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Prediction of some Faba-Bean Foliar Diseases and their Relationship with Climate Change, under Environmental Egyptian Conditions

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Faba-bean (*Vicia faba* L.) is one of the most important legume crops cultivated in Egypt. It is liable to attack by many foliar diseases that cause severe losses in yield and quality in the crop under Egyptian conditions.The present study was carried throughout 2000 to 2011 growing seasons at three governorates (Bani-Sweif, Behera and Gharbia), on four foliar diseases (brown spot , rust , Bean Yellow Moscia virus and Leaf Curl Virus) to study the relation between climate change and disease severity for prediction of foliar diseases in future seasons. Influence of climate change on severity of faba-bean foliar diseases during growing seasons from 2000 to 2011, the highest value of diseases were recorded with the rust diseases at Bani-Sweif governorate and brown spot disease at Behera and Gharbia governorates. Forecasting of severity of diseases during growing seasons 2050s and 2100s compared with 2000s seasons in tested governorates were considerable differences of severity of brown spot during growing seasons 2050s and 2100s compared with 2000s and no considerable differences severity of rust disease and virus diseases during growing seasons 2050s and 2100s compared with seasons 2000s.

Keywords: Brown spot, climate change, Faba-bean, foliar diseases, Forecasting and Virus diseases.

Faba bean attacks by various foliar diseases which considered the limiting factor for its production in Egypt. Chocolate spot (*Botrytis fabe*), rust (*Uromycesvicia-faba*) and Alternaria (*Alternaria alternaria)* and Stemphylium (*Stemphylium botryosum)* leaf spots as well as virus diseases (Bean Yellow Moscia virus and Leaf Roll Virus). These diseases can cause great yield losses and even wipe out crop (Youssef, 2004).

Climate factors that influence the growth, spread and survival of crop diseases including temperature, precipitation humidity, dew, radiation, wind speed, circulation patterns and the occurrence of extreme events. Higher temperature and humidity and greater precipitation result in the spread of plant diseases, as wet vegetation promotes the germination of spores and the proliferation of fungi and bacteria and influence the life cycle of soil nematodes (Rosenzweig *et al*., 2000).Environmental condition is complex term that includes many factors, which must be behind a minimum threshold for disease to occur. A change in one environmental factor may alter the effect of other environmental factors on diseases development (Abdel-Hak *et al.,* 1966).The relationship between weather and plant disease are routinely used for forecasting and managing epidemics and disease severity over a number of years can fluctuate according to climatic variation (Scherm and Yang, 1995).There was positive relation between development and severity of rust diseases and location, date or mean temperatures, at eight governorates, during growing seasons 2005s, under Egyptian conditions. There was not developed for severity of leaf rust disease, during growing seasons 2050s compared with growing seasons 2005s. Meanwhile, severity of stripe rust disease was predicted to decrease during growing seasons 2050s (Abolmaaty, 2006). The present work aims to study the influence of climate change on severity of faba-bean foliar diseases and prediction of foliar diseases under future condition.

Materials and Methodos

Influence of climate change on faba-bean foliar diseases:

This study was carried out in faba bean fields at two governorates in Lower Egypt (Behira and Gharbia) and one governorate in Upper Egypt (Bani-Sweif). Meteorological data were recorded through the growing seasons from December 2000 to April 2001. These data were obtained from the Central laboratory for Agricultural Climate (CLAC). The data consist of average temperature (daily maximum and minimum temperature) and relative humidity (daily maximum and minimum RH %). The diseases severity was estimated as percentage of infected fields. The data of disease severity were obtained from Ministry of Agriculture, Administration intensive pest control, (unpublished data). The effect of each factor separately was obtained by applying simple regression coefficients (Abolmaaty, 2006).

Relationship between climate change in future seasons and faba-bean foliar diseases:

