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Investigation of Dependent Variables on Utilizing Cotton Simulation Model

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Abstract: This research is focused on utilizing cotton simulation model (GOSSYM) to investigate the impact of different dependent variables such as different amount of Carbone Dioxide, rainfall, different Nitrogen Level, UV-B with or without irrigation, or different soil type in a MID-season cultivar for predicting and finding the influence of environmental factors on cotton yield, plant height, main stem nodes, and major phenological events such as squaring, flowering and boll opening during 30 years from 1964 to 1993 in Razan, Hamedan, Iran.

Keywords: Carbone Dioxide; phenological events; RegCM climate model ; Nitrogen level; MID-season

1. INTRODUCTION

Different variety of factors either climatic or inputs affect cotton productivity. There are various factors that influence cotton yield [1-2]. The actual daily solar radiation, maximum and minimum air temperatures, rainfall, and wind speed for 30 years (1964 to 1993) were used as current or ambient weather input scenarios for the model[3-6]. Changes in climate were calculated from results of a regional climate model (RegCM) nested within a General Circulation Model (GCM) from National Center for Atmospheric Research (NCAR) at Boulder, Colorado. The quantified changes in the future climate (i.e., maximum/minimum temperatures, solar radiation, precipitation, wind speed) were predicted using the RegCM climate model [7].

The weather input required to run GOSSYM is on a daily basis. Therefore, the projected monthly means for future weather parameters were used to create daily future weather files by modifying the daily current weather based on the assumption that changes in daily weather parameters will be constant for each month.[8-11] The monthly mean maximum and minimum temperature changes were added to and the ratios for the other three parameters (precipitation, solar radiation, and wind speed) were multiplied with the corresponding values of the daily 30-year current weather parameters to generate the daily future weather files for 30 years (future climate scenario). This methodology[12], however, retains the existing natural variability in the historic weather for the 30 years.

2. METHODOLOGY

In this research by applying the cotton simulation model, GOSSYM, all measurements was carried out. Data was recorded for 30 years and the model was written in Fortran to run the model and get the results. There were different scenarios, from MID- season cotton cultivar in rainfed or irrigated conditions, two different soil types (clay and loamy soil) and different planting dates and different Nitrogen level [12-14]. After running the model, data were collected in an excel file to do some statistics and plotting some graphs in order to investigate in more details. The results in the format of table and results is provided below.

3. RESULTS AND DISCUSSION

As it can be seen in Fig.1, Fig.2 and Fig.3 the slop for both graph is so small so, increasing co2 don't affect corn height and maximum leaf area index and number of nodes in both irrigated or rainfed areas significantly, even fertilizer or water was supplied. There is a slightly decreasing, increasing for corn height and Maximum Leaf Area Index respectively but there is not a constant trend for number of nodes.

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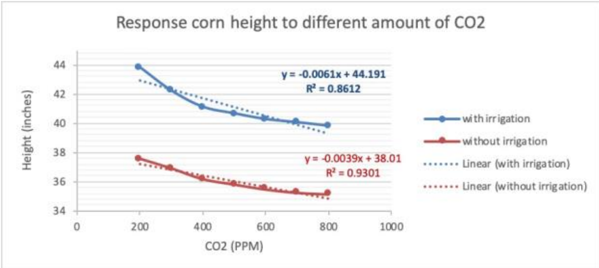

Figure 1. Response corn height to different amount of CO2 with and without irrigation over 30 years simulation period

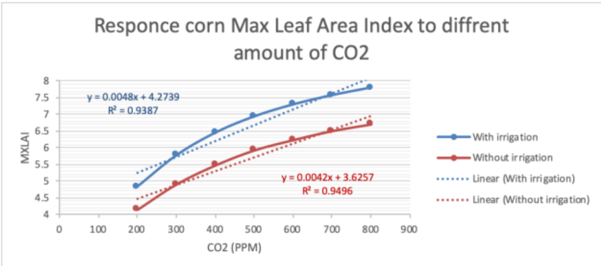

Figure 2. Response Corn Maximum Leaf Area Index to different amount of CO2 with and without irrigation over 30 years simulation period.

