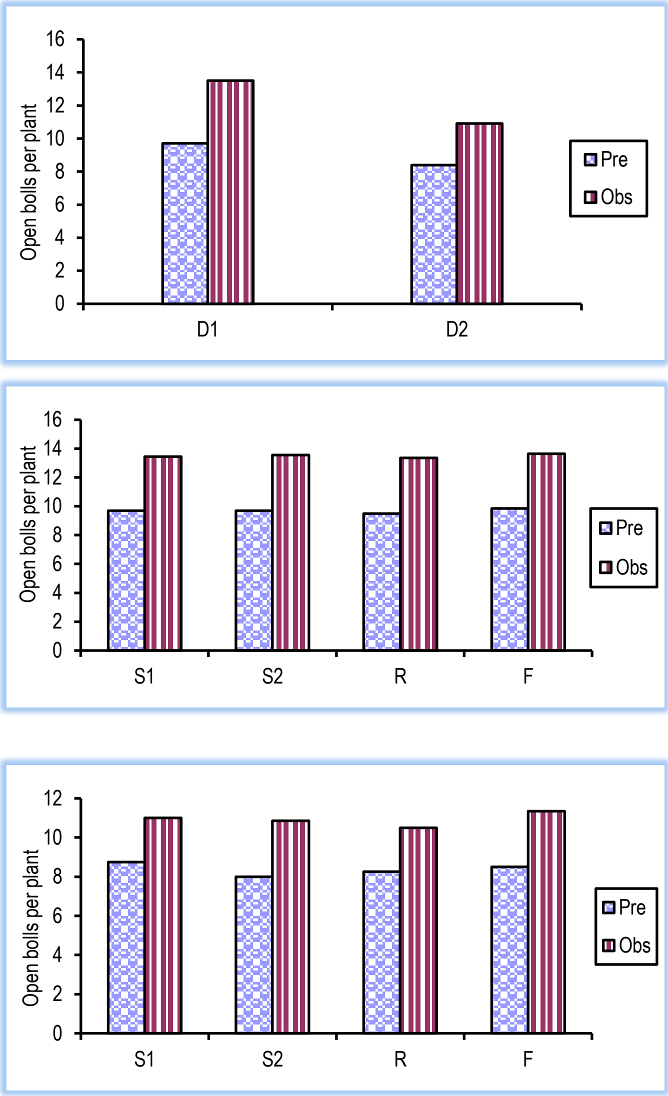


Fig-2 Comparison of model-predicted and field observed number of open bolls per plant of orientations and methods of planting cum irrigation application under sowing dates, orientations and methods of planting cum irrigation application

The model overestimated the seed cotton yield under almost all the treatments.

This may be due to the fact that prediction made by the model for seed cotton yield was mainly based on the number of open bolls per plant and the maximum boll size while under field conditions, all sized bolls (*i.e*., under developed and developed bolls) contributed to the seed cotton yield and also to the number of open bolls per plant. Moreover, the model considered all bolls as open bolls per plant contributing at a potential rate toward seed cotton yield while under field condition there were some unopened bolls which did not contribute to the final seed cotton yield and that too not at a potential rate in case of underdeveloped and smaller bolls. The COTTAM model assumes inverse relationship between the maximum boll size and potential carrying capacity [3]. As the boll size decreases the potential carrying capacity increases proportionately and vice-versa. Therefore, the seed cotton yields were overestimated and numbers of open bolls per plant were underestimated by the model under all the treatments. The model predicted lint yield exactly followed the same trend as that of seed cotton yield which may be due to the constant (34) ginning percentage under all the treatments. Lint percentage determination in COTTAM is based on the average temperature during boll period.

**Conclusion**

The performance of the COTTAM model in simulating the seed cotton yield was satisfactory. The model- predicted seed cotton yield was well agreed (100 to 121 per cent) with the seed cotton yield observed in the field under different sowing dates, orientations and methods of planting cum irrigation application. Under April 26 sowing model-predicted seed cotton yield fell within 107 to 121 per cent, while under May 20 sowing this agreement ranged 100 to 120 per cent. Under S2 orientation the model-predicted and field observed seed cotton yield well matched by 108.5 and 102.5 per cent under April 26 and May 20 sowing, respectively. Under April 26 sowing the model-predicted and filed observed seed cotton yield was well agreed by 108 per cent for ridge-furrow method while it was well matched by 109 per cent for flat method under May 20 sowing. The COTTAM model was found very realistic in predicting seed cotton yield under May 20 sowing with wider row spacing and ridge-furrow method of planting cum irrigation application. Thus it shows a very good scope of using COTTAM model. The study of COTTAM model shows very good scope of using it in predicting seed cotton yield. However, its commercial use as a tool for predicting seed cotton yield, it has to be standardized under different agro climatic and management conditions.

**Application of research**

A validated model with good accuracy can be used for to assist the growers making farm management decision, to improve the important genetic traits of a crop variety and to forecast of regional yields in advance of maturity or harvest. The timely and fairly accurate estimation of production, of a crop like cotton, will result in its price stability and will help the decision makers to regulate the domestic market and lead to optimal utilization of storage, transport and processing facilities. So, the crop model will serve as an important tool for policy planning in the field of agriculture.

**Research Category:** Agro climatic conditions

**Abbreviations:**

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***Research Guide: Dr S S Mathauda**
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**Conflict of Interest: None declared**

**Ethical approval:** This article does not contain any studies with human participants or animals performed by any of the authors.

**References**

[1] Bishnoi O.P. (1993) *Personal communications. Deptt of Agricultural Meteorology Chaudhary Charan Singh Haryana Agricultural University, Hissar, India*.

[2] Ehlig C.F. and Lamert R.D. (1973) *Crop Science* 13, 168-71.

[3] Jackson B.S., Arkin G.F. and Hearn A.B. (1988) *Transactions ASAE* 31, 846-54

[4] Jackson B.S., Arkin G.F. and Hearn A.B. (1989) *COTTAM: a cotton plant simulation model.* Texas A&M University system. Temple, Texas 76583, 1-240.