This study was carried out to severity of foliar diseases in expected future climate change 2050s and 2100s. Climate change scenarios for locations were assessed according to future conditions derived from MAGICC/SCENGEN software of the University of East Angle (UK). In this study one scenario of climate data was used A1 (Table, 1). The principal of MAGICC/SCENGEN data were used to explore the consequences of a medium is allowing the user to explore the consequences of a medium range of future emission scenarios. The user selects two such scenarios from library of possibilities. The reason for two scenarios is to able to compare a no action scenario with an action or policy scenario. Thus, in MAGICC/ SCENGEN the two emissions scenarios were referred to as a reference scenario and policy scenario (Wigley *et al*., 2000). The data which generated from MAGICC/ SCENGEN are represented in one scenario A1. These scenarios are described by IPCC(2001) as "The A1 scenario describes a future world of very rapid economic growth, global population that peaks in mid-century, declines thereafter, the rapid introduction of new and more efficient technologies (Meehl *et al*.,2007**)**. Severity of both diseases from 2050s to 2100s years were estimated using disease severity of chocolate spot (*Botrytis fabae*), rust (*Uromycesvicia-faba*), Alternaria leaf spot (*Alternaria alternaria*) and Stemphylium leaf spot (*Stemphylium botryosum*)as well as virus diseases (Bean Yellow Mosaic Virus and Leaf Roll Virus) from 2000 to 2011 season and using the programs Statistical for windows and MINITAB® program, where the climate data in the future (2050s - 2100s) according to Abolmaaty (2006).

Table1. Simple model results of the climate change versus the current level of climate. Global mean temperature change for the illustrative SRES scenarios (A1)

Month	2025	2050	2075	2100
A1				
Jan.	1.1	1.9	2.5	2.8
Feb.	1.1	1.9	2.5	2.9
Mar.	1.0	1.8	2.4	2.7
Apr.	1.0	1.7	2.2	2.6
May.	1.0	1.8	2.3	2.7
Jun.	1.3	2.3	3.0	3.5
Jul.	1.5	2.6	3.4	3.9
Aug.	1.2	2.1	2.7	3.1
Sep.	1.5	2.6	3.3	3.8
Oct.	1.3	2.3	3.0	3.4
Nov.	1.0	1.8	2.3	2.7
Dec.	1.0	1.8	2.4	2.7

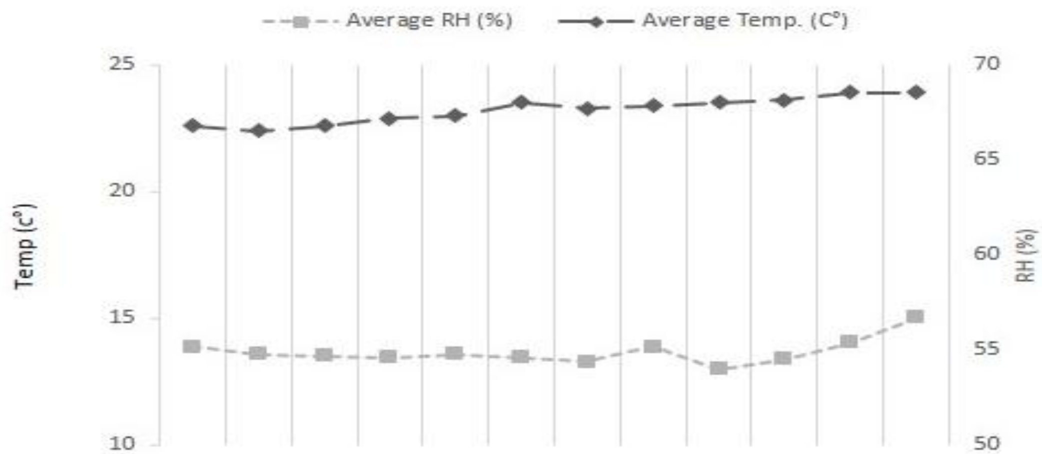
Results and Discussion

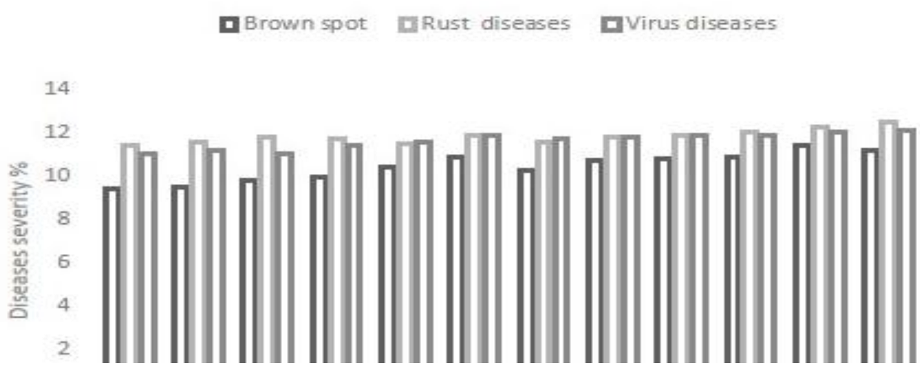
1. Influence of climate change on faba-bean foliar diseases:

The aim of the present experiments is to study influence of climate change on severity of foliar diseases infecting faba-bean during 2000 to 2011 growing seasons at Behera, Gharbia and Beni-Swief governorates, under environmental Egyptian conditions.

