Available online at www.sciencedirect.com
ScienceDirect
Agriculture and Agricultural Science Procedia 10 (2016) 67 – 75
Agriculture and Agricultural Science Procedia

5th International Conference "Agriculture for Life, Life for Agriculture"

Changes of dry matter, biomass and relative growth rate with different phenological stages of corn

Yakup Onur KOCA*, Osman EREKUL

Adnan Menderes University, Faculty of Agriculture, Department of Crop Science, Aydın – 09100, Turkey

Abstract

Crop growth period and the length of the phenological stages on plant are directly affected by climate condition. Therefore, seasonal climate fluctuations such as maximum and minimum daily temperature changing and precipitation rates are important for quantity of annual corn production in Mediterranean area. This study was carried out to determination of dry matter, biomass, relative growth rate (RGR) values in eleven phenological stages [4 leaf (V4), 8 leaf (V8), 12 leaf (V12), 16 leaf (V16), tasseling (VT), silking (R1), blister (R2), milk (R3), dough (R4), dent (R5) and maturity (R6)] of corn during the period 2005, 2006 and 2007 in Aydın location, which is characteristically Mediterranean weather condition in Turkey. Additionally, calculated growing degree days (GDD), per ear weight, plant and ear height (cm), blank tip of ear (shriveled remnants of kernels because of ineffective pollination) (cm) were measured throughout the phenological stages. The data of the study is average of 31G98 and 32K61 corn hybrids value. It is seeming that a significantly differences amongst the years which the field study establishment. All properties except to per ear weight were significantly affected to years. Maximum dry matter and biomass values on the phenological stages were measured in 2005. Maximum per ear weight, plant and ear height values were also obtained from the first year of the experiment. However maximum blank tip of ear value was obtained from 2007. It is suggested that three parameters should be used for yield estimating and determination of biomass and dry matter values among phenological stages of corn. These parameters are: (i) calculating GDD values, (ii) rainfall amounts and air humidity of the years and (iii) determining the number of days when daily temperature rises above 37.5°C during growth in stages of corn.

Peer-review under responsibility of the University of Agronomic Sciences and Veterinary Medicine Bucharest

Keywords: air humidity; dry matter; rainfall amounts; GDD; ear weight; critical temperature limit.

* Corresponding author. Tel.: +90-545-510-5128; fax: +90-256-772-7023.
E-mail address: koca2002@hotmail.com

Peer-review under responsibility of the University of Agronomic Sciences and Veterinary Medicine Bucharest
doi:10.1016/j.aaspro.2016.09.015

1. Introduction

Corn is an important crop for both human consumption and poultry feed as well as increasing production value and harvested area year by year. Nowadays it is one of three most cultivated plants in the world. Despite increasing the productions, local demand (our consumption of Turkey) can't be met for many years and corn import necessity has raised in Turkey (Anonymous, 2013). The demand should be met by only increasing local production.

Plant growth analysis is still basic and certain method to evaluate the contribution of different physiological stages during vegetative and generative periods (Sharifi and Zadeh, 2012). Because of its simple primary data in the form of weights, areas, volumes and contents of plant components to investigate processes within and involving the whole plant (Hunt et al., 2002). Some properties have also been determined in several studies such as dry matter, biomass, RGR, crop growth rate to determination of environmental (temperature, precipitation rate, air humidity etc.) effects on ear yield (Edwards et al., 2005; Sharifi and Pirzad, 2011). The canopy size impact on the absorption of radiation. So the relationship effects dry matter accumulation and yield (Dadashi et al., 2014). Total dry matter is influenced by RGR (Egly and Guffy, 1997). Ozturk et al. (2014) has shown that the effects of different environmental conditions provided with change light intensity changed to RGR values. In addition to the study, it is reported that during plant growth stages RGR values are interrelated to dry matter accumulation and crop growth rate (Wiersma, 2002; Sharifi et al., 2014).

