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Influence of Climatic Changes on Faba Bean (*Vicia faba* L.) Yield in North Nile Delta.

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ABSTRACT

The study was conducted in order to assess the impact of climate change on faba bean (Vicia faba L.) yield and to investigate the possible options for overcoming these negative impacts. To find out the negative effect of climatic change (CC) on faba bean yield, a field trial was carried out at Sakha Agricultural Research Station during the two successive winter growing seasons 2013/2014 and 2014/2015. The investigation consists of four irrigation intervals ; Treatment A: rainfall treatment i.e. given only the planting irrigation and left to rainfall during the growing season (control), Treatment B: given one irrigation following the planting one, Treatment C: given two irrigations after the planting irrigation and Treatment D: given three irrigations following the planting irrigation. The Decision Support System for Agrotechnology Transfer (DSSAT) is the simulating model which compare the observed values obtainded from the experiment with that predicted by the model. To run thus program, input elements of weather, parameters of both soil and faba bean were used. Without adaptation scenario, by using the climatic data, Pods and Seeds with decreased from -12.43 to -26.11% and from -9.32 to -23.16% for yield of pods and seeds, respectively in the years 2025 to 2100. The adverse impacts of CC could be minimized under adptation scenario of deleying one month from current planting data. The corresponding values of pods and seeds will be decreased from -6.34 to -20.11% and from -5.41 to -16.26%, respectively. In conclusion, DSSAT was able to simulate dry bean crop parameters under current conditions with a difference from 0.4 to 0.7% compared to the actual yield. The main results showed that: the impact of CC on faba bean production was evaluated using CC scenario A_1 by the year 2025, 2050, 2075 and 2100 comparing with that predicted under the current conditions of season 2013/2014 and 2014/2015. Mean air temperature is projecting to an increase between 1.9 and 2.5 ºC during faba bean growing seasons for 2025 to 2100.

Keywords: *Irrigation intervals*, faba bean water applied, s*imulation model, DSSAT, sowing date, climatic changes scenario.*

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the most important field crops in Egypt cultivated through-out the county. Dry seeds are important source of plant protein for food and feed.

Cultivated area in Egypt averaged more than 302,800 fed. for dry seed production with an average of 8.54 Ardab per fed. (1 Ardab = 155 kg) and more than 40,200 fed. for fresh green pod consumption and average of 38 ardab per fed.

Faba bean (*Vicia faba* L.) is an important member of Fabaceae. It is used as green consump or dry seeds. Thus, maximizing the productivity of broad bean yield per unit area and improving its quality could be achieved through the selection of the suitable cultural practices such as irrigation, fertilizer, location, sowing date for each variety. Sowing date and locations, as it affects the timing and duration of the vegetative and reproductive stages, contributes largely to yield and yield components.

Decision Support System for Agro-Technology Transfer (DSSAT) is a microcomputer software program combining crop, soil and weather databases and programs to manage them, with crop models and application programs, to simulatee multi-year outcomes of crop management strategies.

The Ben-Gro model, embedded in the Decision Support System for Agro-Technology Transfer (DSSAT 3.5) was used for the crop simulations with current and possible future management practices. It simulates crop growth and develpoment, soil water dynamics and soil nitrogen dynamics in response to wheather, soil characteristics, cultivar characteristics and crop management as reported by El-Marsafawy (2013).

Houghton *et al.* (2001) reported that light, temperature and sowing date are three main inputs for dry bean production.

Under climate change conditions, adptation strategy for minimizing the reduction in faba bean seed yield could be achieved by sowing dates should be on 1st or 10th Decmber instead of the base sowing date of 17th November Abdel-Fattah (2014).

Houghton *et al.* (2001) had pointed out that global temperature will increase by 1.4 to 5.8 °C during the period from 1990 to 2100. Therefore,as stated by McCarthy *et al.* (2001), decreasing in crop yield will be expected by such temperature increasing and it differs among regions. Nonhebel (1993) revealed that the decreasing in yield under CC condition could be attributed to high growth rate higher of both respiration and evapotranspiration.