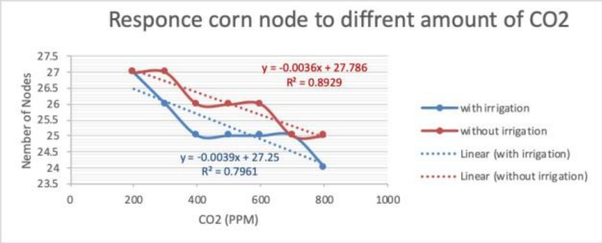

Figure 3. Response corn nodes to different amount of CO2 with and without irrigation over 30 years simulation period.

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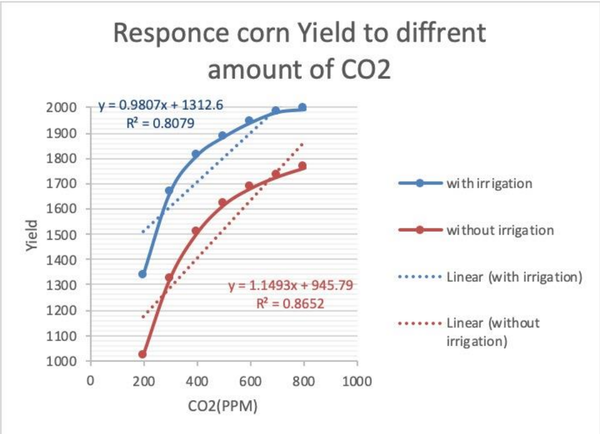

Figure 4. Response corn yield to different amount of CO2 with and without irrigation over 30 years simulation period.

As it can be seen in Fig.4, corn yield will be increased by increasing the amount of co2 and the yield in irrigated situation is more than rainfed and the importance of irrigation in increasing the yield was shown clearly.

Table 1. the impact of rainfall on different corn parameters under constant CO2 simulated over 30 years (1964 to 1993).

Rainfall Factor	Height	MXLAI	Node	Yield	DAE FSQ
0.25	22.17	4.83	27	1336	27
0.5	27.64	5.77	26	1665	27
0.75	32.9	6.45	25	1812	27
1	36.17	6.94	25	1886	27
1.25	38.58	7.3	25	1943	27

Table 2. the impact of different amount of CO2 on different corn parameters over 30 years (1964 to 1993

CO2 PPM	Rainfall Factor	Height	MXLAI	Node	Yield
200	1	43.8	4.83	27	1336
300	1	42.21	5.77	26	1665
400	1	41.1	6.45	25	1812
500	1	40.65	6.94	25	1886
600	1	40.26	7.3	25	1943
700	1	40.04	7.58	25	1984
800	1	39.8	7.81	24	1995
200	1	37.52	4.15	27	1020
300	1	36.88	4.91	27	1325
400	1	36.17	5.48	26	1505
500	1	35.81	5.93	26	1617
600	1	35.48	6.24	26	1683
700	1	35.26	6.51	25	1729

Different amounts of co2 do not have any effects on days to first square, first flower blossom and first open boll. They remained at 27, 49 and 89 respectively. It means 27 days after emergence to appear first square, 49 days after emergence for first blossom and 89 days after emergence to first open boll is needed.

4. INFLUENCE OF RAINFALL ON CROP GROWTH AND YIELD:

Rainfall in one of the important factor for researchers and farmer. It is not necessary to arrange irrigation by having the good amount precipitation on time.

As it can be seen in table.2, increasing rainfall does not have any effect on corn phenology processes which are be constant in 27, 49 and 89 days after emergence respectively for first square, first flower blossom and first open boll. there is not a constant trend for number of nodes also (Fig. 7).

