EFFECT OF SOIL TYPE AND IRRIGATION SYSTEMS ON WHEAT YIELD LOSSES UNDER CLIMATE CHANGE: A REVIEW

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ABSTRACT

Soil type and irrigation systems could play an important role in determination of yield losses under climate change conditions. This concept is tackled in this review, in order to shed a light on the importance of developing a strategy to reduce climate change risk on wheat. In recent years, global climate change models were introduced in Egypt and have been used to develop climate change scenarios. They are the only tools that could provide detailed regional predictions of future climate change. Two scenarios (A2 and B2) were developed and used to predict the effect climate change on the yield of wheat. Wheat was grown in eight sits in Egypt. CropSyst model was calibrated and validated for wheat and the two climate change scenarios were incorporated in the model. The model was run and the effect of climate change was assessed. The results revealed that the yield of wheat will be reduced under climate change. The percentage of yield reduction depend upon the location of the experimental site, soil type and irrigation system. High yield losses could occur in the Middle of Egypt, compared with the North of Egypt. Furthermore, growing of these crops in sandy soil and under surface irrigation will increase yield losses. Therefore, the best way to adapt to some uncertain future climate is to improve adaptation to present day climate variability and reduce vulnerability to extreme events.

Key words: Adaptation strategy, global climate change models, climate change scenarios, CropSyst model.

INTRODUCTION

Understanding the potential impacts of climate change is very important in developing both adaptation strategies and actions to reduce climate change risks. A range of valuable national studies have been carried out and published. However, assessing the impact of climate change is a challenge for scientists and it needs collaboration of multidiscipline. Unfortunately, the limitation in the information regarding to past and future climate change and its impacts on crops reduce the ability of policy makers in Egypt to adjust their future plans to cope with the future.

For over the past 200 years, the burning of fossil fuels, such as coal and oil, in addition to deforestation has caused concentrations of heat-trapping "greenhouse gases" to increase significantly in our atmosphere. As the concentrations of these gases continue to increase in the atmosphere, the Earth's temperature is climbing above past levels affecting people, plants, and animals **(IPCC, 1996)**. The Earth has warmed by 0.7˚C on average since 1900. Most of the warming since 1950 is due to human activities that have increased greenhouse gases **(IPCC 2001)**. There has been an increase in heat waves, fewer frosts, warming of the lower atmosphere and upper ocean, retreat of glaciers and sea-ice, an average rise in global sea-level of approximately 17 cm and increased heavy rainfall in many regions **(IPCC, 2001 and Alexander *et al*. 2006)**. Many species of plants and animals have changed their location or behavior in ways that provide further evidence of global warming **(Hughes *et al*. 2003).**

In Egypt, several researchers have studied the effect of climate change on wheat grown in clay soil and under surface irrigation **(Eid, 1994; Eid *et al*., 1994a and b; Eid *et al*., 1996; Eid and Mowelhi, 1998 and Eid *et al*., 2002, Khalil *et al*., 2009).** However, wheat is also grown in other soil types and under sprinkler irrigation **(Ouda *et al*., 2010; Ouda *et al*., 2012a and b; and Taha 2012).** Therefore, soil type and irrigation systems could play an important role in determination of yield losses under climate change conditions. Furthermore, changing irrigation schedule or sowing date could play an important role in reducing climate change risks on growing crops and be used as an adaptation strategy. This concept is tackled in this review, in order to shed a light on the importance of developing an adaptation strategy to reduce climate change risk on wheat. The objective of this paper is to discuss the effect of soil type and irrigation system on reducing climate change risks on wheat productivity.