With food shortage, a major problem facing today's world, accurate and timely information on the crop production has taken on greater importance and value. While many countries of the world collect crop production information in some form, in many cases it is neither accurate nor timely Ibrahem (2000). Today, one of the most promising applications of crop simulation model technology is its ability to obtain reliable information about agricultural crop production. It has the potential to revolutionize the detection and characterization of many agriculture phenomena.

A model as a simplified representation of the dynamics of a real-life system. Crop-weather model has been defined as simplified representations of complex relationships between weather and climate on one hand and crop performance (such as growth, yield or yield components). On the other hand, by using established mathematical and/ or statistical techniques Baider (1979). Decision making system consists of a "user" who utilizes a system to carry out a "task" in a given environment. The components of a decision support system are: A database, a model base and a control program.

It is important to answer the quotation of why crop model are built. There are three possible answers: as aids in interpreting experimental results, as agronomic research tools and as farm management tools Whisler *et al*. (1986).

Many crop models or part of crop models have been built to assist researchers to understand the operation of some part of crop growth and development or soil-water dynamics e.g., soil water glow, stomata control, or fertilizer nutrient movement. Such model usually strongly reflect the interests and strengths of modeler, and will often be weak to nonexistent in those areas where it has little knowledge. Abdel-Azeem (1995) indicated that crop modeling could be used as a instrument in both the integration of information and diagnosis of problem areas. It is in itself a feedback system. Prior to the construction of a model, deficiencies in the information base are the subject of the experimentation testing and modification.

In recent years, crop models have been advanced from restricted academic exercises and tools with potential for wide application in agriculture. Crop models are valuable tools for synthesizing our understanding of physiological processes, hypothesizing genetic improvement, and evaluating crop and soil management strategies Boote *et al*. (1996). The CROPGRO model was developed by Hoogenboom *et al*. (1994 b) and adapted the CROPGRO legume model to simulate growth of faba bean Boote *et al*. (2002). Although there is a model for faba bean developed by Stutzel (1995a, 1995b), adaptation of the CROPGRO model is better option because it simulates soil water balance, soil N balance, soil organic matter-residue dynamics, pest and disease damage, and other processes. In addition, adaptation of CROPGRO allows the use of weather information, risk management, and geographic information system (GIS)-spatial programs and to take advantage of the standard input file conventions of the DSSAT models Hoogenboom *et al.* *(*1994a) and Tsuji *et al*.(1998).

Model building is an enjoyable if arduous task whereas model testing can be heartbreaking. Perhaps, this is why so many crop models are published without being tested. Testing of a model takes two main forms: validation, in which model predictions are compared with field observations, and sensitivity and uncertainty analysis which test the response of the model to change in certain variables and parameters. Lemon (1977) has defined validation as of comparison between a verified model to the real world. Builders of the CROPGRO legume models aimed at predicting the yield of any genotype, in any soil, at any location, and any weather where the crop can be grown.

The present investigation aimed to find out impact of climatic change on faba bean yield in Noth Nile Delta. Moreover, to mitigate the expected reverse effect by adaption strategy of change planting date.

MATERIALS AND METHODS

1. Field experiment

A field trial was executed in during the two winter seasons 2013/2104 and 2014/2015 at Sakha, Kafr El-Sheikh Governorate to find out the impact of four irrigation treatments, Treatment A: rainfall treatment i.e. given only the planting irrigation and left to rainfall during the growing season (control). Treatment B: given one irrigation following the planting one. Treatment C: given two irrigations after the planting watering. Treatment D: given three irrigations following the planting irrigation on faba bean (c.v. Giza 843) yield. The experimental design was in a complete randomized block design with three replicates, each replication contains 6 furrows of 75 cm inbetween with furrow length of 30 m. Sowing contained 3-4 seeds/hill.

Effective rainfall (Rf_e): Rainfall is subjected to different losses before reaching the soil of the growing plants, then the definition of effective rainfall is raised up which is useful in crop water consumption and was computed as rainfall multiply by 0.7 Novica *(* 1979).