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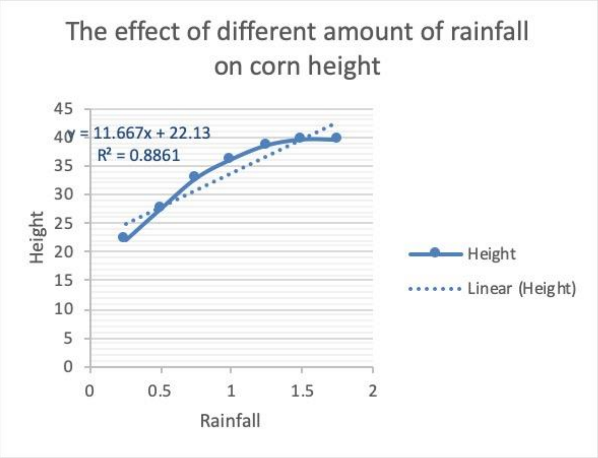


Figure 5. The effect of different amount of rainfall on corn height for 30 years..

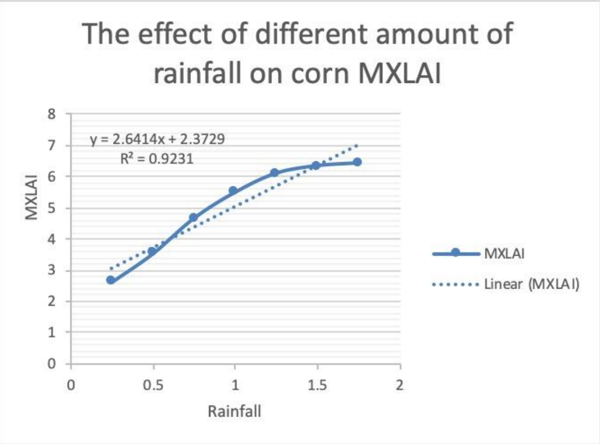


Figure 6. The effect of different amount of rainfall on corn MXLAI for 30 years.

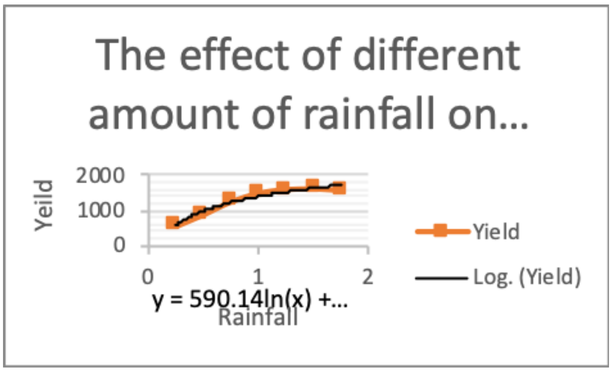


Figure 7. The effect of different amount of rainfall on yield for 30 years.

As it is shown in Fig. 5, Fig.6 and 7, by increasing rainfall, there is a increasing trend in corn height and max leaf area index. The increasing rainfall from 0.25 to 0.5 and 0.5 to 0.75 have more effect on yield rather than 1 to 1.25 and 1.25 to 0.5.

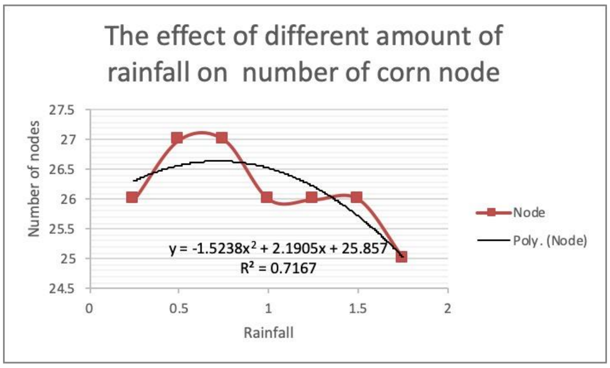


Figure 8. The effect of different amount of rainfall on number of corn node.

5. INFLUENCE OF NITROGEN ON CROP GROWTH AND YIELD UNDER TWO DIFFERENT SOIL TYPES

Nitrogen is a critical factor for plants. And different soil types have different ability to keep fertilizers in themselves. Moreover, irrigation or rainfall have an important impact on keeping Nitrogen fertilizer in soil.