1.1.**Bani-Swief:**Data in (Fig. 1) show that several fields of faba-bean, in Bani-Sweif governorate were severity incidence of foliar diseases from 2000 to 2011 seasons. The results reveal that mean severity of brown spot, rust and virus diseases were 10.5, 11.7 and 11.9%, respectively. The highest value of prevalence of diseases was recorded for rust disease was 11.9%, where the mean temperature recorded 23.2°C and the mean percentage of relative humidity recorded 54.8%. Statistical analysis for the effects of mean temperature and relative humidity on faba bean foliar diseases, during 2000 to 2011growing seasons at Bani-Sweif governorate are shown in Table (2). The results also show that the mean temperature had high significant positive effect whereas, "r" value were 0.87, 0.88 and 0.87 on the severity of brown spot, rust and virus diseases, respectively. While, the mean percentage of relative humidity had insignificant negative effects whereas, "r" value were -0.42, -0.31 and -0.46 on the severity of brown spot, rust and virus diseases, respectively. The percentages of explained variances (E.V) for the selected ecological factors at seasons were 76, 79 and 76% on the severity of brown spot, rust and virus diseases, respectively. "F" values were 14.62**, 17.24*** and 14.50**, respectively.

1.2.**Behera:**Data shown in Fig. (2) show that several fields of faba-bean, at Behera governorate were severity incidence of foliar diseases during seasons from 2000 to 2011. The results revealed that mean prevalence value of brown spot, rust and virus diseases were 32.1, 14.1 and 18.4%, respectively. The highest value of prevalence of diseases was for brown spot (32.1%). Whereas the mean temperature was 20.7 °C and the mean percentage of relative humidity was 60.8%.Statistical analysis for the effects of mean temperature and relative humidity on faba-bean foliar diseases, during 2000 to 2011 growing seasons at Behera governorate are shown in Table (3).The results show that the mean temperature had highly significant positive effect whereas "r" value were 0.84, 0.72 and 0.87on severity of brown spot, rust and virus diseases, from 2000 to 2011 growing seasons, respectively. While the mean percentage of relative humidity had insignificant negative effects whereas, "r" value were -0.54, -0.17 and -0.46on the severity of brown spot, rust and virus diseases, during seasons from 2000 to 2011, respectively. The percentages of explained variances (E.V.) for the selected ecological factors at seasons were 71, 69% and 76%on the severity of brown spot, rust and virus diseases, during 2000 to 2011growing seasons, respectively. "F" values were 3.23*, 17.24*** and 14.50**,





respectively.

Fig.1. Relationship between climatic changes and severity of faba-bean foliar diseases, from 2000 to 2011 seasons at Bani-Sweif governorate under field conditions.

Table 2. Simple correlation and partial regression values of the climatic changes and severity of some diseases corresponding percentage of explained variance in faba-bean plant fields at Beni-Sweif governorate, from 2000 - 2011 seasons

Seasons from 2000 to 2011						
Brown spot	Simple		Partial			%
Testedfactors	Correlation		Regression			
	r	P	b	S.E.	P	E .V.
Avg.Temp. °C	0.87	0.0002	1.4709	0.31059	0.0011	76%
Avg. RH %	-0.42	0.172	0.0057	0.17243	0.9741	
F= 14.62**						
Rust disease	Simple		Partial			%
Testedfactors	Correlation		Regression			
	r	P	b	S.E.	P	E .V.
Avg.Temp. °C	0.88	0.0002	1.53719	0.27985	0.0004	79%
Avg. RH %	-0.31475	0.319	0.13485	0.15537	0.408	
F= 17.24***						
Virus diseases	Simple		Partial			%
Testedfactors	Correlation		Regression			
	r	P	b	S.E.	P	E .V.
Avg.Temp. °C	0.87265	0.0002	1.00306	0.21925	0.0013	76%
Avg. RH %	-0.4607	0.1317	-0.03007	0.12172	0.8104	
F= 14.50**						

