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PATH ANALYSIS AND RELATIONSHIPS BETWEEN SOME CLIMATIC PARAMETERS AND SUGAR CONTENT OF SUGAR BEET

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Abstract

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This study has been made to determine the relationships between climatic parameters and sugar beet produced in Konya (Cumra) plain. There were statistically significant relationships between monthly mean sugar content of sugar beet and the climatic factors; rainfall, temperature, cloudiness mean and wind velocity (r=0.630*, r=-0.898**, r=-0.900**, r=-0.700* in 1999; r=0.528, r=-0.980**, r=0.673, r=-0.545 in 2000, respectively). According to path analysis results, temperature, cloudiness mean and rainfall have more direct and indirect effects than other climatic factors on sugar content of sugar beet.

Key words: path analysis, climatic parameters, sugar beet

Introduction

Sugar beet plant is important in the world and Turkish economy. The Konya plain is one of the most important sugar beet sowing areas in Turkey.

This plant is sown in about 450 000 ha area in Turkey. Approximately 47.4 % of this area is located in central Anatolia, and 19.8 % of it is in Konya.

The sugar produced in the world is about 125 million tons according to 1997 statistics. Seventy % of this amount (85 million tons) is from sugar cane and 30 % of it (40 million tons) is from sugar beet.

The world's sugar consumption changes from 90 to 110 million tons recently and the 15 to 35 million tons remaining are kept as stock. The person consumption in the world is about 24 kg (Er and Mulayim, 2005).

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The aim of the growing sugar beet is to obtain higher sugar beet and sugar yields from a unit area. To obtain high sugar yield, the climatic conditions are very important just as performing management practices such as selecting a high quality cultivar, irrigation, fertilization and crop protection against diseases. The climatic conditions are very important for agricultural practices and they can not be controlled. The climatic conditions such as light, temperature, rainfall, and wind velocity affect greatly the yields of sugar beet. It is widely accepted that sugar beet needs approximately 600 mm rainfall (Arslan, 1987).

Sugar beet yield is positively affected when the sunny and cloudy days follow each other during the sugar beet growing season. Especially when the days were always sunny, the sugar contents of sugar beet increases; and when the days were always cloudy the

sugar content increases[1]. Although the sugar beet irrigation is very well done during droughty season; the lower yields are as a result of low relative humidity and high temperature.

During the sugar beet growing season, sugar beet needs 25-29°C total temperature. Soil temperature increases the sugar content of sugar beet shoot. Sugar content becomes the highest when the soil temperature is about 20°C (Arioglu and Halis, 1997). Summer rains decrease the incidence of above 20°C extreme daily temperature, and they increase mean daily sugar accumulation and allow higher sugar beet production. On the other hand, pre-harvest rainfalls stimulate foliage formation and decrease sugar content. For this reason, the weather being very dry during day times and cool during nights at maturity and harvest is very important for sugar accumulation in sugar beet (Tortopoglu**,** 1994).

The lower night-time temperatures during the sugar beet growing season causes sugar content of sugar beet shoot to increase and also they affect the yield negatively. Various researches have been carried out using path analysis different plants by many scientists (Budak et al., 1995; Simena et al.1990; Shelembi and Wright, 1992; Soylu et al., 2006; Tomer and Prasad, 1988; Yildirim et al., 1995)

Sugar beet is long day plant. It needs 14 h lightening period when it goes from vegetative period to generative period.

For sugar formation in sugar beet, sunlight should be continuos during July, august, September, and October. Because the cloudy interferes with the sunlight, the sugar content of sugar beet is usually low in the areas where cloudiness ratio is high (Tortopoglu, 1994).

The objective of this study is to determine the relationship between the monthly sugar beet mean sugar content values and climatic factors in Konya plain (Cumra); and to determine the direct and indirect climatic factors on sugar content by path analysis.

Materials and Methods

Material

Some physical and chemical properties of the study soils are given in Table 1.

Most of the study soils are slightly alkaline and have high $CaCO_3$ content. Probably these soils developed onto a calcareous bed rack. The study soils are generally low in organic matter.

Are parted that the soil Fe content limiting plant growth is approximately 4.5 mg kg^{-1}. According to

Table 1

Some statistical measurements of the soil physical and chemical properties

Soil properties	Minimum	Maximum	Mean	Median
Clay, %	11	64.8	48.2	47.3
pH	7.05	7.48	7.35	7.32
Total salt, %	0.04	0.21	0.09	0.08
$CaCO_3$, %	11.71	30.4	22.1	20.7
Org. matter, %	0.8	4.21	2.85	2.7
CEC, me/100g	8.3	34.3	24.7	21.3
P, mg kg^{-1}	1.85	52.68	18.37	16.5
Fe, mg kg^{-1}	1.18	7.85	5.3	5.12
Zn, mg kg^{-1}	0.38	1.08	0.51	0.5
Mn, mg kg^{-1}	0.8	7.85	9.42	5.36
Cu, mg kg^{-1}	0.2	2.3	0.98	0.88
B, mg kg^{-1}	0.129	3.227	0.59	0.56

this limit, 32 % of the study soils are deficient in Fe. The risk of Fe deficiency is less pronounced in clayed soils but one should consider high bicarbonate content in these types of soils (Lindsay and Norwell, 1978).