The weather conditions in Mediterranean region is dramatically changing from year to year and plants which are growing around the region are affected by these changeable environmental conditions conducted by Mallet (2008), so does corn. Effective temperature rate on corn plant, light intensity and air humidity during growing period are shown volatility values. Sometimes effective rainfall rates are very low in the growing season of year and the rates are not similar every year. The result which normal air humidity values are approximately 60% for corn is conducted by Abendroth et al. (2011). Therefore, ideal pollination and corn seed development may be effected by extreme air humidity values (high or low) in the growing period (Van Hout et al., 2008). These factors affect biomass, dry matter assimilation and all the growth parameters. Because of changes in regional climate conditions from year to year corn production is affected directly by them.

The objective of this study is to determine the effect of different environmental conditions from year to year the growth parameters of corn. Moreover, it is defined that relationship between corn yield, agronomic characteristics and some growth parameters which were effected with periodic (short-term) climate changes.

2. Materials and Methods

The research has been carried out during 2005, 2006 and 2007 in summer growth periods at the experiment farms of the Adnan Menderes University, Agriculture Faculty in Aydin with typical Mediterranean climate (hot summer and mild winter), located in west Turkey at 37º 44' N 27º 44' E at 65 m above sea level. Monthly temperature, precipitation and air humidity values for 2005, 2006 and 2007 and long term average (temperature and precipitation) are presented in Table 1. Monthly temperatures in growing season of the third year were greater than the first and the second years. Moreover, monthly precipitation values in growing season of third year (by including January, February and March) were lower than the other years. Therefore, we said that growing season of the third year was really hot and dry for ideal development of corn. Furthermore, the air humidity values in 2007 (growing period) were lower than approximately 60% for ideal pollination and corn seed development (Abendroth et al., 2011).

Analysis of the sample soil taken from the experiment area has revealed that the soil is sandy-loam with reactive alkaline character (pH 8.0) and low organic matter content (%1.8). When soil properties are examined it can be seen that nutrient content of the soil is considered K amount is high with 300 ppm and P amount (16 ppm) is medium. Before sowing of the plant materials, 500 kg ha^{-1} of 15-15-15 (75 kg ha^{-1} N, 75 kg ha^{-1} P_2O_5 and 75 kg ha^{-1} K_2O) and before first irrigation, 300 kg ha^{-1} of urea fertilizers (138 kg ha^{-1} N) were applied.

Irrigation scheduling was based on the percentage depletion of ASW (available soil water) in the root zone. Soil moisture was determined in soil layers that are 0–30 cm, 30-60 cm and 60-90 cm depth by gravimetric method. Therefore, soil which was collected from the field experiment area [(0-30 cm, 30-60 cm and 60-90 cm depth (Rd)] was put into pots. The water content of the soil after being saturated by irrigation and allowed to drain is called field capacity (FC). Crop can no longer take up water from the soil is referred wilting point (WP). The water held by the soil between field capacity and the permanent wilting point is considered as available water (AW). Corn is capable of using 50% of the available water. Irrigation water requirement (100 mm) was calculated with the following formulas (Martin and Gilley, 1993; Lamm et al., 1994).

$$AW = Rd\ (FC\text{-}WP)\ 100^{-1}$$

Table 1. Average and total climate data values for the experiment's three years and regional long term period