Climate change models

To estimate future climate change, scientists have developed greenhouse gas and aerosol emission scenarios for the 21st century. These are not predictions of what will actually happen. They allow analysis of "what if?" questions based on various assumptions about human behavior, economic growth and technological change **(Church and White 2006)**. Computer models of the climate system are the best tools available for simulating climate variability and change. These models called General Circulation Models (GCMs). These types of GCM are a mathematical representation of the general circulation of a planetary atmosphere (AGCM) or the ocean (OGCM) and it was used to develop climate change scenarios. As it was stated by **IPCC (1996)**, the output of GCM was not generally of a sufficient resolution or reliability to estimate regional climate even for present-day. To solve this problem and to develop climate change scenarios, baseline observational data was used to represent the present day climate, and then adjusted to represent the $2XCO_2$ climates. These obtained values, then, added to the current weather file to develop climate change scenario. These types of models are generally susceptible to simple analysis and their results are generally easy to understand, which endure less accuracy **(Charlston, *et al*., 1991).**

Since 1992, Atmospheric General Circulation Models (AGCMs) have been introduced in Egypt to develop climate change scenarios **(Eid, and Salh 1992; Eid *et al.*, 1992a, b; Eid *et al.*, 1994a and b; Eid, 1994; Eid *et al.*, 1994a; Eid *et al.*, 1994b; Eid and Sergany, 1993; Eid *et al*., 1996; Eid *et al*., 1997a and b; Eid and Mowelhi, 1998 Eid *et al.*, 2002 and Hassanein and Medany 2007).**

Atmospheric and Oceanic GCMs (AGCM and OGCM) are key components of Global Climate Models along with sea-ice and land-surface components. These models include representations of the atmosphere, oceans, biosphere and Polar Regions **(Vinnikov *et al.* 2006)**. Confidence in the reliability of these models for climate projections has also improved **(IPCC 2001),** based on tests of the ability to simulate the present average climate, including the annual cycle of seasonal changes, year-to-year variability, extreme events, such as storms and heat waves, climates from thousands of years ago, and observed climate trends in the recent past. Atmospheric and Oceanic General Circulation Models (AOGCMs) represent the pinnacle of complexity in climate models and internalize as many processes as possible. They are the only tools that could provide detailed regional predictions of future climate change.

An example of these models is HadCM3 model. The HadCM3 developed at the Hadley Centre for Climate Prediction and Research, United Kingdom **(Gordon *et al.*, 2000 and Pope *et al*., 2000)** and considered as significantly and more sophisticated than earlier versions **(Hulme *et al*., 1998).** This model has a spatial resolution of 2.50 X 3.75 (latitude by longitude). HadCM3 provide information about climate change over the entire world during the 21st century and present information about three times slices: 2020s, 2050s, and 2080s.

Climate change scenarios

Scenarios A2 and B2 were used the most and have received the most scientific peer review. Because their output data are widely available, these two were adopted for use in this review. The A2 Climate change scenario storyline depicts a world of regional self-reliance and preservation of local culture. In A2, fertility patterns across regions converge slowly, leading to a steadily increasing population and per capita economic growth and technological change is slower and more fragmented than for the other storylines. The B2 storyline places emphasis on local solutions to economic, social and environmental sustainability. The population increases more slowly than that in A2. The economic development is intermediate and less rapid, and technological change is more diverse **(Hennessy 2006).**

Regarding HadCM3 climate model, A2 and B2 climate change scenarios consider a rise in global annual mean temperature by 3.1 and 2.2°C, respectively, CO_2 concentration 834 and 601 ppmv, respectively and global mean sea level rise 62 and 52 cm, respectively. As the resolution of the model is too big, using simple interpolation techniques of these percentages have been applied to fit the station site. HadCM3 climate variables are monthly precipitation, solar radiation, minimum and maximum temperatures. This model was used to develop climate change scenarios for all the experimental data used in this review.

Use of crop simulation models

Crop simulation models can be used to assess the likely impact of climate change on grain yield and yield variability. These crop models must accurately predict several key characteristics over a wide range of climatic conditions, such as timing of flowering and physiological maturity, through correct descriptions of phenological responses to temperature and day length. Furthermore, accumulation of yield needs to be predicted by accurately predicting the development and loss of leaf area and, therefore, a crop's ability to intercept radiation, accumulate biomass, and partition it to harvestable parts such as grain. Crop water use is also need to be accurately predicted by correctly predicting evapotranspiration and the extraction of soil water by plants roots **(Richter and Semenov 2005)**. CropSyst model **(Stockle *et al*., 1994)** is one of these models that could be used along with a set of daily weather data spanning on a reasonable number of years to assess the impact of climate change on crops **(Tubiello *et al*., 2000; Torriani *et al*., 2007a).** The application of such models allows the simulation of many possible climate change scenarios from only a few experiments for calibration.

