The impact of rainfall decrease and temperature increase in the change of crop pattern in Adana and Konya

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Summary

Temperature increase and rainfall decrease were chosen as climatic variable on the change of crop pattern. At the same time the other variables which may affect crop production pattern such as pesticide use in crop breeding, price index for crop and crops group, price index for competitive crops to current one for use of land, migration from rural to urban, agricultural subsidies, quota, and impulsive supports by the government, rented land, and fallow land were analyzed in order to estimate their impact on the change of crop pattern too. The data of 34 years (1970-2004) were taken from the directorate of Meteorology Department in Adana and Konya as well as from Ministry of Agriculture and Rural Affairs. As a result, the impact of global warming and rainfall increase were found to be significant in the change of crops pattern. It seems that climate change will be an important variable for creating mostly forage crops pattern in the research area in the Ceteris Paribus circumstance.

1. Introduction

The basic growing goals in all crops include the achievement to produce maximum produce of sufficient quality. When assessing crop productivity, it is necessary to assess and analyze many indicators describing yield as to the natural and geographical conditions, economic situation, human potential, social levels, environment and others. Some impacts of agricultural productivity can be identified as climate (temperature and rainfall quantity), soil condition, and biological power. To increase productivity in agriculture, people have been using inputs intensively in the soil, at the same time trying to restrict it against climate effect such as green house. Currently, biological power like modified seed and sperm is the most important innovation for increasing agricultural productivity in order to have enough food to feed fast growing world population. In the opposite direction, climate change such as global warming and rainfall decrease has been a serious impact on agricultural productivity.

In this study which has been going on last four years project with Turkish and Japanese scientist collaboration, the impact of rainfall decrease and temperature increase in the change of crops pattern was examined for the rainfed and irrigated conditions of Adana and Konya provinces. The objective of the study is to determine correlation between crop pattern and climate change in order to predict farmers' response or adaptation to the climate change.

2. Material and Method

Monthly data of rainfall and temperature of 34 years (1970-2004) were taken from Directorate of Meteorology Department in Adana and Konya. The other factors that may effect crop pattern were collected from the Ministry of Agriculture Department in Adana and Konya as well as statistical publications.

The variable factors that may affect crop pattern were selected as follow;

- Annual rainfall, mm, (X_1)
- Average monthly rainfall, mm, (X_2)
- Total monthly rainfall for the some critical month of crop grow, mm, (X_3)
- Average monthly rainfall for the some critical month of crop grow, mm, (X_4)
- Total monthly temperature for the some critical month of crop grow, mm, (X_5)
- Average monthly temperature for the some critical month of crop grow, mm, (X_6)
- Pesticide use in crop breeding, kg. (Those data were collected just for the wheat and sugar beet precisely) (X_7)
- Price index for crop and crops group (X_8)
- Price index for competitive crops to current one for use of land (X_9)
- Migration from rural to urban in the cities (X_{10})
- Agricultural subsidies, quota, and impulsive supports by the government (dummy) (X_{11}),
- Total rented land, da. (X_{12})
- Total fallow land, da. (X_{13}).

Rainfall, temperature, and price were choused as lagged variable in agricultural production functions by concerning farmer reaction to the variables.

3. Results and Discussion

3.1. Konya Province

3.1.1. Rainfed Area in Konya

The changes of crop pattern were examined for leguminous seeds, forage crops, and grain in rainfed area in Konya.

Factor effecting quantity of grain production areas were estimated as follow;

$$Y = -724{,}8 + 1{,}32\,(X_3) + 1{,}31\,(X_6) + 0.02\,(X_{12}), \qquad (R^2 = 0{,}788).$$

In the function, significant factors that effecting quantity of grain production areas were estimated as;

- Total quantity of rainfall in March, April, and May (X_3),
- Average quantity of temperature in March, April, and May (X_6),
- Total quantity of rented land (X_{12}).

These three variables determine 78,8% of the changes of grain production area. Farmers changed quantity of grain production area by concerning rainfall in the March-May, average temperature in the March-May, and possibility of rented land. They increased quantity of grain production area by concern the significant variables. Most significant variables were estimated as total quantity of rainfall in March-May (X_3). The effect of only rainfall in March-May on the quantity changes of grain production area was estimated as Figure 1. The impact of this variable (X_3) on the quantity of grain area (Y) was estimated the best in Quadratic Model as follow;

$$Y = -0{,}0037X^2 + 2{,}2752X - 214{,}14$$

The variable (X_3) explained the change of grain area by 69,0% ($R^2 = 0{,}690$).