Table 3. Influence of nitrogen on crop growth and yield under two different soil types over a simulation period of 30 years

CO2 (ppm)	Soil type	Nitrogen Level	Height	MXLAI
400	1	1	35.27	5.78
400	1	2	37.62	6.18
400	1	3	39.48	6.37
400	1	4	41.1	6.45
400	1	1	32.12	5.12
400	1	2	33.61	5.39
400	1	3	34.95	5.47
400	1	4	36.17	5.48
400	2	1	34.73	5.56
400	2	2	37.44	6.01

400	2	3	39.51	6.2

This simulation investigates the influence of nitrogen in 4 different amount of nitrogen fertilizer (50, 100,150 and 200lbs) under 2 different soil types (1 for clay and 2 for loam) with and without irrigation.

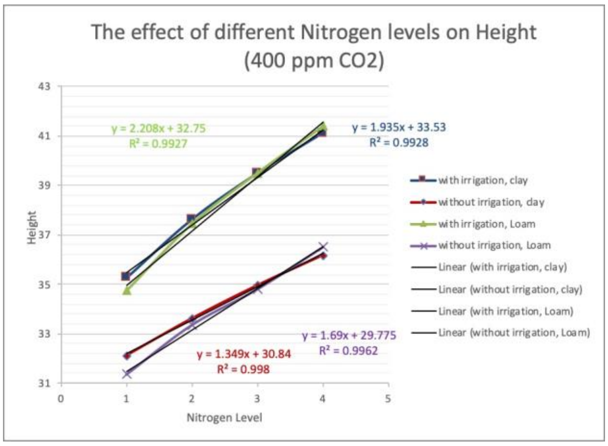


Figure 9 .The effect of different Nitrogen levels on Height (400 ppm CO2) over 30 years

As it can be seen in Fig. 9, increasing Nitrogen fertilizer cause to increase corn height but the impact in irrigated condition is more than rainfed condition. The irrigation condition has more effect than type of soil (clay or loam)

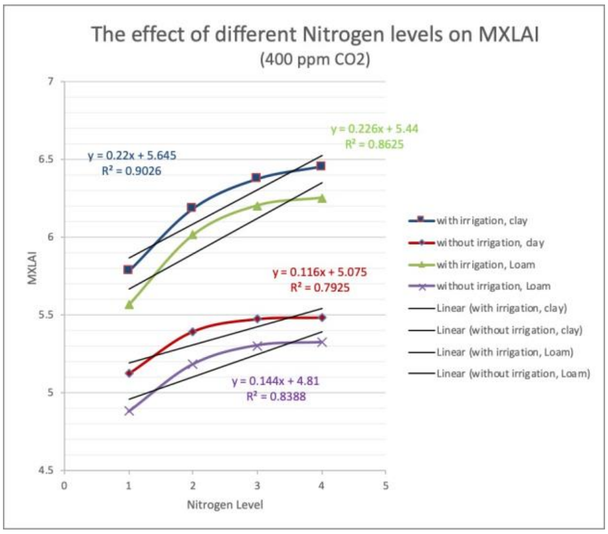


Figure 10 . - The effect of different Nitrogen levels on MXLAI (400 ppm CO2) over 30 years

As it can be seen in Fig. 10, increasing Nitrogen fertilizer cause to increase corn max leaf area index but the impact in irrigated condition is more than rainfed condition. The irrigation condition has more effect than type of soil (clay or loam) but the max leaf area index in clay soil is more than loamy soil. On both soil types maximum LAI remained at stable growth under irrigated conditions but reduced slightly under non- irrigated conditions for all amount of fertilizer (N) applied.