Agronomic practices:

All agronomic practices and fertilization were performed as recommended for faba been at the irrigation area except the studied treatments. Daily climatic elementswere recorded; air temperatures (°C), solar radiation (MJ/m^2) and rainfall data (mm) were measured by Automated Weather Station as a daily data (Tables 1&2). Particle size distribution and soil water constants such as soil field capacity (F.C) and permanent wilting point were determined at the site according to James (1988). Soil bulk density, the soil texture and the particle size distribution were determined according to Klute, (1986). The obtained results indicated that the soil texture is clayey as shown in Table (3). Soil chemical analysis are presented in Table (4) such as total soluble salts (soil Ec, dS/ m), soil reaction (pH), both soluble cations and anions were determined according to the methods described by (Jackson, 1973). So_4^{--} was calculated by the difference between soluble cations (meq/ L) and anions (meq/ L). Faba bean yield of pods and seeds were registered in g/ plant, then computed in kg/ fed. as input data for CROPGRO-legume model.

Table 1. Average climate elements during two winter seasons of 2013/2014 and 2014/2015 at Sakha, Khafr El-Sheikh erea*.

Month	Temperature (C°) max.	Temperature (C°) min.	Solar Radiation (MJ/m^2)	Rainfall (mm)
November	25.39	15.14	16.0	23.88
December	19.64	8.51	11.6	9.91
Janauary	20.34	7.55	14.2	79.51
February	20.64	8.19	17.6	37.86
March	22.94	11.71	18.9	4.57
April	27.50	15.53	19.6	19.3

*** Data obtained from the Central Laboratory for Agriculture Climate (CLAC), A. R. C. Egypt**

Table 2. Average temperature (A_1 scenario) of faba bean winter season (Nov., Dec., Jan., Feb., Mar. and Apr.) at Sakha, Khafr El-Sheikh erea*.

Years	2025	2050	2075	2100
Max. Temp.	23.84	24.64	25.24	25.64
Min. Temp.	12.21	13.01	13.61	14.01

MAGICC 4.1/SCENGEN climate model.

Table 3. Particle size distribution and soil water constants of the studied experimental site:

Soil Depth, cm.	Particle Size Distribution Sand %	Silt %	Clay %	Texture Class	F.C %	P.W.P %	AW (%)	Bd, Mg/m³
0 – 30	19.05	32.05	48.90	Clay	42.41	24.00	18.63	1.07
30 – 60	21.80	40.60	37.60	Clay loam	37.50	20.22	17.29	1.14

Where:- F.C % = Field capacity, P.W.P % = Permanent wilting point, AW % = Available water, and Bd, Mg/m³ = Soil bulk density.

Table 4. Some chemical properties of the studied experimental site

Soil Depth, cm	EC, dSm^{-1}	PH (1: 2.5) soil water suspension	Soluble ions, meq/l Cations Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Anions CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
0-30	2.14	8.60	8.43	3.64	9.15	0.21	0.00	4.10	8.95	8.38
30-60	2.79	8.43	10.59	5.89	11.01	0.18	0.00	3.65	7.40	16.62

Water applied (Wa): Therefore, water applied equaled irrigation water (IW) plus total rainfall (Rf) are shown in Table (5).

Table 5. Seasonal water applied (Wa)as affected by irrigation treatments for faba bean ($m^3 fed^{-1}$).

Season / Treatment	1st season W.a m^3 fed^{-1}.	2nd season W.a m^3 fed^{-1}.	Mean W.a m^3 fed^{-1}.
A	1289.6	1257.3	1273.5
B	1513.3	1493.3	1503.4
C	1777.5	1713.3	1745.5
D	1901.5	2002.4	1952.0

2. Crop model validation for current climate

Collected data were used as input elements by CROPGRO- legume model under the umbrella of DSSAT program to simulate and predict dry bean growth development and its yield. The CROPGRO-model was developed by Hoogenboom *et al.* (1994b) and was adapted to simulate growth of legumes by Boote *et al*. (2002). The experiment data were prepared on the basis of IBSNAT data set (1988).

3. Climate change data

Under climate change (CC) conditions the climatic data forecasted to the years 2025, 2050, 2075 and 2100 at the experimental location were derived using monthly maximum and minimum air temperature (°C) (Table 2). Increasing in regional air temperature was used the MAGICC 4.1/SCENGEN climate model tool Wigley *et al.* (2003).