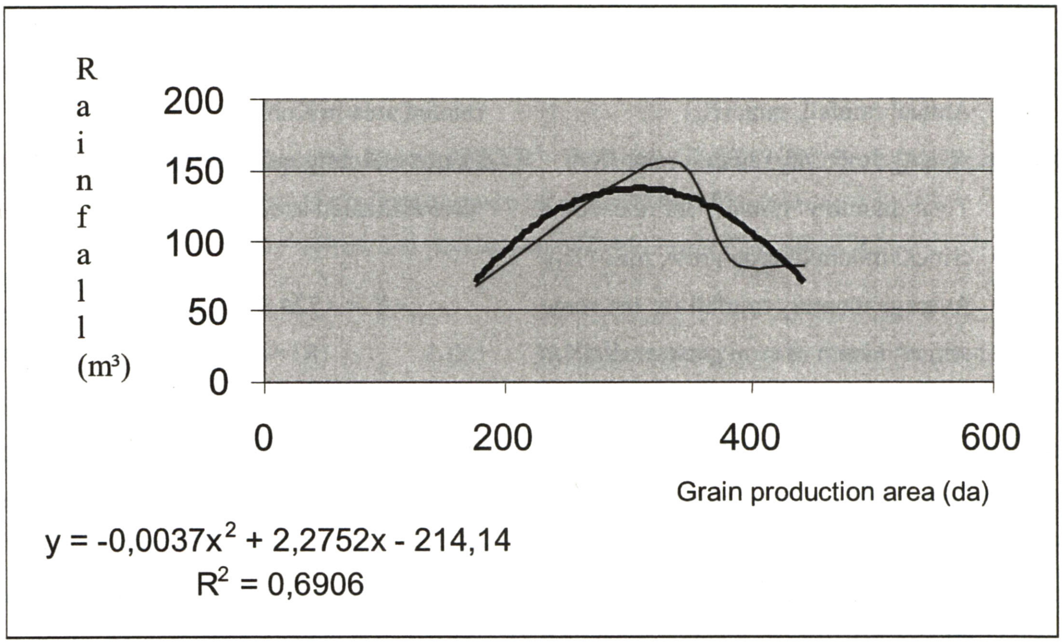

Figure 1.The Impact of Rainfall in March-May in the Changes of Grain Production Area

The changes of leguminous seeds (pea and lentil) production area were estimated as follows;

$Y = - 210,8 + 0,44\ (X_3) + 4,08\ (X_6) -0,006\ (X_{12})$, $(R^2 = 0,782)$.

These three variables determined 78,2% of the changes of leguminous seeds production area. Farmers increased leguminous seeds production area by concerning rainfall in the March-May and average temperature in the March-May.

They decreased leguminous seeds production area by concern the rented land (X_{12}). Most significant variables were estimated as total quantity of rainfall in March-May (X_3). The effect of only rainfall in March-May on the quantity changes of leguminous seeds production area was estimated as Figure 2.

The impact of this variable (X_3) on the quantity of leguminous seeds area (Y) was estimated best in Quadratic Model as follows;

$Y= - 0,0622X^2 + 14,37X - 616,78$, $(R^2 = 0,503)$.

The variable (X_3) explained the change of leguminous seeds production area by 50,3% ($R^2 = 0,503$).