Year	2005			2006			2007			Long term (1975–2014)	
Months	Tem. (°C)	Precip. (mm)	Hum. (%)	Tem. (°C)	Precip. (mm)	Hum. (%)	Tem. (°C)	Precip. (mm)	Hum. (%)		
January	9.4	62.2	78.4	6.8	90.6	76.1	8.9	29.4	66.1	8.2	121.0
February	8.2	155.7	76.4	9.3	109.1	76.0	10.0	30.0	70.4	8.9	95.5
March	12.1	92.6	71.8	12.1	115.7	72.9	13.3	26.4	59.3	11.7	71.1
April	15.7	39.8	66.7	17.2	19.5	65.4	16.2	16.4	47.0	15.7	45.5
May	21.1	61.1	65.9	21.6	0.7	56.2	22.8	44.5	49.8	20.9	33.5
June	25.3	7.9	59.2	26.2	1.1	51.5	27.7	9.4	41.8	25.9	14.0
July	28.8	9.3	59.8	28.2	4.4	51.8	30.3	-	34.7	28.4	3.5
August	28.2	12.6	62.8	28.7	0.2	52.6	29.3	-	43.5	27.2	2.2
September	23.5	0.5	64.1	24.0	13.6	58.5	24.3	-	44.6	23.2	14.4
October	17.0	39.2	70.1	18.9	81.7	69.8	19.6	134.2	64.3	18.4	47.5
November	12.1	160.4	73.8	12.1	76.7	71.0	12.8	160.4	79.5	12.9	74.4
December	10.7	38.2	75.3	8.7	6.0	69.4	7.9	184.6	81.2	9.4	135.1
Average /Total	17.6 (Ave.)	679.5 (Tot.)	68.6 (Ave.)	17.8 (Ave.)	519.3 (Tot.)	57.9 (Ave.)	18.6 (Ave.)	635.3 (Tot.)	56.9 (Ave.)	17.5 (Ave.)	657.7 (Tot.)

Tem.: temperature, Precip.: precipitation, Hum.: air humidity

2.1. Experimental design

The experimental design was randomized block arrangement in four replications. For both crops plots of length 7m and 20 rows have been planted. The row spacing was set to be 70 cm and the intra row spacing was set to be 17.5 cm. The plot area during plantation was 98 m^2, 10 rows in the middle of the plot (49 m^2) were separated for yield and components such as per ear weight, plant and ear height (cm) and blank tip of ear (shriveled remnants of kernels because of ineffective pollination). Other properties and physiological observations in eleven phenological stages (GDD, dry matter, biomass and RGR) were measured on the side 8 rows.

During the experiment years, sowing dates have been determined as 25.04.2005, 28.04.2006 and 28.04.2007 and the emergence dates have been determined as 01.05.2005, 07.05.2006 and 06.05.2007. P31G98 corn hybrid in the FAO 680 group and 32K61 corn hybrid in the FAO 600 group were used to material of the study. The data of the study is average of P31G98 and 32K61 corn hybrids values.

2.2. The traits measured and calculated in this research

Growing degree days (GDD): Plant development subjected to stress of certain extreme temperature ranges either too high or too low results in stress during the period of development (Zachary, 1999). It is rather simple to calculate and then add up the daily growing degree days to know exactly what is happening to crop development. It was reported that the value of temperature in the range of: 10oC and 30oC for corn plants created optimum conditions with rapid development of the plant at temperatures around 30°C. Many researchers have developed the following formula to calculate GDD values for corn and determined using the following equilibriums according to Germany et al. (1996).

$$GDD = [(Tmax. + Tmin.)/2] – Tbase$$

Tmax.: Daily maximum temperature (up limit 30°C), Tmin.: Daily minimum temperature (down limit 10°C), Tbase: for corn 10°C

In order to understand the interactive effects of daily temperature variations on plant growth we observed and recorded the temperature during the two years to better understand the relationship between corn plant growth and daily effective temperature, GDD values. These were calculated to clearly explain how the daily range of temperature of both upper and lower limits affects growth and ultimately yield.

The number of days that temperature values exceeded the limit value for C4 plant is presented in Table 2. Data showed upper point indicated at 37.5°C and critical upper at 40°C. Table 2 indicated of number of days that temperature exceeded the limit of range during the three years of this experiment (Crafts-Brandner and Salvucci 2002).

Table 2. The number of days which daily temperature upper point indicated at 37.5°C and critical upper at 40°C in months

	2005		2006		2007	
	37.5°C	40°C	37.5°C	40°C	37.5°C	40°C
May	-	-	1	-	2	-
June	-	-	8	-	13	6
July	17	2	11	-	22	5
August	7	4	15	4	18	5
Total	**24**	**6**	**35**	**4**	**55**	**16**

Ear weight (g): Per ear weights were taken by weighting 20 ears selected from each parcel and were averaged (both P31G98 and 32K61).