4. Option to mitigate the negative impacts of climate change on dry bean production

The adaptation could be achieved through changes in sowing date. A simulation analysis was carried out by shifting one month after current sowing date in order to study the impact of climate change on of dry bean production using A_1 scenario.

5. Statistical analysis

Statistical analysis were performed according to Snedecor and Cochran (1980), and the means of treatments compared by significant difference were (LSD) test at 0.05 level of significance.

RESULTS AND DISCUSSION

1. Field experiment

2. Yield of pods and seeds significantly effected with irrigation treatments Table (6).Treatment D produced the highest yield of pods (5870.9 kg fed^{-1}.) and seeds (1843.8 kg fed^{-1}) followed by treatment C (pods 5629.8 kg fed^{-1}., seeds 1759.2 kg fed^{-1}.) followed by treatment B (pods 5555.9 kg fed^{-1}., seeds 1689.8 kg fed^{-1}.) and the treatment A (pods 5015.4 kg fed^{-1}., seeds 1266.9 kg fed^{-1}.) respectively. **Crop model validation for current climate**

The comparisons between observed data, which were collected from experiment trials the simulated area from the DSSAT model for pods and seeds faba bean yield (kg fed^{-1}.) for the four irrigation treatments are presented in Table (7).

Table 6. Effect of number of irrigations on yield, and yield components for faba bean.

Treatment	Biological yield kg fed^{-1}. 1st season	2nd season	Mean	Seed yield kg fed^{-1}. 1st season	2nd season	Mean	Straw yield kg fed^{-1}. 1st season	2nd season	Mean
A	5147.5	4883.3	5015.4	1317.5	1216.7	1266.9	3830.0	3666.7	3748.4
B	5569.0	5542.7	5555.9	1746.7	1632.9	1689.8	3812.3	3909.8	3861.1
C	5640.0	5619.5	5629.8	1813.3	1705.0	1759.2	3826.7	3914.5	3870.6
D	5800.0	5941.7	5870.9	1871.7	1815.8	1843.8	2928.3	4125.8	3527.1

Table 7. Effect of irrigation intervals on actual and estimated faba bean production.

Treatmens	Irrigation levels	Yield, kg fed^{-1}. Pods Predicted Mean of two seasons kg fed^{-1}	Measured Mean of two seasons kg fed^{-1}	Percenage of Predicted Mean of two seasons	Seed Predicted Mean of two seasons kg fed^{-1}	Measured Mean of two seasons kg fed^{-1}	Percenage of Predicted Mean of two seasons
Treatment A	Rainfall treatment	5038.4	5015.4	0.5	1271.5	1266.9	0.4
Treatment B	Given one irrigation	5595.9	5555.9	0.7	1698.8	1689.8	0.5
Treatment C	Given two irrigations	5649.8	5629.8	0.4	1771.2	1759.2	0.7
Treatment D	Given three irrigations	5903.9	5870.9	0.6	1854.8	1843.8	0.6
Averages		5547.00	5518.00		1649.08	1639.93	

Regarding pods and seed yield of faba bean, the predicted data of different treatments could be arranged in descending order as; D, C, B and A. Such findings were true for both observed and predicted data.

Percentage difference difference between the observed and predicted data is between 0.4 to 0.7%. This means that the CROPGRO-legume model validated to be used in North Nile Delta region. These results are in the same line with that obtained by El-Marsafawy *et al.* (2000). And Rinaldi *et al.* (2010) reported that the model was confirmed to be used.

Which visualed that such yield is decreased among treatments from D through A.Meaningfully, that to increase the faba yield of both pods and /or seeds should by irrigated based on treatment D(3irrigations following the sowing one and vise versa for treatment A.

3. Prediction of faba bean yield under climatic change (CC) conditions

Results of expected pods and seeds of faba bean showed that decreasing from treatment D through A are shown in Tables (8-11). presented show that treatmens from D to A gradually reduced the yield of pods and seeds faba beans. Therefore, faba bean should be irrigated as treatment D due to its highest yield compared with treatment A (rainfall treatment).