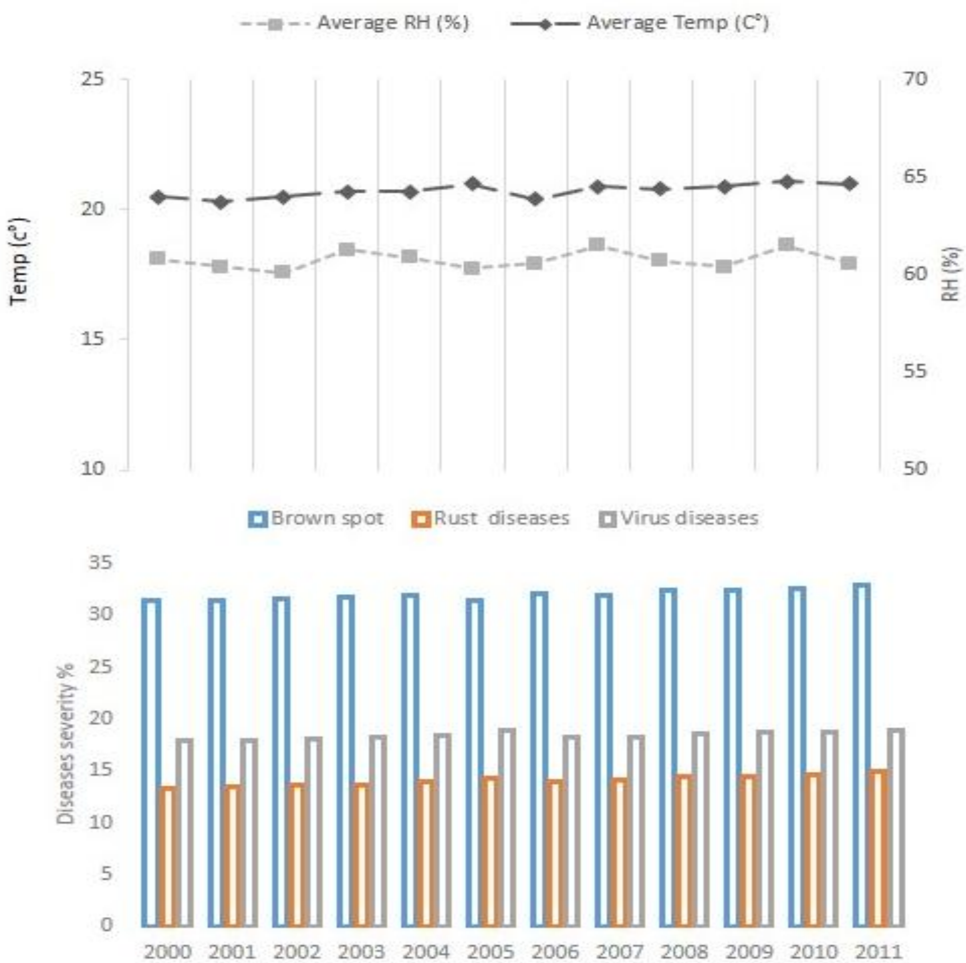


Fig.2. Relationship between of climatic changes and severity of faba bean foliar diseases, during growing seasons from 2000 to 2011, at Behera Governorate, under filed conditions.

Table 3. Simple correlation and partial regression values of the climatic changes and severity of some diseases corresponding percentage of explained variance of faba-bean plant, at Behera governorate, from 2000 to 2011 seasons

Seasons from 2000 to 2011						
Brown spot	Simple Correlation		Partial Regression			%
Tested factors	r	P	b	S.E.	P	E .V.
Avg. Temp. °C	0.87	0.0002	1.4709	0.31059	0.0011	67 %
Avg.RH %	-0.42	0.172	0.0057	0.17243	0.9741	
F= 14.62**						
Rust disease	Simple Correlation		Partial Regression			%
Tested factors	r	P	b	S.E.	P	E .V.
Avg. Temp. °C	0.88	0.0002	1.53719	0.27985	0.0004	79 %
Avg. RH %	-0.31475	0.319	0.13485	0.15537	0.408	
F= 17.24***						
Virus diseases	Simple Correlation		Partial Regression			%
Tested factors	r	P	b	S.E.	P	E .V.
Avg.Temp. °C	0.87265	0.0002	1.00306	0.21925	0.0013	76 %
Avg.RH %	-0.4607	0.1317	-0.03007	0.12172	0.8104	
F= 14.50**						

1.3.**Gharbia:** Data in (Fig. 3) show that several fields of faba bean, at Gharbia governorate were severity incidence of foliar diseases from 2000 to 2011 growing seasons. The results revealed that mean prevalence value of brown spot, rust and virus diseases were 28.2, 13.1 and 16.3 % during seasons 2000-2011, respectively. The highest value of prevalence of these diseases was for brown spot disease were (28.2%) it during seasons 2000-2011. Whereas the mean temperature recorded 20.9°C and the mean percentage of relative humidity recorded 60.7%.