The available Zn content of the study soils ranged from 0.38 to1.08 mg kg^{-1}. According to limits reported, approximately 77 % of these soils are deficient in Zn. Soil Mn content ranged from 0.80 to 7.85 mg kg^{-1}. According to limit (1 mg kg^{-1} Mn) reported 84 % of the study soils have sufficient Mn. The soil Cu content ranged form 0.20 to 2.30 mg kg^{-1}. According to limit (1.20 mg kg^{-1} Cu) the soils have enough Cu for plant growth (Lindsay and Norwell, 1978).

Many times the factor limiting the plant growth is a deficient nutrient in soil. We believe that the use of Zn and Fe fertilizers should be increased by demonstration studies and other researches.

The monthly mean sugar content values used in this study were obtained from sugar contents in adequate numbers of sugar beet samples taken from the areas of sugar beet planting in Konya (Cumra) region in July-October period in 2005-2006 by Konya Sugar Institute Co., Konya. The climatic data were obtained from Cumra Meteorology region Institute Monthly mean sugar content and climatic values are given in Table 2.

Method

The TARIST package program developed by Aegean University Agricultural Faculty Field Crops Department was used to determine the relationships between sugar beet values and climatic factors and statistical evaluation about the direct and indirect effects of climatic factors on sugar content.

Results and Discussion

According to the regression analyses, climatic factors had statistically significant effects on sugar content at 5 % significance level. Climatic data had significant effect on sugar beet in July-October period. This indicates the variation in sugar content changes depending on the climatic data.

It was determined whether there is a relationship between the dependent variable sugar content and 7 independent variables in the years 2005-2006 [x_1=rainfall (mm); x_2=temperature (^oC); x_3=relative humidity (%); x_4=soil temperature (^oC); x_5=cloudiness; x_6=the amount of evaporation (Pis.); x_7=wind veloc-

Table 2
Monthly mean sugar content and climatic values

Years	Month	Rainfall, mm	Temperature mean, ^oC	Relative humidity, %	Soil emp., ^oC20 cm	Cloudiness mean	The amount of evap.	Wind velocity	Sugar content, %
2005	July	4.8	24.3	47.1	27	2.3	6.7	0.4	11.5
	August	7.2	23.4	50	27.9	2.4	6.2	0.3	12.2
	September	0.2	18.8	49.9	23.8	2.6	5.2	0.1	13.3
	October	9.8	13.5	61.3	17.5	3.5	2.9	0.2	16.9
2006	July	0.1	25	47.5	26.8	0.3	7.6	0.3	10.4
	August	1.9	22.1	57	26	1.3	6	0.6	11.95
	September	1.8	18.4	57.8	23.1	1.8	5.2	0.2	14.35
	October	33.7	10.9	69.7	14.7	4	2.3	0.2	16.65
	Min.	0.1	10.9	47.1	14.7	0.3	2.3	0.1	10.4
	Max.	33.7	25	69.7	27.9	4	7.6	0.6	16.9
	Mean	7.73	19.55	55.03	23.35	2.27	5.26	0.29	13.4
	Median	3.35	20.45	53.5	24.9	2.35	5.6	0.25	12.75

Table 3
Regressions equations

2005		2006	
Regression Equations	R-sq	Regression Equations	R-sq
$Y = 11.8 + 0.298\ x_1$	25.60%	$Y = 12.0 + 0.140\ x_1$	68.50%
$Y = 22.9 - 0.473\ x_2$	95.40%	$Y = 21.8 - 0.443\ x_2$	96.90%
$Y = -5.99 + 0.374\ x_3$	96.10%	$Y = -3.21 + 0.285\ x_3$	89.50%
$Y = 25.5 - 0.498\ x_4$	95.50%	$Y = 23.9 - 0.465\ x_4$	88.10%
$Y = 1.69 + 4.37\ x_5$	99.30%	$Y = 10.2 + 1.69\ x_5$	92.80%
$Y = 20.9 - 1.42\ x_6$	99.50%	$Y = 19.7 - 1.20\ x_6$	94.60%
$Y = 16.0 - 10.1\ x_7$	29.50%	$Y = 15.9 - 7.90\ x_7$	29.70%

x_1=rainfall (mm); x_2=temperature (^oC); x_3=relative humidity (%); x_4=soil temperature (^oC); x_5=cloudiness; x_6=the amount of evaporation (Pis.); x_7=wind velocity ($m.sec^{-1}$ at 10 meter)

ity ($m.sec^{-1}$ at 10 meter]; The regression equations were determined (Table 3).