Negative impact of CC on pods and seeds yield of faba bean was evaluated by simulating different treatments (regarding the so-called different air temperatures) and irrigation intervals on simulated faba bean production with CC scenario (A_1) by the years 2025, 2050, 2075 and 2100 in comparison with the arange of the two season 2013/2014 and 2014/2015. Results of faba bean yield differed according to irrigation intervals and CC scenario. The difference between current yield (average of two seasons 2013/2014 and 2014/2015) and the predicted values under CC was decreased gradually from -12.43 to -26.11% for pods and from -9.32 to -23.16% for seeds under no adaptation conditions in the years 2025 to 2100. The stated values are obtained without adptation strategies.

Table 8. Effect of irrigation intervals on actual and estimated production of faba bean under futuristic CC conditions, year 2025, with and no adaptation in comparison with predicted yield.

		Yield									
		Pods					Seeds				
Treatmens	Irrigation levels	Predicted Mean of two seasons (kg fed^{-1})	Without adaptation 2025 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	With adaptation* 2025 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	Predicted Mean of two seasons (kg fed^{-1})	Without adaptation 2025 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	With adaptation 2025 (kg fed^{-1})	Percenage of Predicted Mean of two seasons
Treatment A	Rainfall treatment	5038.4	4277	-15.11%	4579	-9.12%	1271.5	1117	-12.13%	1168	-8.14%
Treatment B	Given one irrigation	5595.9	4801	-14.21%	5136	-8.22%	1698.8	1508	-11.23%	1576	-7.21%
Treatment C	Given two irrigations	5649.8	4897	-13.33%	5236	-7.32%	1771.2	1586	-10.46%	1657	-6.45%
Treatment D	Given three irrigations	5903.9	5170	-12.43%	5530	-6.34%	1854.8	1682	-9.32%	1754	-5.41%
Averages		5547	4786		5120		1649.08	1473		1539	

*** Change in planting date +30 days from normal date.**

Table 9. Effect of irrigation intervals and planting date on actual and estimated production of faba bean under futuristic CC conditions, year 2050, with and without adaptation compared to predicted yield.

		Yield									
		Pods					Seeds				
Treatmens	Irrigation levels	Predicted Mean of two seasons (kg fed^{-1})	Without adaptation 2050 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	With adaptation* 2050 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	Predicted Mean of two seasons (kg fed^{-1})	Without adaptation 2050 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	With adaptation 2050 (kg fed^{-1})	Percenage of Predicted Mean of two seasons
Treatment A	Rainfall treatment	5038.4	4171	-17.21%	4472	-11.25%	1271.5	1090	-14.25%	1153	-9.31%
Treatment B	Given one irrigation	5595.9	4694	-16.12%	5026	-10.18%	1698.8	1474	-13.21%	1559	-8.25%
Treatment C	Given two irrigations	5649.8	4790	-15.21%	5129	-9.22%	1771.2	1555	-12.21%	1641	-7.33%
Treatment D	Given three irrigations	5903.9	5068	-14.15%	5425	-8.11%	1854.8	1648	-11.16%	1740	-6.21%
Averages		5547	4681		5013		1649	1442		1523	

*** Change in planting date +30 days from normal date.**

Expected increasing temperature will resulted in decreasing crop yield. In order to reduce the negative impact of CC on faba bean crop productivity, different irrigation intervals were tested and evaluated.

In general, the obtained results confirmed that reported by Saleh *et al.* (2012) stated that expected increasing in temperature will be between 1.9 and 2.5ºC in years 2025 to 2100 under no adaptation strategy, decreasing of pods yield will be ranged between -11.4 and -25.1%, while it will be -8.3 and -22.2% for seeds in the abovementioned years 2025 through 2100.

4. Minimizing the negative impact of CC on decreasing faba bean yield:

Tables (8-11) showed the predicted yield in the years of 2025, 2050, 2075 and 2100, compared to the predicted yield under the current conditions of

2013/2014 and 2014/2015 seasons. In order to reduce the reverse effect of CC minimize should be planting date was delayed one month from current planting date. These results emphasized that the faba bean yield could be enchanced under adptation strategy by delaying sowing data with one month compared with that executed under no adeptation. Meaningfully, that under CC conditions, values of pods yield with adptation strategy will be -6.34 to -20.11% compared with -12.43 to -26.11% under without adptation. The corresponding percentages regarding seed yield are -5.41 to -16.26% compared with -9.32 to -23.16%. The average of the abovementioned values for the years 2025, 2050, 2075 and 2100.