Statistical analysis for the effect of mean temperature and relative humidity on faba bean foliar diseases, during 2000 to 2011 growing seasons at Gharbia governorate is shown in Table (4). The results also show that the mean temperaturehad highlysignificant positive effect where, "r" value was 0.84, 0.72 and 0.86 on severity of brown spot, rust and virus diseases, during 2000 to 2011 growing seasons, respectively.

Fig.3. Relationship between of climatic changes and severity of faba bean foliar diseases, during 2000 to 2011 growing seasons at Gharbia governorate, under field conditions.

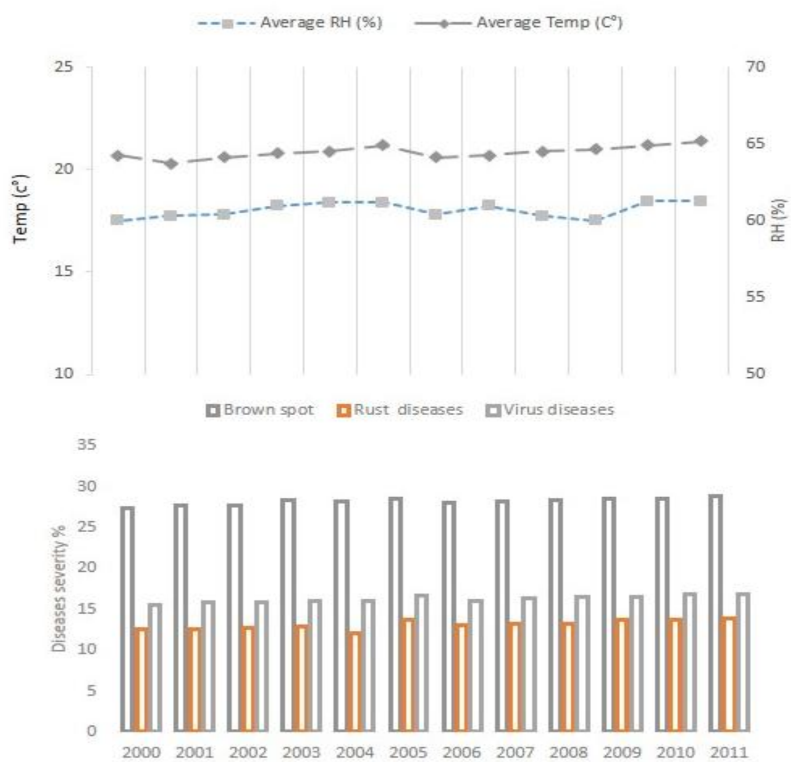


Table 4. Simple correlation and partial regression values of the climatic changes and severity of some diseases corresponding percentage of explain*e*d variance faba bean plant, at Gharbia governorate, during from 2000 to 2011 seasons

Brown spot	Simple		Partial			%
Tested Factors	Correlation		Regression			
	r	P	b	S.E.	P	E .V.
Avg. Temp. °C	0.84	0.0006	1.12	0.31	0.0059	71%
Avg. RH %	-0.54	0.0664	0.03	0.19	0.8506	
F= 11.05**						
Rust disease	**Simple**		**Partial**			**%**
TestedFactors	Correlation		Regression			
	r	P	b	S.E.	P	E .V.
Avg. Temp. °C	0.72	0.007	1.15	0.54	0.0617	54%
Avg. RH %	-0.56	0.05	-0.21	0.33	0.5376	
F= 5.35*						
Virus diseases	**Simple**		**Partial**			**%**
Testedfactors	Correlation		Regression			
	r	P	b	S.E.	P	E .V.
Avg. Temp. °C	0.86	0.0003	1.27	0.29	0.0021	75%
Avg. RH %	-0.49	0.1091	0.06	0.17	0.7434	
F= 13.25**						

While the mean percentage of relative humidity had insignificant negative effect where, "r" value were -0.54, -0.56 and -0.49 on severity of brown spot, rust and both virus diseases, during 2000 to 2011 growing seasons, respectively. The percentages of explained variances (E.V.) for the selected ecological factors at these seasons were 71, 54 and 75% on severity of brown spot, rust and both virus diseases, respectively. “F” values were 11.05**, 5.35* and 13.25**, respectively.