As the regression equations imply, there are significantly important ($p<0.01$) relationships between sugar content and temperature, relative humidity, soil temperature, cloudiness mean, the amount of evaporation in the year 2005. Seven independent variables account for 97.2 % of the variability in % digestion

Table 4
The correlation coefficients and the percent effect of direct and indirect path coefficients determined for the relationships between monthly (July-October) sugar content and climatic values for 2005 and 2006^

Years	2005	2006	2005		2006	
Climatic values	Cor. coefficients	Cor. coefficients	Effect of direct, %	Effect of indirect, %	Effect of direct, %	Effect of indirect, %
Rainfall, mm	0.680*	0.528	44.70%	Temperature 56%	23%	Temperature 73% Relative Humi. 4%
Temperature, ^oC	-0,898**	-0,980**	91%	Rainfall 9%	76%	Rainfall %20 Relative Humi. 4%
Relative humidity, %	0.770*	0.546	-----	Rainfall 14% Temperature 86%	4%	Rainfall 20% Temperature 76%
Soil temperature, ^oC	-0,877**	-0.539	2%	Rainfall 8% Temperature 90%	4%	Rainfall 22% Temperature 74%
Cloudiness mean	0.900**	0.673*	1%	Rainfall 12% Temperature 87%	-----	Rainfall 34% Temperature 66%
The amount of evaporation, pis.	0.998**	-0,770*	10%	Rainfall 11% Temperature 79%	20%	Cloudiness 32% Temperature 48%
Wind velocity, $m\ sec^{-1}$ at 10 m	0.700*	-0.545	10%	Rainfall 35% Temperature 55%	23%	Cloudiness 27% Temperature 50%

^ Values are means of 3 samples

* and ** indicates the significance of R^2 at p= 0.05 and p= 0.01, respectively.

for the year 2005.

There are significantly important ($p<0.05$) relationships between sugar content and temperature, cloudiness mean and the amount of evaporation in regression equations for the year 2006. The seven independent variables account for 94.7 % of the variability in sugar content for 2006.

The correlation coefficients and the percent effect of direct and indirect path coefficients determined for the relationships between monthly (July-October) sugar content and climatic values for 2005 are given in Table 4.

According to path analysis results, for the negative and significant relationships between sugar content and temperature and the amount of evaporation, the correlation coefficients were 0.898 and 0.998, respectively; 91.65 % and 10.20 % of these correlation coefficients were due to direct effects and 8.35 % and 89.80 % of them were due to indirect effects, respectively.

The highest percentage for the direct effects was due to temperature (79.10 %).Reported that sugar accumulation and sugar content decrease in very dry periods because the leaves loss water and deform and the stomates close (Tortopoglu**,** 1994). Furthermore, there are significant relationships between sugar content and cloudiness mean and the wind velocity ($r=0.900^{**}$ and $r=-0.700^{*}$, respectively). The 1.00% and 10.00% of the correlation coefficients were due to direct effects and 99.00% and 80% of the correlation coefficients were due to indirect effects, respectively. Determined that sugar beet yield is positively affected when the sunny and cloudy days follow each other (Arioglu and Halis, 1997).

On the other hand, the 44.17% of the correlation coefficient (0.630) for the positive and significant relationship between sugar content and rainfall is due to direct effects and the remaining 55.83% is due to indirect effects.

The summer rainfalls bring cool weather and decrease extreme daily temperatures above 29^{o}C thus increase sugar accumulation period in sugar beet and sugar content. Similar observations were made (Gezgin and Uyanoz**,** 1995).

According to path analysis results, the relative humidity does not have an effect on sugar content; the direct effects of soil temperature and wind velocity are very low (2% and 10%, respectively). The indirect effects of these properties are more important. The temperature effect is more pronounced in terms of indirect effects (83% and 55%, respectively). The correlation coefficients and the percent direct and indirect path for the relationship between sugar content and climatic values for 2006 are given in Table 3.

Conclusion

According to these results, especially temperature, cloudiness mean and partially rainfall among the selected climatic parameters have high direct effects on sugar content in sugar beet grown in Konya (Cumra). For this reason, these climatic parameters should be taken into account when estimating the sugar content of sugar beet. Furthermore, the sugar content of sugar beet is affected by climatic factors widely in addition to management practices such as fertilization, irrigation, and crop protection.

According to path analysis results, the correlation coefficients for the relationships between sugar content and temperature and the amount of evaporation are negative and significantly important ($r=-0.980^{*}$ and $r=-0.770^{*}$, respectively). The 76.00% and 2.00% of these correlation coefficients were due to direct effects and 24.00% and 98.00% of them were due to indirect effects, respectively. The correlation coefficient for the positive and significantly ($p<0.05$) important relationship between sugar content and cloudiness_mean does not have a direct effect; the indirect effects are via rainfall and temperature (34% and 66%, respectively). There is positive but insignificant relationship between sugar content and rainfall, the relative humidity; there is negative but insignificant relationship between wind velocity and soil temperature.

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