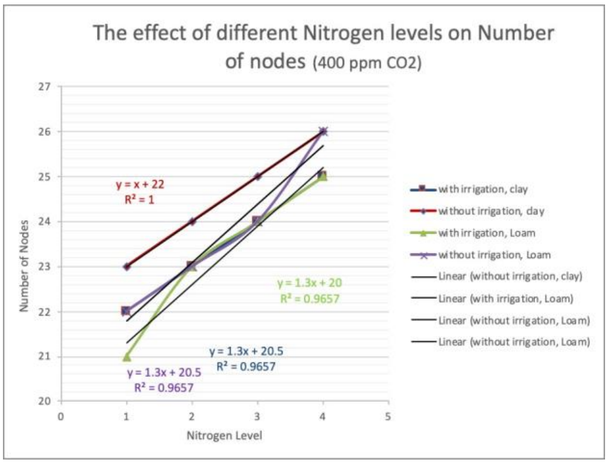
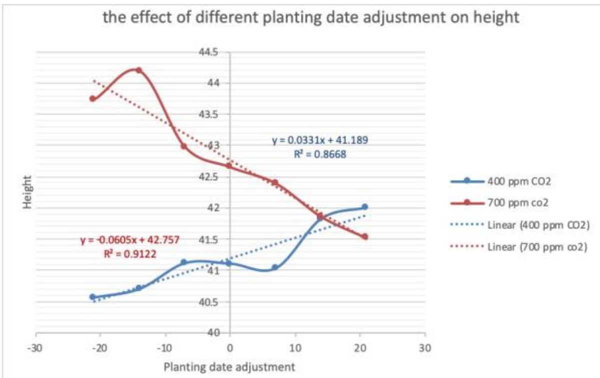


Figure 11 . - The effect of different Nitrogen levels on MXLAI (400 ppm CO2) over 30 years

The number of nodes does not have any difference in clay soil with or without irrigation conditions. But by increasing the amount of nitrogen, the number of nodes increased in clay soil too. The difference is just when the type of soil change to loam.

6. FUTURE WEATHER SCENARIOS WITH MITIGATION OPTIONS

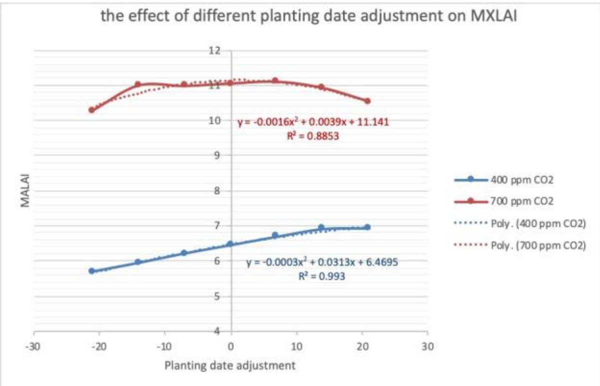
Plant growth and production can be affected by weather patterns together with other external factors. It can effect on plant phonological processes as well. Under current carbon dioxide conditions, cotton cultivar tends to be in high production, but it will be greatly affected by the future climate condition. In order to increase cotton production in a changing climate condition, one option probably is changing the planting dates.



Base on the simulations, changing planting dates, -21, -14 and -7 days earlier than standard planting date, shows that plant growth remains constant under present CO2 level (400 PPM). But under future CO2 concentration, 700PPM, cotton plants are taller when planted at earlier planting dates but remains constant in height after planting at zero days and later. In addition, based on simulations, cotton cultivar had more LAI at future climate condition than plants grown at the current conditions. In future condition, in comparison to current condition, plants had more nodes when planted at earlier days.

Based on model predictions for cotton yield, over a 30 year on 700 ppm CO2 level, and adjusted planting date, yield will decrease as compare to the current condition, (700ppm CO2 concentration). Maximum decreased occurred at -21 earlier planting days at 37% and the least decreased at 21 days later plant date at 25%. Changing scenarios and planting dates also have huge effects on cotton plant phenology, where first squaring, first flower bloom and first open boll will take place much earlier under future 700ppm CO2 concentration.

By increasing the planting date from -21 to 0, days to first square, first flower blossom and first open boll will appear earlier. But it does not have any effect on 0 to +21 for to first square and first open boll.



7. CONCLUSION

Cotton simulation model (GOSSYM), is a very important tool for researchers and farmers, especially during cotton growth which it can be easily affected by various factors. It is important to have proper management practices such as irrigation and fertilization program for cotton in order to gain maximum yields. By having some models like GOSSYM, farmers can notify that by every condition what they can do to avoid reduction in yield and growth or sometimes they know which factors effect on phenological processes.

8. Acknowledgment

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