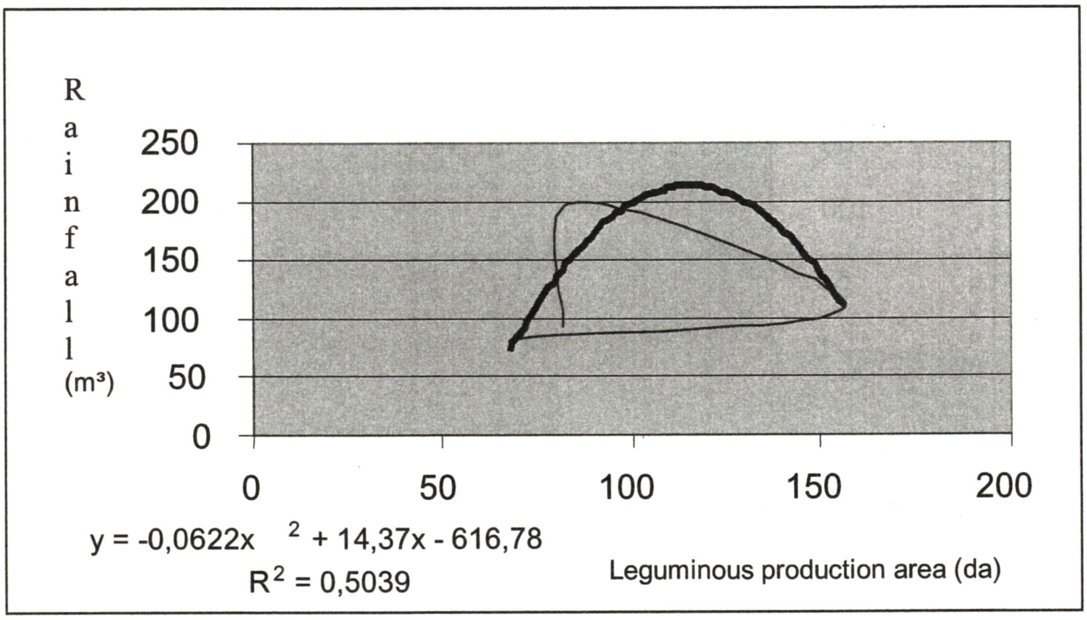

Figure 2.The Impact of Rainfall in March-May in the Changes of Leguminous Seeds Production Area

The changes of forage crops production area were estimated as follows;

$Y = -2,04 + 0,02 (X_3) - 0,002 (X_{12})$, ($R^2 = 0,788$).

As can be seen in the function, farmers increased forage crops production area by concerning rainfall in the March-May and average temperature in the March-May.

The impact of this variable (X_3) on the quantity of forage crops production area (Y) was estimated the best in Quadratic Model as follows;

$Y = -2,3135X^2 + 79,034X - 520,86$, ($R^2 = 0,9481$).

The variable (X_3) explained the change of forage crops production area by 94,8% ($R^2 = 0,948$).

The effect of only rainfall in March-May on the quantity changes of leguminous seeds production area was estimated as Figure 3.

3.1.2. Irrigated Area in Konya

The changes of crop pattern were examined for grain, sugar beet, and forage crops in irrigated area in Konya.

Factor effecting quantity of grain production areas were estimated as follows;

$Y = 212,1 - 0,28 (X_3) - 2,79 (X_6) + 0,03 (X_{12})$, ($R^2 = 0,872$).

In the function, significant factors that effecting quantity of grain production areas were estimated as;

- Total quantity of rainfall in March, April, and May (X_3),
- Average quantity of temperature in March, April, and May (X_6),
- Total quantity of rented land (X_{12}).

Those three variables were estimated significant for the grain production in rainfed area. Those three variables determined 87,2% of changes of grain production area.

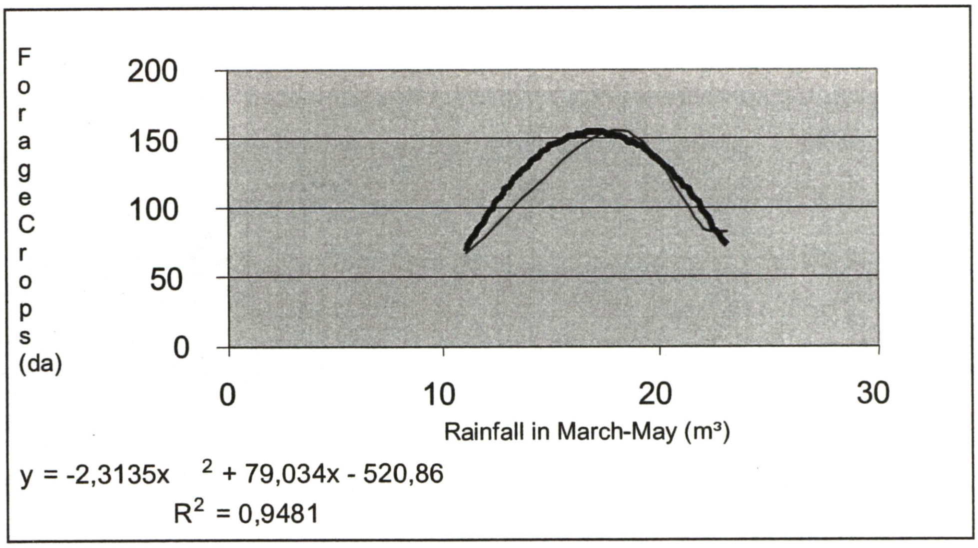

Figure 3.The Impact of Rainfall in March-May in the Changes of Forage Corps Production Area

Those three variables were estimated significant for the grain production in rainfed area. Those three variables determined 87,2% of changes of grain production area.