Plant height (cm): Pre-harvest plant height was measured with 30 plant from parcel (both P31G98 and 32K61).

Ear height (cm): Post-harvest ear height was measured with 30 ear from parcel (both P31G98 and 32K61).

Blank tip of ear (cm): Blank tip of ear is one of the important problem caused yield loss with kernel set stem from ineffective pollination, kernel abortion, or both (Anonymous, 2008). Therefore, post-harvest, blank tip of ear was measured with 30 ear on which measured ear height from parcel (both P31G98 and 32K61).

Dry matter, biomass and RGR (relative growth rate): During the growing period, biomass and dry matter values were measured from the sampled 10 plants. Sampling was made for 5 times throughout the vegetative growth period of corn [(4 leaf (V4), 8 leaf (V8), 12 leaf (V12), 16 leaf (V16), tasseling (VT)] and 6 times throughout the generative growth period [(silking (R1), blister (R2), milk (R3), dough (R4), dent (R5) and maturity (R6)] (Bean and Patrick, 2007). Sampling dates during the corn growing period is presented in Table 3.

Table 3. Sampling dates during the corn growing period for biomass and dry matter measurements

Growing Stages	Dates		
	2005	2006	2007
4 leaf	May 11th	May 19th	May 17th
8 leaf	May 31th	June 07th	June 06th
12 leaf	June 13th	June 20th	June 19th
16 leaf	June 23th	June 29th	June28th
Tasseling	June 30th	July 05th	July 05th
Silking (R1)	July 03th	July 08th	July 08th
Blister (R2)	July 11th	July 15th	July 15th
Milk (R3)	July 25th	July 29th	July 28th
Dough (R4)	Aug 06th	Aug 10th	Aug 10th
Dent (R5)	Aug 19th	Aug 22th	Aug 22th
Maturity (R6)	Aug 31th	September 03th	September 01th

In predetermined growing stages, 10 plant for the measurement of total weight and the dry matter were cut from the root collar and divided in leaf, stem and ear. The samples were weighted to determine biomass values in the growing stage. The samples were held at 70°C for 48 hours to determine dry matter in the growing stage (Perry and Compton, 1977). The dried samples were weighed. Thus the dry matter in a plant was determined. Relative growth rate (RGR) were calculated by placing the measured dry matter amount and growing season length (day) places in the formula. The formulas of the calculated parameter are given below (Kassem, 2013).

Relative growth rate (RGR) [g kg^{-1} DM d^{-1}] = (1/W) X (ΔW/Δt) (Hunt et al., 2002).

(W: total dry weight, ΔW: dry matter increase amount, Δt: Time difference)

2.3. Statistical analysis

All data (per ear weight, plant height, ear height and blank tip of ear) collected from the treatments were statistically analyzed using the TARIST package software (Açıkgöz et al., 2004) as a randomized block design with four replications using analysis of variance to evaluate the effect of different years on the corn. Means among treatments were compared using Least Significant Difference (LSD) at $P \leqslant 0.05$ probability.

3. Results and Discussions

GDD values and length of each phenological stages were calculated for all phenological stages during corn growing period and were presented in Table 4. Although total length of growing period in 2005 was the biggest of the experiment, total GDD of 2005 was the second biggest value of the experiment. Third year of the experiment (2007) was given the biggest GDD value. Besides GDD values of 6 phenological stages [(4 leaf (V4), 12 leaf (V12), 16 leaf (V16), tasseling (VT), milk (R3), dough (R4)] in 2007 were bigger than the others. In addition, the number of days that temperature values exceeded the limit value for corn plant conducted by Crafts-Brandner and Salvucci (2002) is presented in Table 2. Number of days upper 37.5°C and critical 40°C during 2007 growing season was higher than other years (2005 and 2006). Therefore, we said that in growing period in 2007 corn plants were exposed to higher temperature (from GDD) and heat stress (number of day upper 37.5°C and critical 40°C).