Field experiments for wheat

Wheat occupies about 33% of the total winter crop area and is the major staple crop, consumed mainly as bread. More than one third of the daily caloric intake of Egyptian consumers and 45% of their total daily protein consumption is derived from wheat.

Eight experiments were implemented in four governorates and used in the analysis. These governorates are from north to south: Domiatte, (located on the Mediterranean Sea in North Egypt), El-Behira, (located in the North of the Nile Delta), El-Kalubia, (located in the South of the Nile Delta) and El-Giza, (located in Middle Egypt).

The first site is El-Serw (31.49º N, 31.25º E), at Demiatte governorate. The soil of this site is salt affected and surface irrigation is used (Ouda *et al*., 2012b). The second and the third sites are at El-Bustan (30.25º N, 31.02º E), in El-Behira Governorate. It is a newly reclaimed land, where its soil is sandy and wheat grown under sprinkler irrigation **(Ouda *et al*., 2010 and Taha 2012)**. The fourth site is El-Bosily in the same governorate, where the soil is clay and irrigation system is sprinkler **(Abd Raboh *et al*., 2011).** The fifth site is Banha (31.1º N, 30.28º E) at El-Kalubia Governorate. The soil of this site is characterized by being clay soil and surface irrigation is applied **(Moneir, 2012)**. The sixth and seventh sites are at El-Giza city (31.13º N, 30.02º E) in El-Giza Governorate. The soil type is clay and surface irrigation is applied **(Khalil *et al*., 2009 and Moneir 2012)**. The eighth site is also at El-Giza city, but wheat was grown under sprinkler irrigation **(Abd Raboh *et al*., 2011).**

Effect of climate change on wheat yield

Wheat grain yield at all sites was reduced under both A2 and B2 climate change scenarios. Similar trend was observed for wheat planted at the other three sites However, the highest percentage of yield reduction was observed at Giza governorate as a result of being located at Middle Egypt. The results can be summarized as follows:

1. Wheat experiments at Demiatte

The aim of that experiment was to simulate the effect of using improved agricultural management practices to reduce wheat yield losses under climate change using a simulation model called CropSyst. Three irrigation treatments were used, i.e. farmer irrigation (characterized by large applied irrigation amount), required irrigation amount for wheat and irrigation amount applied for raised bed cultivation. The cultivated cultivar was Sakha 93. The results indicated that farmer irrigation increase wheat vulnerability to climate change, where the average value of yield losses were between 44-50% under A2 climate change, and between 41-46% under B2 climate change scenario average over the two seasons, with the lowest water productivity. Lower yield losses, compared with farmer irrigation, were obtained when wheat was irrigated by required amount in both growing seasons. Furthermore, raised bed irrigation amount resulted in even lower yield losses, with the highest water productivity as a result of better growing environment for wheat plants **(Ouda *et al*. 2012a)**.

Growing wheat in salt affected soil of El-Serw, Demiatt Governorate is a common practice. Wheat yield is reduced in this type of soil, compared with its yield in clay soil. Grain yield of wheat is highly dependent upon the number of spike-bearing tillers produced by each plant **(Nerson, 1980)**. The number of productive tillers depends on the environmental conditions presented during tiller bud initiation and subsequent development stages. Environmental stress during tiller emergence can inhibit their formation and, at later stages, can cause their abortion. Numerous studies have shown that tiller appearance, abortion, or both are affected by salt stress **(Maas and Grieve, 1990; Nicolas *et al*., 1993).** Soil salinity decreases grain yield of wheat more when plants are stressed prior to booting than when stressed later. The yield component affected most by salt stress is the number of spikes produced per plant **(Maas and Grieve, 1990)**.

2. Wheat experiments at El-Behira governorate

2.1. Wheat grown in sandy soil

The effect of using improved agricultural management practices, i.e. fertigation on wheat cultivar Sakha 93 grown in sandy soil was tested in two field experiments. The aim of these experiments was to determine whether these practices will reduce the vulnerability of wheat to the aboitic stress of climate change. Eight fertigation treatments (interaction between irrigation with 0.6, 0.8, 1.0 and 1.2 of ETc and fertigation application in 60 and 80% of irrigation time), in addition to farmer irrigation were tested. The results showed that the highest yield reduction, i.e. 39 and 37% was obtained under A2 and B2 climate change scenarios, respectively for farmer irrigation. The lowest yield reduction was obtained under irrigation with 1.0 of ETc and fertigation application in 80% of irrigation time, i.e. 27 and 24% under A2 and B2 climate change scenarios, respectively.