The effect of only average temperature in April-June on the quantity changes of grain production area was estimated as Figure 4. The relation was explained the best in logarithmic function as follows;

$$Y = -341,21Ln(X)+979,85, \quad (R^2 = 0,905).$$

The variable (X_6) explained the change of grain production area by 90,5% (R^2 = 0,905).

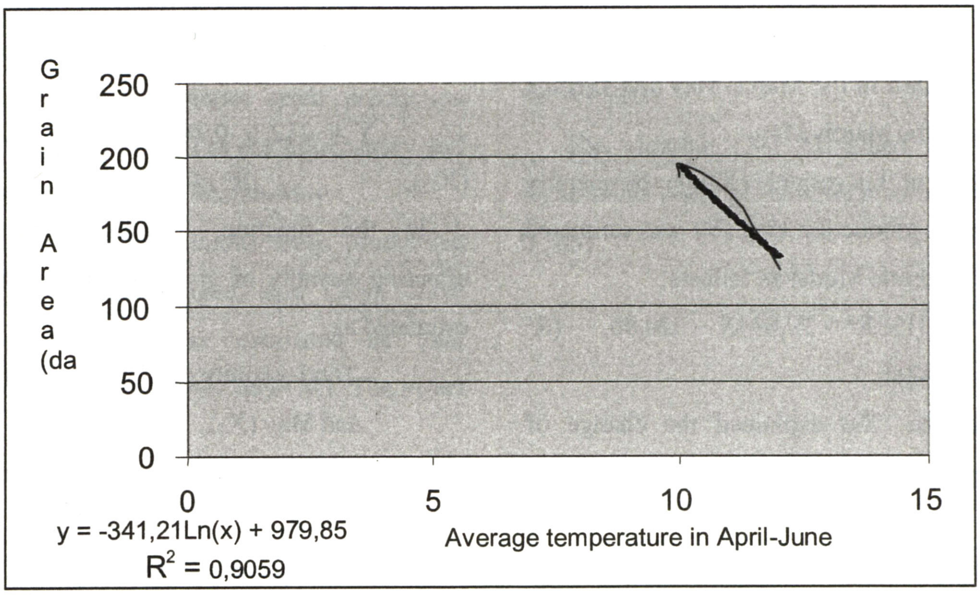

Figure 4.The Impact of Average Temperature in April-June in the Changes of Grain Production Area

The relation between changes of sugar beet production area and variable factors were estimated as

$$Y = 113,3 - 0,13 (X_3) - 1,70 (X_6) + 0,017 (X_{12}), \quad (R^2 = 0,983).$$

The most important variable was average temperature in April-June. The regression between change of sugar beet production area and the average temperature was estimated 84,9% as can be seen in Figure 5 and following function;

$$Y= - 97,85Ln(X)+310,91. \quad (R^2 = 0,849).$$

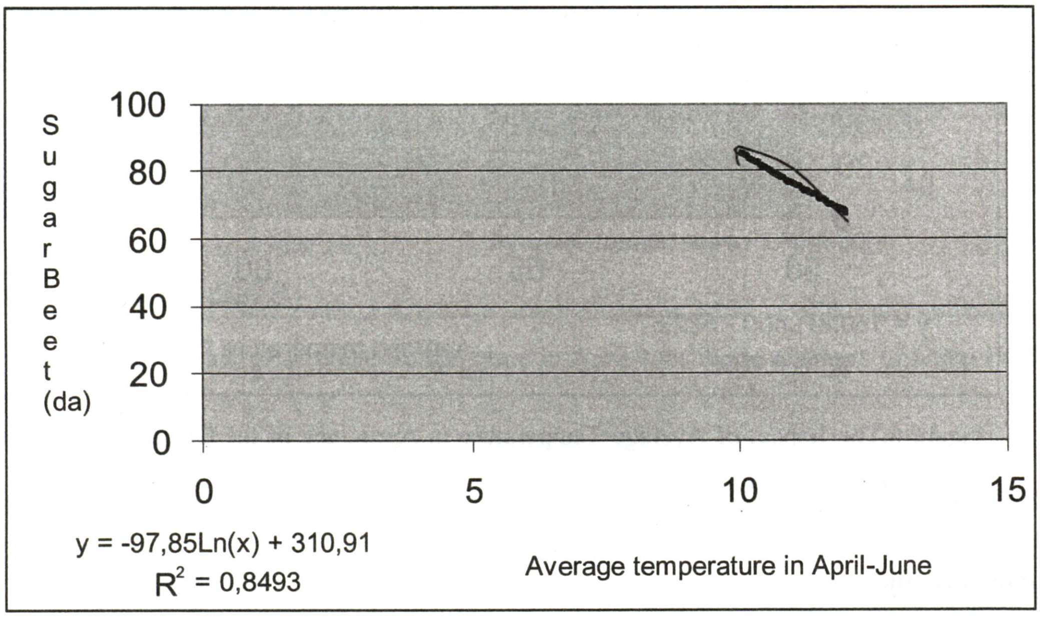

Figure 5.The Impact of Average Temperature in April-June in the Changes of Sugar Beet Production Area