Table 4. Day length and GDD value of different corn phenological stages during in 2005, 2006 and 2007

Growing Stages	2005		2006		2007	
	Length (day)	GDD	Length (day)	GDD	Length (day)	GDD
4 leaf	10	99	12	118	12	169
8 leaf	20	250	19	268	20	247
12 leaf	13	168	13	167	13	186
16 leaf	10	141	9	144	9	155
Tasseling	7	103	6	95	7	111
Silking (R1)	3	47	3	42	3	46
Blister (R2)	7	122	7	108	7	109
Milk (R3)	14	222	14	223	13	224
Dough (R4)	12	200	13	187	13	206
Dent (R5)	13	199	12	195	12	194
Maturity (R6)	12	186	12	183	10	170
Total	**121**	**1737**	**120**	**1730**	**119**	**1817**

Least Square means of measured parameters (ear weight, plant height, ear height and blank tip of ear) was calculated through variance analysis (Table 5). It was found that year provided significant different results for all parameters expect of ear weight parameter. Average values of parameters and calculated LSD values of the important ones among variation resources are presented under the Table 6.

As it shown in Table 6, the average of plant height was 224.9 cm. The highest plant height value (256.8 cm) obtained from the first year and the lowest value (195.5 cm) was obtained from the third year of the experiment. The second year value (222.3 cm) of the experiment was located between the first year and the third year value. Precipitation rate which can be used to estimate the amount of water stress is used to explain variation in yields. It is an indirect indicator for soil moisture and also affects some morphological properties besides yield (Tabor, 2000). Lower monthly precipitation rate during the last months of 2006 (November and December) and at the early of 2007 (January, February, March and April) influenced plant height. We can say that increment in plant height was rapid on suitable conditions according to distribution of monthly precipitation rate within the year.

Table 5. Combined analysis of variance (mean squares) of Plant height, Ear height, Blank tip of ear, Ear weight

Variance source	Plant height	Ear height	Blank tip of ear	Ear weight
Year	3779,9**	179,8**	0,7*	372,6ns
Error	53,4	11,9	0,1	102,0

** P<0.01; * P<0.05, ns: insignifiant

Ear height values of corn were presented in Table 6. The average of plant height was 109.0 cm. The highest plant height value (114.2 cm) obtained from the first year and the lowest value (101.4 cm) was obtained from the third year of the experiment. The second year value (111.4 cm) of the experiment was located between the first year value and the third year value.

Table 6. Obtained mean values of investigated yield parameters

Year	Plant height (cm)	Ear height (cm)	Blank tip of ear (cm)	Ear weight (g)
2005	256,8	114,2	1,8	163,3
2006	222,3	111,4	1,8	152,8
2007	195,5	101,4	2,5	144,0
Average	224,9	109,0	2,0	153,4
LSD	**12,7**	**6,0**	**0,6**	**ns**

Blank tip of ear values of corn was presented in Table 6. The average of blank tip of ear was 2.0 cm. The greatest blank tip of ear value (2.5 cm) obtained from the third year. First and second years of the experiment were showed same value (1.8 cm). Poor seed number is determined in pollination date from Anonymous (2008) and through the early stages of kernel development stages (2 to 3 weeks after pollination). These dates were indicated July in all years of the experiment. But extreme hot weather (upper point 37.5^{o}C and critical upper at 40^{o}C showed Table 2) were appeared in 2007. Besides very low air humidity rates also were observed in 2007 (Table 1). If the relative humidity is too low at this stage after that the stigma or the pollen can desiccate as a result of which prevents the germination of the pollen. Abnormal humidity rates (low or high) have been found to be culprit in a poor seed set (Ozores-Hampton and McAvoy, 2010; Abendroth et al., 2011). Therefore, poor kernel set is not surprising for us that are obviously the severely stressed in 2007.