Another experiment was done in the above mentioned site with same cultivar, i.e. Sakha 93 to compare between the effect of farmer's application of field chemicals (broadcasting fertilizers, insecticide and herbicide on the soil) and chemigation (application all field chemical via irrigation water) on yield losses under climate change. Moreover, the effect of the interaction between each treatment and two early sowing dates was simulated to develop effective adaptation strategy to reduce climate change risk on wheat yield grown in sandy soil. The results showed that under the two climate change scenarios, wheat grain was reduced by average of 30% under farmer irrigation and by an average of 25% when chemigation. The results also revealed that sowing wheat one week earlier under chemigation treatment improved wheat yield by an average of 6 and 5% under A2 and B2 scenarios, respectively.

2.2. Wheat grown in clay soil

Four wheat cultivars, i.e. Sakha 94, Sakha 93, Giza 168 and Gemmiza 9 were used. Each cultivar was planted in three sowing dates: 9th of November, 24th of November and 8th of December. Wheat was grown under sprinkler irrigation in four irrigation treatments, i.e. irrigation with 0.6, 0.8, 1.0 and 1.2 of ETc. The results showed that the highest reduction in wheat yield was obtained under A2 climate change scenario for all cultivars and under the three sowing dates. The results also revealed that irrigation with 0.6 of ETc gave the highest yield reduction and irrigation with 1.2 of ETc gave the lowest yield reduction for all the cultivars and under the both climate change scenarios. Furthermore, yield losses of the four cultivars were lower when wheat was planted in the 24th of November, compared with the other two sowing dates. Sakha 93 was found to be more tolerant to the aboitic stress of climate change, compared with the three other cultivars under the two climate change scenarios. The reduction in its yield, when it planted on the 24th of November, was 21 and 18% under A2 and B2 climate change scenarios, respectively.

3. Wheat experiments at El-Kalubia governorate

CropSyst model was used to simulate wheat grain yield by using field experimental data under A2 and B2 climate change scenarios. Two wheat cultivars, i.e. Giza 168 and Sakha 93 were grown in clay soil under surface irrigation. Under each climate change scenario, the effect of four sowing dates, four irrigations schedules and the interaction between them was simulated. Sakha 93 was found to be more tolerant to climate change than Giza 168, where its yield losses were 35 and 41% under A2 and B2, respectively. The best adaptation strategy under A2 and B2 climate change scenario was sowing wheat in the 1st week of November and applying second irrigation four weeks after sowing and then every 30 days.

4. Wheat grown at El-Giza governorate

4.1. Wheat grown under surface irrigation

The effect of climate change on the yield of three wheat varieties (Sids1, Sakha 93 and Giza 168) grown under surface irrigation in clay soil was studied using A2 and B2 climate change scenarios. The effect of two early sowing dates on wheat yield was simulated and used as adaptation options, i.e. 1st of November and 21st of October to reduce the harm effect of climate change and a new irrigation schedule was used. The results revealed that for both climate change scenarios, Sakha 93 variety was found to be more tolerant to heat stress, where yield losses were 45 and 38% under A2 and B2 scenarios, respectively. The results also showed that wheat yield improvement and irrigation water saving could be attained using the proposed adaptation strategies. Under cultivation in November, 1st, a slight improvement in yield losses could be achieved with a slight increase in the amount of applied irrigation water. Whereas, under sowing in October, 21st, a decrease in yield losses could be achieved with a decrease in the amount of applied irrigation water.