Table 10. Effect of watering periods and planting date on actual and estimated production of faba bean under futuristic CC conditions, year 2075, with and without adaptation in comparison with predicted yield.

Treatmens	Irrigation levels	Yield									
		Pods					Seeds				
		Predicted Mean of two seasons (kg fed^{-1})	Without adaptation 2075 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	With adaptation* 2075 (kg fed-1)	Percenage of Predicted Mean of two seasons	Predicted Mean of two seasons (kg fed^{-1})	Without adaptation 2075 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	With adaptation 2075 (kg fed^{-1})	Percenage of Predicted Mean of two seasons
Treatment A	Rainfall treatment	5038.4	3964	-21.32%	4266	-15.34%	1271.5	1039	-18.32%	1114	-12.42%
Treatment B	Given one irrigation	5595.9	4464	-20.23%	4798	-14.26%	1698.8	1405	-17.27%	1507	-11.31%
Treatment C	Given two irrigations	5649.8	4566	-19.19%	4909	-13.11%	1771.2	1486	-16.13%	1590	-10.23%
Treatment D	Given three irrigations	5903.9	4832	-18.15%	5185	-12.18%	1854.8	1572	-15.25%	1681	-9.35%
Averages		5547	4457		4789		1649	1375		1473	

*** Change in planting date +30 days from normal date.**

Table 11. Effect of irrigation intervals and planting date on actual and estimated production of faba bean under futuristic CC conditions, year 2100, with and without adaptation compared to predicted yield.

Treatmens	Irrigation levels	Yield									
		Pods					Seeds				
		Predicted Mean of two seasons (kg fed^{-1})	Without adaptation 2100 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	With adaptation* 2100 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	Predicted Mean of two seasons (kg fed^{-1})	Without adaptation 2100 (kg fed^{-1})	Percenage of Predicted Mean of two seasons	With adaptation 2100 (kg fed^{-1})	Percenage of Predicted Mean of two seasons
Treatment A	Rainfall treatment	5038.4	3672	-26.11%	4022	-20.11%	1271.5	977	-23.16%	1065	-16.26%
Treatment B	Given one irrigation	5595.9	4179	-25.32%	4513	-19.32%	1698.8	1321	-22.23%	1438	-15.33%
Treatment C	Given two irrigations	5649.8	4285	-24.15%	4623	-18.15%	1771.2	1397	-21.11%	1520	-14.19%
Treatment D	Given three irrigations	5903.9	4538	-23.14%	4893	-17.14%	1854.8	1481	-20.16%	1609	-13.26%
Averages		5547	4169		4513		1649	1294		1408	

*** Change in planting date +30 days from normal date.**

Adaptation of faba bean would do little to counterbalance the negative impact of high temperature as pronounced in the simulations. Current Egyptian faba bean production is restricted to cultivars that need a period of cold weather for seed initiation. The only viable strategy to reduce yield losses is change in planting date, to enchance the storage of carbohydrates and to give sufficient time for leaf area development. Such results are in harmony with that obtained by Saleh *et al*., (2012) indicated that the negative impact of climate change was decreased under adaptation strategy, decreasing of pods yield will be range between -3.2 and -14.2%, while it be -4.4 and -13.4% for seeds in the abovementioned years 2025 through 2100.

CONCLUSION

Results of using the simulation model CROPGRO – Legume under the umberella of (DSSAT) program regarding the effect of Cimatic change on faba bean productivity in North Nile Delta revealed that:

- The predicted (P) output data from the model is very closed to the measured (M) findings obtained from the experiments with only 0.4 – 0.7% difference between M and P.
- There is a negative impact of the expected increasing in temperature which resulting in decreasing faba bean yield in years; 2025, 2050,2075 and 2100 in comparsion with the current agerage yield of 2013/2014 and 2014/2015.
- Such decreasing in faba bean yield could be minizing by adaptation scenario with delaying sowing date with a month. The reduction was in average with 19.27% for pods and 16.24% for seeds under no adaptation while the corresponding percentages under adaptation were 13.23 and 10.84 %, respectively.