The changes of forage crops production area were estimated as follows;

$$Y = -7,46 +0,076 (X_3) +0,679 (X_6) + 0,0002 (X_{12}), \quad (R^2 =0,789).$$

These three factors explained the change of forage production area by 78,9%. Farmers increased forage crops production area by concern on rainfall and temperature that were in the function.

The most significant factor was average temperature in April-June, and the regression between the temperature and the yield was estimated by 29,9% as can be seen in Figure 6. Since the relation was not significant, comment could not be made on it. Logarithmic function explained in the relation as follows;

$$Y= 150,87Ln(X)-522,67. \quad (R^2 = 0,299).$$

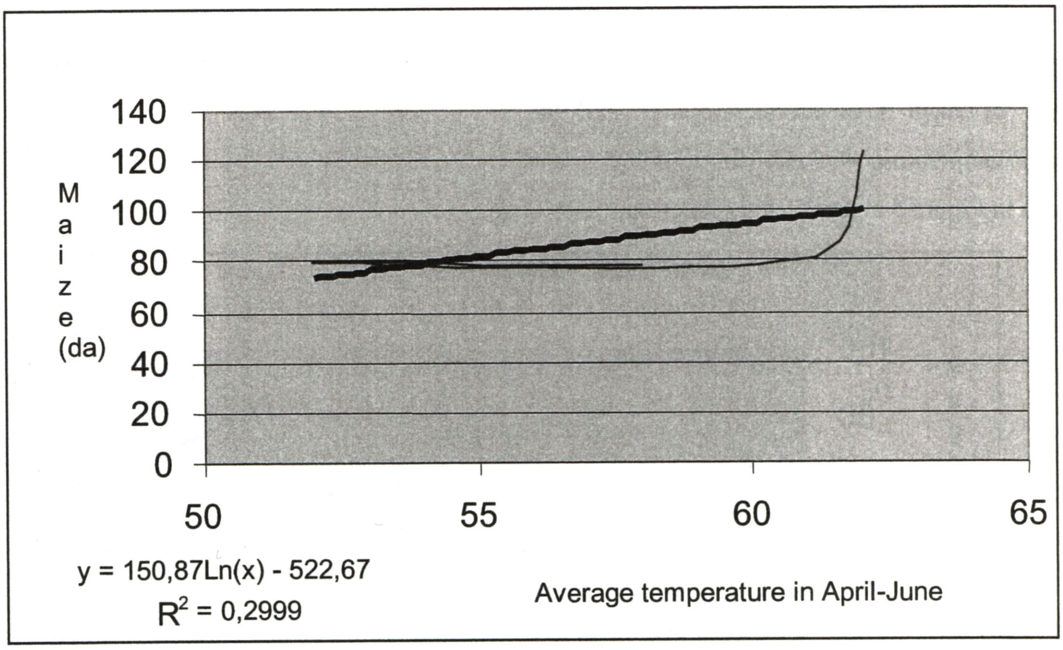

Figure 6.The Impact of Average Temperature in April-June in the Changes of Forage (Maize) Production Area

3.2. Adana Province

3.2.1. Rainfed Area in Adana

The changes of crop pattern were examined for grain (wheat and barley) and cotton in rain fed area in Adana.

Factor effecting quantity of grain production areas were estimated as follows;

$Y= - 866{,}5+ 0{,}086(X_3) + 0{,}066(X_{12}) +0{,}86 (X_6)$, $(R^2 = 0{,}787)$.

In the function, significant factors that effected quantity of grain production areas were estimated as;

- Total quantity of rainfall in March, April, and May (X_3),
- Average temperature in April-June (X_6),
- Total quantity of rented land (X_{12}).

Those three variables determine 78,7% of changes of grain production area. Farmers mostly changed quantity of grain production area by concerning average temperature in the April-June since the most significant variables were estimated as average temperature in April-June (X_6).

The effect of only average temperature in April-June on the quantity changes of grain production area was estimated as it can be seen in Figure 7. The impact of this variable (X_6) on the quantity of grain area (Y) was estimated by 22,8% ($R^2 = 0{,}228$).