4.2. Wheat grown under sprinkler irrigation

Four wheat cultivars, i.e. Sakha 94, Sakha 93, Giza 168 and Gemmiza 9 were grown in silty clay soil. Each cultivar was planted in three sowing dates: 9th of November, 24th of November and 8th of December. Wheat was planted under sprinkler irrigation in four irrigation treatments, i.e. irrigation with 0.6, 0.8, 1.0 and 1.2 of ETc. The results revealed that irrigation with 0.6 of ETc gave the highest yield reduction and irrigation with 1.2 of ETc gave the lowest yield reduction for all the cultivars and under the both climate change scenarios. Furthermore, yield losses of the four cultivars was lower when wheat was planted in the 24th of November, compared with the other two sowing date. Sakha 93 was found to be more tolerant to the aboitic stress of climate change, compared with the three other cultivars under the three sowing dates and the two climate change scenarios. The reduction in its yield when it planted on the 24th of November was 39 and 34% under A2 and B2 climate change scenarios, respectively.

The comparative study between the studied wheat cultivars in the previous experiments revealed that Sakha 93 could posses yield stability traits under the stressful condition of climate change. Furthermore, in these experiments, Sakha 93 had high value of water productivity under current climate and under climate change conditions. Therefore, it is important to develop data base to classify the available wheat cultivars according to their ability to tolerate abiotic stress such as, heat and water stresses, in addition to document how efficient these cultivars in using irrigation water under climate change conditions.

The previous results also implied that yield losses of wheat dependent upon soil type and irrigation system. Regarding to soil type, Figure (1) indicated that the highest percentage of yield reduction will be occurring for wheat grown in salt affected soil. In parallel to that, high percentage of yield reduction took place in El-Giza. El-Giza is located in middle Egypt, where temperature is higher than Demiatte. This result implied that soil type can be detrimental as high temperature in a site. Figure (1) also showed that reduction in wheat yield as result of climate change (PR%) is lower at El-Behira governorate compared with the other three governorates, although its soil is sandy in two sites out the three in this governorate. Furthermore, yield losses were lower for wheat grown in silty clay soil site, compared to its counterpart grown in sandy soil. This result implied that soil type plays an important role in determination of yield losses under climate change conditions. Therefore, the impact of climate change on soils needs to be considered in parallel with impacts caused by unsustainable land-management practices. In many cases, it is impossible to separate the effects of these impacts; often they interact, leading to a greater cumulative effect on soils than would be predicted from a simple summation of their effects **(Brinkman and Sombroek, 1993).**

With respect to irrigation system, Figure (2) suggested that yield losses (PR%) were lower for wheat grown under sprinkler irrigation in El-Behira governorate, which located in North Nile Delta. Furthermore, in El-Giza governorate yield losses were reduced under sprinkler irrigation. This result implied that sprinkler irrigation could be use as an adaptation strategy to reduce climate change risks on wheat.

Figure (1): Percentage of wheat yield reduction (PR%) under climate change as affected by soil type.

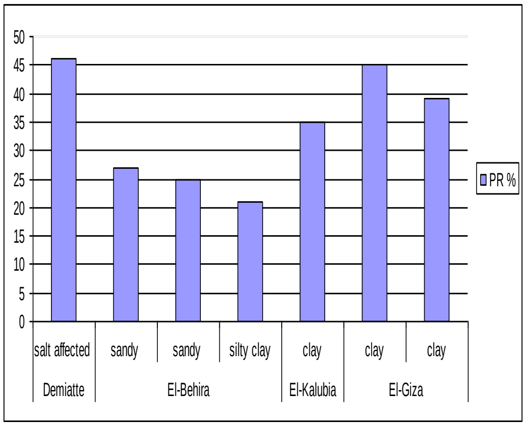
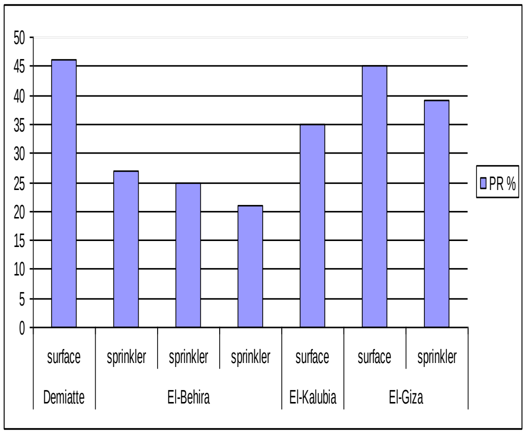


Figure (2): Percentage of wheat yield reduction (PR%) under climate change as affected by irrigation system.