Climate change can have positive, negative or neutral impact on individual patho systems because of the specific nature of the interaction of host and pathogen. Also, climate change can influence the geographical and growth of plant species around the world (Coakley *et al.*, 1999). Nicholls (1997) analyzed historical trends in Australian wheat yield and found that recent climate changes are responsible for as much as 30 to 50% of the variation explained by an increase in minimum temperature. In New Zealand (Presidge and Pottinger, 1990) concluded that disease problems in the kiwifruit and pome fruit industries would probably amplified by increases in temperature and precipitation. In contrast, the impact on the vegetable industry should be minimal because this industry is annual and intensive in nature and management changes required to mitigate climate change impacts may be mode more easily. A climate change has the potential to modify host physiology and resistance and to modify host and resistance and to alter stages and rates of development of the pathogen. The most likely impact could be shift in the geographical of the host and the pathogen, which may be could changes in the physiology of host-pathogen interactions and changes in crop loss. Change may occur in the type, amount and relative importance of pathogens and affect the spectrum of diseases affecting a particular crop. This would be more pronounced for pathogens with alternate hosts (Coakley *et al*., 1999). Increase in temperature can modify host physiological and resistance arise in temperature above 20^{o}C can inactivate temperature – sensitive resistance to stem rust in oat cultivars with Pg3 and Pg4 genes (Martens *et al*., 1967). In contrast, lignifications of cell walls increased in forage species at higher temperatures (Wilson *et al*., 1991) to enhance resistance to fungal pathogens (Strange, 1993). The disease may develop if plants are stressed in a warmer climate. High temperatures may increase the damage caused by the disease such as scleroderris canker lodge pole pine. Karlman *et al*. (1994) and Lonsdale and Gibbs (1996)suggest that severe weather events are making an important contribution to the emergence of plant diseases in new locations. There is a greater likelihood that invasive disease can become established as climate change can also allow some plants and pathogens to survive outside their historic ranges (Harvell *et al*., 2002).

Prediction of faba-bean foliar diseases in future seasons:

This study was carried out to figure out the influence of climate change on severity of brown spot, rust and two virus diseases of faba-bean, during 2050s and 2100s growing seasons, at three governorates, under Egyptian condition, using the multiple equation regression analysis (MINITAB®).The severity of the studied disease on faba bean has been predicted by regression estimated diseases severity versus the accumulative diseases severity values during 2000 to 2011 growing season and average temperature and humidity during the these seasons. Prediction of diseases has been formed as $Y= b_0+b_1x_1+b_2x_2+..........\ b_qx_q$(Fahim, 2002). Nine models were created to describe the severity disease by multiple regressions (MINITAB® program, 1995). Regression between diseases severity values at during growing season from 2000 to 2011 and average temperature and humidity during the seasons resulted in the following relationship:

(1) Bani-Sweif:

1.1. Brown spot $y = 1.2 + 1.47\ X_1 + 0.006\ X_2$ $R^2 = 76.50\%$

1.2. Rust $y = -26.0 + 1.54\ X_1 + 0.135\ X_2$ $R^2 = 79.30\%$

1.3. Virus diseases $y = -0.6 + 1.00\ X_1 - 0.030\ X_2$ $R^2 = 76.30\%$

(2) Behera:

2.1. Brown spot $y = 12.0 + 1.23\ X_1 - 0.090\ X_2$ $R^2 = 76.30\%$

2.2. Rust $y = -18.6 + 1.55\ X_1 + 0.009\ X_2$ $R^2 = 69.40\%$

2.3. Virus diseases $y = -5.8 + 1.17\ X_1 - 0.001\ X_2$ $R^2 = 74.20\%$

(3) Gharbia:

3.1. Brown spot $y = 7.0 + 1.13\ X_1 - 0.037\ X_2$ $R^2 = 71.10\%$

3.2. Rust $y = 1.7 + 1.16\ X_1 - 0.210\ X_2$ $R^2 = 58.30\%$

3.3. Virus diseases $y = -13.8 + 1.27\ X_1 + 0.061\ X_2$ $R^2 = 74.60\%$

Where:
Y= prediction of disease severity,
$X_{1=}$average temperature (°C), and
$X_{2=}$average humidity (%).