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تأثير التغيرات المناخية على محصول الفول البلدي فى شمال دلتا النيل

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تهدف هذه الدراسة إلى تقييم مدى حساسية محصول الفول البلدى لإرتفاع درجة حرارة الهواء المتوقعة تحت ظروف التغيرات المناخية المستقبلية ومدى تأثيرها على إنتاجية محصول الفول البلدى تحت الظروف المناخية لجمهورية مصر العربية. وقد أجريت هذه الدراسة على خطوات متتابعة، حيث تم قياس بعض صفات النمو الخضري والمحصولى للفول البلدى عن طرق إجراء التجربة الحقلية بشمال دلتا النيل فى منطقة سخا – محافظة كفر الشيخ في العروة الشتوية موسمي (٢٠١٣/٢٠١٤ ، ٢٠١٤/٢٠١٥) ، وشملت التجربة أربع معاملات لمواعيد الري. وتم إستخدام النتائج المتحصل عليها من التجربة الحقلية فى التأكد (التحقق) من مصداقية البرنامج المستخدم (CROPGRO-legume model)، ثم بعد ذلك تم دراسة أثر إرتفاع درجة حرارة الهواء تحت الظروف المناخية المستقبلية المتوقعة على إنتاجية محصول الفول البلدى باستخدام نظم المحاكاه الزراعية، حيث تم إستخدام برنامج دعم إتخاذ القرار الزراعي (DSSAT) فى هذه الدراسة، ومن خلال هذا البرنامج تم دراسة بعض خيارات الأقلمة للتخفيف من الآثار الضارة لإرتفاع درجات الحرارة على محصول الفول البلدى خلال العروة الشتوية. وقد تبين من خلال الدراسة وجود علاقة بين النمو والمحصول فى الفول البلدى ومواعيد الري المختلفة، وكذا درجة الحرارة السائدة أثناء الليل والنهار حيث أن إرتفاع أو إنخفاض درجة الحرارة عن المجال الحراري الأمثل لنمو محصول الفول البلدى يؤدي إلى نقص فى النمو والمحصول، وكذلك أظهرت نتائج أستخدام نظم المحاكاة الزراعية، وجود إختلاف غير معنوي بين النتائج الحقيقية والمتوقعة من برنامج الـ DSSAT، حيث وصلت من٠.٤ إلى ٠.٧ % وتم التنبؤ بحدوث تأثير سلبي لإرتفاع درجات الحرارة تحت ظروف التغيرات المناخية المستقبلية المتوقعة لسنوات (٢٠٢٥، ٢٠٥٠، ٢٠٧٥، ٢١٠٠) مما أدي إلى حدوث إنخفاض فى محصول الفول البلدى بالمقارنة بمتوسط موسمى (٢٠١٣-٢٠١٤ ، ٢٠١٤-٢٠١٥) كما أنه يمكن خفض هذا التأثير السلبي عن طريق تغيير ميعاد الزراعة، حيث بلغت نسبة الإنخفاض في الإنتاج بدون أقلمة من (-١٢.٤٣-٢٦.١١% بالنسبة القرون ومن -٩.٣٢- ٢٣.١٦% بالنسبة للبذور)، ومع الأقلمة بلغت هذه النسبة من (-٦.٣٤-٢٠.١١% للقرون ومن -٥.٤١-١٦.٢٦% للبذور). هذا ويتطلب الأمر المزيد من الدراسات حول بعض خيارات تخفيف الأثر الضار لإرتفاع درجات الحرارة تحت ظروف التغيرات المناخية، مثل إيجاد أصناف جديدة تتحمل ظروف إرتفاع درجات الحرارة، كما يمكن تغيير معدلات الري، ومعدلات التسميد، تغيير أماكن الزراعة، .... وغيرها، وذلك للتخفيف من حدة أثر التغيرات المناخية على محصول الفول البلدي بصفة خاصة والمحاصيل الحقلية بصفة عامة.