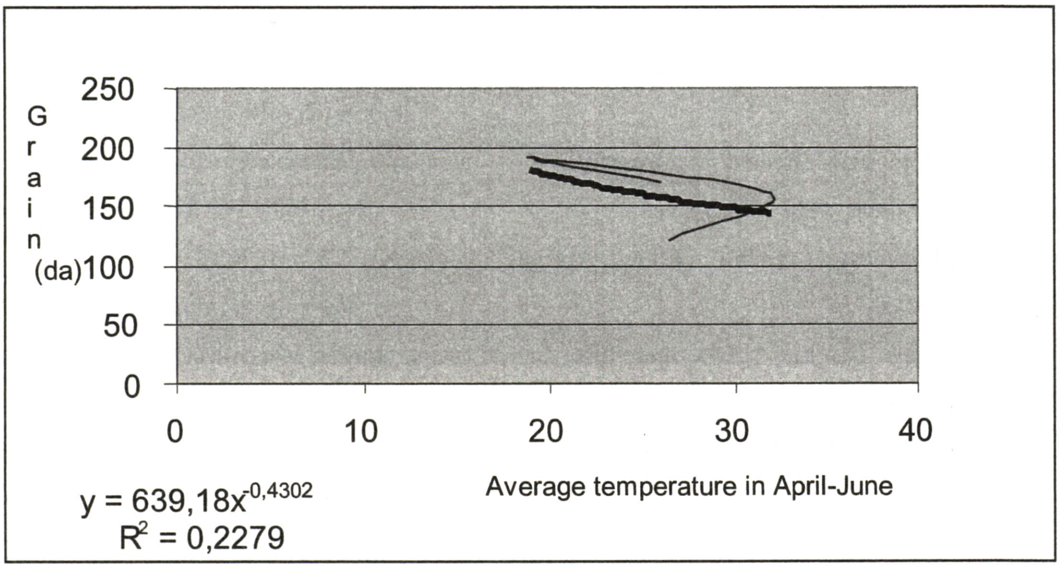

Figure 7. The Impact of Average Temperature in April-June in the Changes of Grain Production Area

The changes of cotton production area were estimated as follow;

$$Y = -8{,}15 + 0{,}002(X_{12}) + 0{,}09(X_6) - 0{,}014(X_3), \quad (R^2 = 0{,}768).$$

These three variables determine 76,8% of changes of cotton production area. The variable (X_3) explained the change of grain production area by 0,73% ($R^2 = 0{,}726$) as it can be seen in Figure 8.

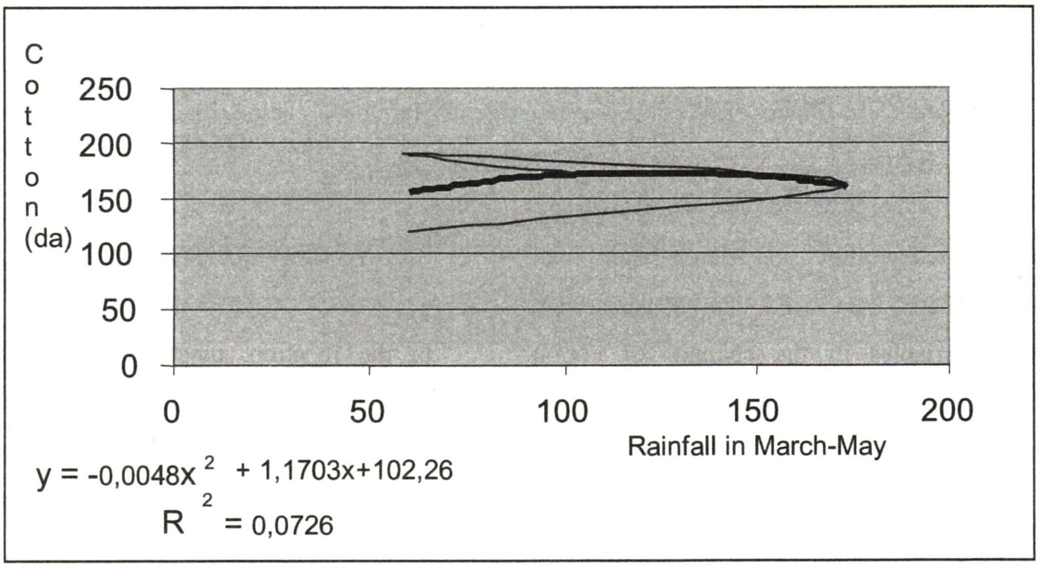

Figure 8.The Impact of Rainfall in April-June in the Changes of Cotton Production Area

3.2.2. Irrigated Area in Adana

The changes of crop pattern were examined for grain (wheat), cotton, and forage crops in irrigated area in Adana.