Model 1, 2, 3, 4, 5, 6, 7, 8 and 9 could Lower Egypt and Upper Egypt, respectively. Formal tests have been used to evaluate statistical assumption. The coefficient of determination R^2 were ranged 58.30-79.30. Climate change scenarios for Bani-Swief, Behera and Gharbia Governorates were assessed according to future conditions derived from MAGICC/SCENGEN Software of the University of East Angle (UK) (Meehl *et al*., 2007)and these relation with severity of Brown spot, rust and virus diseases of faba-bean.

From data presented in Fig (4) show that severity of brown spot, rust and both virus diseases of faba-bean, during 2050s and 2100s growing season in tested governorates were studied. In case of brown spot, high changes in severity of the disease was expected during 2050s and 2100s growing seasons compared with growing seasons 2000s, where recorded diseases severity was 11.7% during 2000s season and was 28.31 and 30.79% during 2050s and 2100s seasons at Bani-Sweif governorate, respectively.

Also, in case of Brown spot disease, highest changes in severity of the diseases during growing season 2050s and 2100s compared with growing seasons 2000, where recorded diseases severity was 25% during 2000s season and was 32.39% and

34.77 during 2050s and 2100s seasons at Behera governorate, respectively. Slight changes in severity of the diseases during growing season 2050s and 2100s compared with growing seasons 2000s, where recorded diseases severity were 24.1% during 2000s season and was 25.41 and 23.42% during 2050s and 2100s seasons at Gharbia governorate, respectively. In case of rust disease slight changes in severity of the diseases during 2050s and 2100s growing season were expected compared with growing seasons 2000s, where recorded diseases severity was 11.3 during 2000s season and was 8.17% and 10.66% during 2050s and 2100s growing seasons at Bani-Sweif governorate, respectively. Highest changes in severity of the diseases during 2050s and 2100s growing season were expected compared with growing seasons 2000s, where recorded disease severity was 16.8% during 2000s season and was 6.78% and 9.39 during 2050s and 2100s seasons at Behera governorate, respectively. Also, slight changes in severity of the diseases during 2050s and 2100s growing season compared with growing seasons 2000s, where the recorded disease severity were 15.9% during 2000s season and was 16.59 and 12.74% during 2050s and 2100s seasons at Gharbia governorate, respectively. In case of virus diseases slight changes in severity of the diseases where recorded diseases severity was 18.7% during 2000s season and was 16.32 and 18.03% during 2050s and 2100s seasons at Bani-Sweif governorate, respectively. Also, highest changes in severity of the diseases during growing season 2050s and 2100s compared with growing seasons 2000s, where recorded diseases severity was 24% during 2000s season and was 13.62 and 15.6% during 2050s and 2100s seasons at Behera governorate, respectively. Highest changes in severity of the diseases during growing season 2050s and 2100s compared with growing seasons 2000s, where recorded diseases severity was 24.1% during 2000s season and was 25.41 and 23.42%during 2050s and 2100s seasons at Gharbia governorate, respectively. Hulme *et al*. (2002) predicate that temperature will rise by 0.5-1.5°C by the 2020s and by 2-4°C by the 2080s.Warning will be great in summer than in winter and there will be an increased frequency of very hot summers, partially by the 2080s. Total annual projected to fall by up to 10% and % by the 2020s and 2080s, respectively.

Climate change may have minor impact on diseases compared with the impact of crop management and genetic improvement (Kropff *et al.*, 1993). Paruelo and Sala (1994) stated in studies carried out on rice and Mize, respectively. Increase in temperature can modify host physiological and resistance arise in temperature above 20°C can inactivate temperature – sensitive resistance to stem rust. Harvell *et al*. (2002) suggested that severe weather events are making an important condition to the emergence of plant diseases in new location.