The high reduction in wheat yield under climate change conditions could be attributed to heat and water stresses that wheat plants exposed to. High temperature reduces numbers of tillers **(Friend 1965)** and spikelet initiation and development rates **(McMaster, 1997)**. Furthermore, high temperature during anthesis causes pollen sterility **(Saini and Aspinall, 1982)** and reduces number of kernels per head, if it prevailed during early spike development **(Kolderup, 1979).** The duration of grain filling is also reduced under heat stress **(Sofield *et al*., 1977)**, as well as growth rates with a net effect of lower final kernel weight **(Bagga and Rawson 1977; McMaster, 1997)**.

Furthermore, exposing wheat plants to high moisture stress depressed seasonal consumptive use and grain yield **(El-Kalla *et al*., 1994 and Khater *et al*., 1997).** During vegetative growth, phyllochron decreases in wheat under water stress **(McMaster, 1997)** and leaves become smaller, which could reduce leaf area index **(Gardner, *et al*. 1985)** and reduce the number of reproductive tillers, in addition to limit their contribution to grain yield **(Mosaad *et al*., 1995)**. Furthermore, water stress occurs during grain growth could have a sever effect on final yield compared with stress occurred during other stages **(Hanson and Nelson, 1980)**.

Effect of adaptation strategies on crop water productivity of wheat

Adaptation to climate change has received very little attention compared with mitigation, this may be partly because adaptation seems more complicated than mitigation, emission sources are relatively few, but the array of adaptation is vast, yet to ignore adaptation is both unrealistic and perilous **(Parry *et al*., 1998)**. Adaptation refers to efforts to reduce system’s vulnerabilities to climate. A wide range of responses can be implemented exogenously by management or policy decisions at the regional or national level. These adjustments are adaptation strategies **(Carter 1996)**. Agricultural adaptation to climate change at the farm level depends on the technological potential (different varieties of crops, irrigation technologies); basic soil, water, and biological response. The capability of farmers to detect climate change and undertake any necessary actions will then be reflected on achieving high crop water productivity.

Crop water productivity is a quantitative term used to define the relationship between crop produced and the amount of water involved in crop production. It is a useful indicator for quantifying the impact of irrigation scheduling decisions, with regard to water management **(FAO 2003)**. Achieving greater water productivity became the primary challenge for scientists in agriculture. This should include the employment of techniques and practices that deliver more accurate supply of water to crops **(Tariq *et al*. 2003)**.

Under climate change conditions, water productivity was highly reduced in all wheat experiments, compared with its counterpart value under current climate conditions (Figure 3). The deterioration in water productivity was high in salt affected soil, in sandy soil cultivation at El-Behira and under surface irrigation at El-Giza. The use of adaptation strategies in all the previous experiments (either simulated or applied in the field) impro/ved water productivity for wheat (Figure 3). However, the effect was more pronounce under irrigation with sprinkler, compared with surface irrigation (Figure 4). This result implied that sprinkler irrigation could play an important rule in reducing climate change risks on wheat, compared to surface irrigation.

Figure (3): Wheat water productivity under current climate, climate change and after using adaptation strategies as affected by soil type.

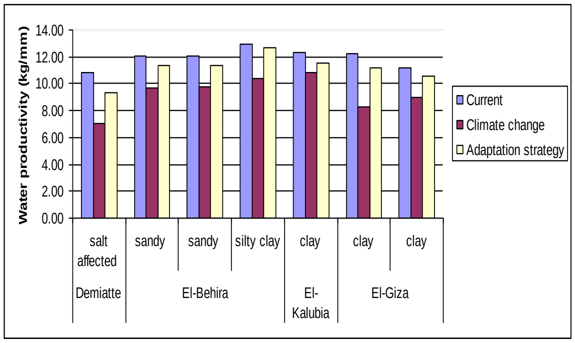
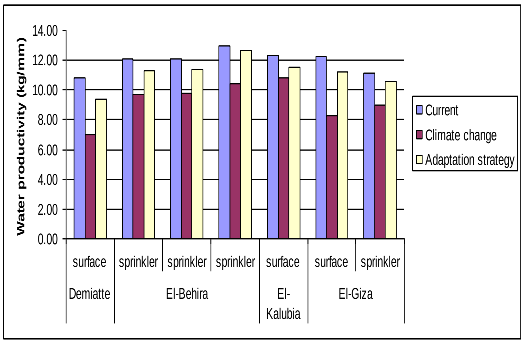


Figure (4): Wheat water productivity under current climate, climate change and after using adaptation strategies as affected by irrigation system.