Significant factors that effected the quantity of wheat production areas were estimated as;

- Total quantity of rainfall in March, April, and May (X_3),
- Average quantity of temperature in March, April, May, and June (X_6),
- Total quantity of rented land (X_{12}).

These three variables determined 76.8% of the changes of wheat production area.

Factor effecting quantity of grain production areas were estimated as follows;

$$Y= 748{,}15+0{,}0186(X_{12}) -0{,}736(X_6) - 0{,}116(X_3), \quad (R^2 = 0{,}768).$$

T he most important variable was average temperature in March-May.The regression between the change of wheat production area and the average temperature was estimated as it can be seen in Figure 9.

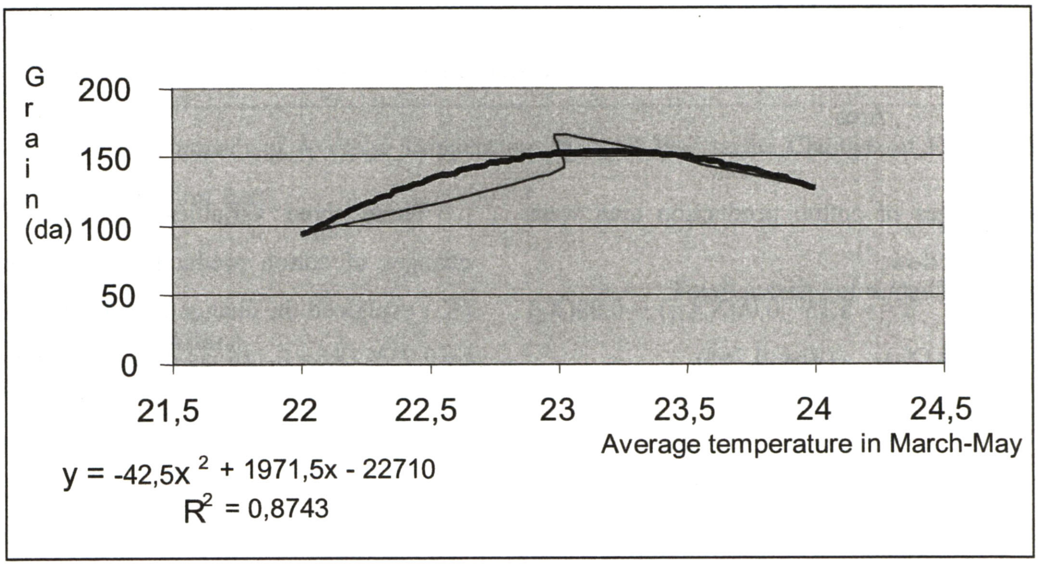

Figure 9.The Impact of Average Temperature in March-May in the Changes of Grain Production Area

Average temperature in March-June, total rainfall in March-May, and rented land were significant variables in the changes of cotton production area. The function was estimated as follows;

$$Y= 696{,}9+0{,}023(X_{12}) + 0{,}806(X_6) +0{,}218 (X_3), \quad (R^2 = 0{,}893)$$

In the function, most important factor was temperature which explained cotton production area by 77,7% (Figure 10).