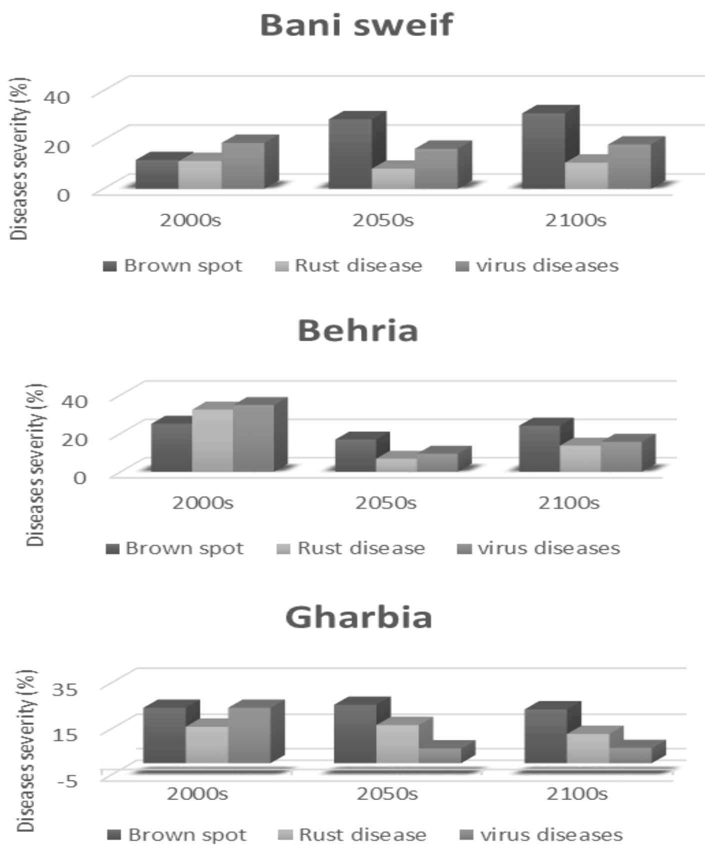


Fig.4. Forecasting of severity of brown spot, rust and both virus diseases of faba bean, under climate change in Egypt, from 2050s to 2100s growing seasons using estimated diseases severity in 2000s season, at different governorate.

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التنبؤ ببعض أمراض المجموع الخضرى فى الفول البلدى وعلاقتها بالتغيرات المناخيةتحت الظرف البيئية المصرية

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**المعمل المركز للمناخ الزراعى – مركز البحوث الزراعية – جيزة – مصر.*

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يعتبر الفول من أهم المحاصيل البقولية فى مصر . يهاجم الفول البلدى بالعديد من أمراض المجموع الخضرى خلال موسم النمو تحت الظروف المصرية مما يسبب اضراراً كبير ة للمحصول تضمنت هذه الدراسة دراسة تأثير التغيرات المناخية (حرارة – رطوبة نسبية) على شدة الإصابة بأهم أمراض المجموع الخضرى للفول خلال موسم النمو من 2000 حتى 2011 ودراسة العلاقة بين العوامل المناخية وشدة الإصابة أمكن حساب شدة الإصابة المرضية خلال موسمى الزراعة 2050 و 2100 من خلال معادلات احصائية بواسطة برنامج (MINITAB®) for window وبالتالى أمكن الاستفادة للتنبؤ بالأمراض التى تصيب نبات الفول تحت ظروف تغير المناخ مستقبلاً فى مصر .سجلت أعلى متوسط شدة إصابة بمحافظة بنى سويف كان لمرض الصدأ خلال مواسم النمو 2000 حتى 2011 و حيث متوسط درجة الحرارة خلال تلك المواسم 23.2ºC والرطوبة النسبية 54.8% وسجلت أعلى متوسط شدة إصابة لمرض التبقع البنى بمحافظتى البحيرة والغربية كان خلال مواسم النمو من 2000 حتى 2011 وكان متوسط درجة الحرارة 20.9°C, 20.8 ºC ومتوسط الرطوبة النسبية % 60.7, 60.8 % على التوالى.بالتحليل الاحصائى كان متوسط درجة الحرارة ذات تأثير معنوى موجب خلال مواسم النمو من 2000 حتى 2011 بينما كان تأثير متوسط الرطوبة النسبية غير معنوى سالب على شدة الإصابة فى المحافظات الثلاثة. وأمكن الاستفادة من دراسة العلاقة بين العوامل البيئية وشدة الإصابة بأمراض المجموع الخضرى لنباتات الفول خلال مواسم النمومن 2000 إلى 2011 باستخدام برنامج (MINITAB® program)لإيجاد العلاقة والتنبؤ بتطور وشدة الأمراض تحت الدراسة مستقبلاً فى ثلاثة محافظات مختلفة تحت الظروف المصرية . لوحظ اختلاف كبير بين شدة الإصابة بمرض التبقع البنى تحت الظروف المستقبلية (2050s - 2100s)والظروف الحالية لسنة 2000 بينما لا يوجد اختلاف كبير بين شدة الإصابة بمرض الصدأ والمرضين الفيروسين تحت الظروف المستقبلية والظروف الحالية.