Conclusion

Climate change is urgently needs to be assessed at the level of the farm, so that poor and vulnerable farmers dependent on agriculture can be appropriately targeted in research and development activities on poverty alleviation **(Jones and Thronton 2003)**. Assessing the possible impact of climate change on production risks is therefore necessary to help decision makers and stakeholders identify and implement suitable measures of adaptation **(Torriani *et al*., 2007b).**

Rapid changes of climate may seriously inhibit the ability of some crops to survive or to achieve the desired yield in their current region. Sustainable land and water management combined with innovative agricultural technologies could mitigate climate change and help poor farmers adapt to its impacts. New knowledge, technology and policy for agriculture have never been more critical, and adaptation and mitigation strategies must urgently be applied to national and regional development programs. Without these measures developing countries will suffer from increased food insecurity. The positive effects of adaptation strategies on agriculture under climate change have been confirmed in many studies. The best way to adapt to some uncertain future climate is to improve adaptation to present day climate variability and reduce vulnerability to extreme events.

Plant breeders could use the results of the application of the simulation models to help them in developing new varieties adapted to climate change. Wheat breeders will need to focus on overcoming heat stress rather than improving drought tolerance as a result of climate change. Moreover, breeding for varieties with higher water use efficiency is also very important goal to be achieved. Under climate change, achieving greater water use efficiency is the primary challenge for scientists in agriculture. Therefore, changing irrigation schedule could provide a cheap and easy to implement irrigation management techniques to relief the harm effect of climate change, with no additional economic costs.

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تأثير نوع التربة و نظم الري علي نقص محصول القمح تحت التغير في المناخ : تقييم عام

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[٢] المعمل المركزى لبحوث التصميم و التحليل الإحصائى – مركز البحوث الزراعية

يمكن أن يلعب نوع التربة ونظام الرى دور هام فى الحد من الفاقد من المحصول تحت ظروف التغير فى المناخ، ويتم تناول هذا المفهوم فى هذا البحث من أجل تسليط الضوء على أهمية وضع استراتيجية للحد من مخاطر تغير المناخ على القمح ، في السنوات الأخيرة أدخلت نماذج تغير المناخ العالمي في مصر والتي استخدمت لعمل سيناريوهات التغير فى المناخ ، وهذه النماذج هى الوحيدة التي يمكن أن تقدم توقعات مفصلة لتغيرات المناخ الإقليمية في المستقبل، وقد وضع سيناريوهين A2 xو B2 واستخدما للتنبؤ تحت تأثير التغير فى المناخ على محصول القمح، وتمت زراعة محصول القمح في ثمانية مواقع في مصر، ثم تم عمل معايرة لنموذج CropSyst والتحقق من صحته للقمح وتم أدراج اثنين من سيناريوهات تغير المناخ في النموذج، ثم تم تشغيل النموذج وحساب تأثير التغير في المناخ.

وأظهرت النتائج أن محصول القمح سوف ينخفض في ظل تغير المناخ، ونسبة الانخفاض سوف تتوقف على الموقع المنزرع فيه القمح ونوع التربة ونظام الري المستخدم ، وعلى ذلك فمن المتوقع أن تحدث في مصر الوسطى خسائر عالية لمحصول القمح مقارنة مع شمال مصر، وعلاوة على ذلك فإن نقص المحصول سوف يزيد في التربة الرملية وتحت الري السطحي، ولذلك فإن أفضل طريقة للتكيف مع التغير فى المناخ المستقبلى أن نحسن بيئة نمو المحصول تحت ظروف الجو العادية والتقلبات المناخية مما يساعد على تقليل حساسية المحاصيل ونقص المحصول عند التعرض للتغيرات المناخية المستقبلية.