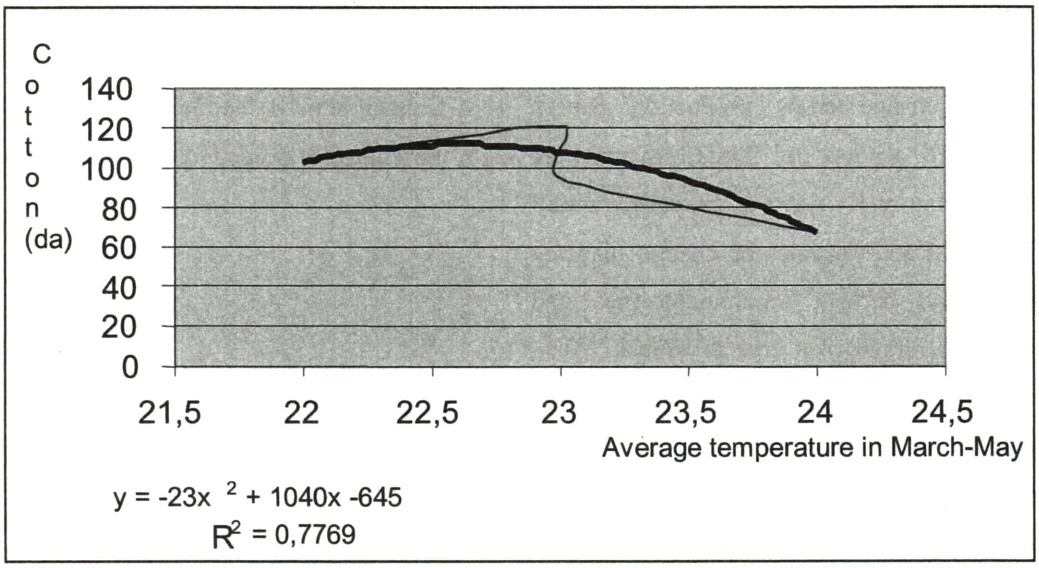

Figure 10.The Impact of Average Temperature in March-May in the Changes of Cotton Production Area

Average temperature in March-June, total rainfall in March-May, and rented land were significant variables in the changes of forage crop (Maize) production area. The function was estimated as follows;

$Y= -477,8+0,0147(X_{12}) -0,177(X_3) +0,555 (X_6)$, ($R^2 = 0,934$).

Average temperature was the most significant variable in the change of maize production area and that explained by 70, 2% itself (Figure 11).

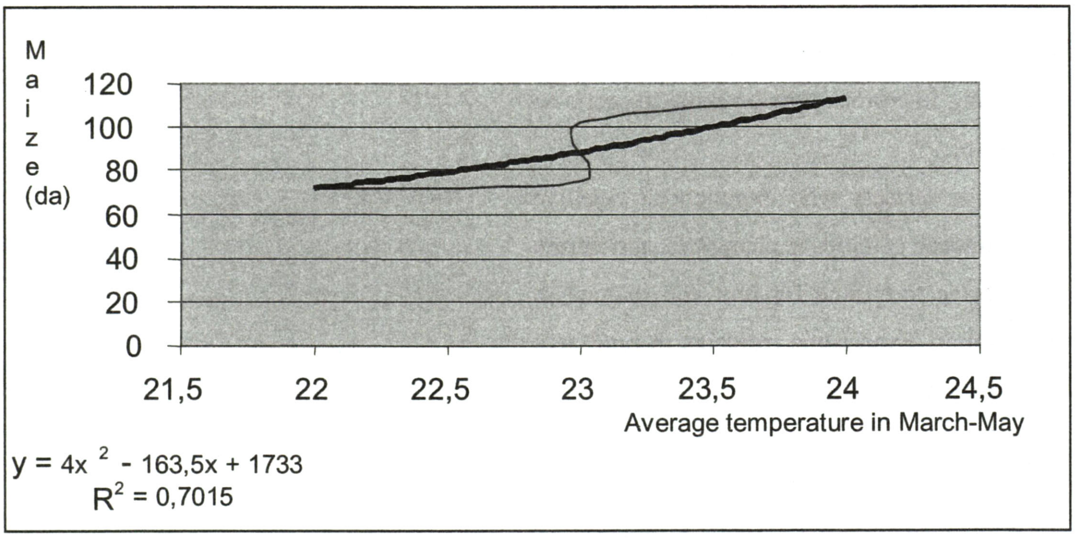

Figure 11.The Impact of Average Temperature in March-May in the Changes of Maize Production Area

4. Results

The results of the study can be interpreted or summarized;

- Farmers change crops production pattern taking into account of rainfall quantity in March- May in Konya. For example, rainfall was significant variable for change of grain (wheat and barley), leguminous (pea and lentil) and forage crop area in Konya. Also, rented land is significant variable in the change of crop pattern. For instance, farmers decrease forage crops production area by taking into account of rainfall decrease day to day.
- Farmers change crops production pattern by taking into consideration climate change such as global warming and rainfall decrease in Adana province too. The impact of climate change on the change of crop pattern was more significant in Konya than in Adana since soil fertility is higher and irrigation area is larger in Adana.
- As the impact of climate change on change of crop pattern both in Adana and Konya, the following interprets cane be issue to work on that more;
    - The farmers who experienced negative impact of climate change in agriculture leave their land for rent and migrate to urban. Even some residents in rural area rented their land.
    - It seems that global warming and rainfall decrease will leave forage crops production and livestock husbandry as agriculture especially in the rainfed area. The combination of forage crops and livestock production may useful changed by the aspect of environment since farmers use fertilizer and chemical in grain, sugar beet, and cotton production.

Closing remark, the impact of climate change in agriculture is needed to be study on it more.