Because of influenced directly the final grain yield, per ear weight is one of the significant properties for corn (Min, 2012). Ear weight values of corn were presented in Table 6. The average of ear weight was 153.4 g and maximum ear weight (163.3 g) was registered in the first year of the experiment (2005). Than average of ear weight in 2006 (152.8 g) and 2007 (144.0 g) were ordered according to size. Precipitation rate of four months (January, February, March and April) in 2007 was very low. Besides air humidity rate during generative phases (June, July and August) was lower than normal. For these reason lack of water in the soil at the seedling stage of plant and low air humidity during the generative phases damaged standard corn plant growth and obtained finally yield. Stomatal closure occurs in response to a number of environmental factors, most notably darkness, low air humidity and high temperature (Willmer and Fricker, 1996). Low humidity and heat stress affect negatively stomatal density (Beerling et al., 1997), leaf-air vapor pressure difference (Lawsonet al., 2002) and water use efficiency (Ferris et al., 1996) correspondingly many physiological and morphological properties (Boccalandro et al., 2009). Therefore, all measured parameters (plant height, ear height, blank tip of ear and ear weight) in 2007 were lower than 2005 and 2006. We said that abiotic stress factors were really affected corn growing. It is also claimed that environmental conditions are very important for the corn plant growing and yield production.

Biomass and dry matter are important signal that indicative of environmental factors and condition of corn growing. Dry matter movements during the vegetative and generative period (eleven phenological stages) were presented Figure 1 and biomass movements were also presented Figure 2. Dry matter and biomass values were divided in leaf, stem and ear. Calculated RGR values movements of corn plant during the experiment (3 years) were presented Figure 3.

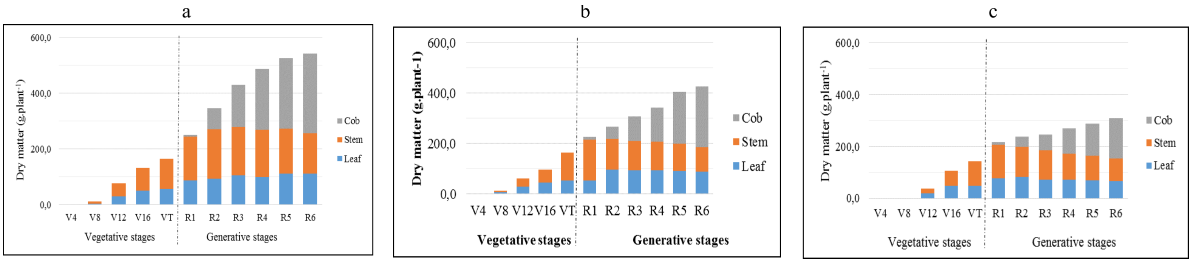

Fig. 1. Average of dry mater at different phenological stages of corn in 2005 (a), 2006 (b) and 2007 (c).

Dry matter production increased from emergence until maturity of the corn plant in all years. The greatest dry matter value was given physiological maturity stage in 2005 (542.6 g plant-1), second year and third year values in physiological maturity were listed according to size as 425.9 g plant-1 and 309.1 g plant-1 respectively (the data not presented). Dry matter values in 2007 growing season was much less than 2006 and 2005 years (Figure 1). A sharp increase was achieved till the early fruiting stage where the dry matter was allocated to different parts of the corn plant (leaves and stem). Measured dry matter of ear was beginning from R1 stage to R6 stage. Initial dry matter value of ear was low during R1 stage and maximum value was achieved by R6 stage continuously increased in further stages of seed. Dry matter of ears on the R6 stage was greater than total of the other plant parts (leaf and stem) in 2005 and 2006. At vegetative stages of corn (R1, R2, R3, R4, R5 and R6) the dry matter allocation was confined only for ear development in these years. But dry matter of plant parts (ear: 155.3 g, total of stem and leaf: 153.8 g) calculated on the R6 stage in 2007 were nearly equal (the data not presented). The majority of dry matter which accumulating in the stems and leaves during vegetative period is transported ear and seed of corn during generative period under suitable growing conditions. If biotic or abiotic stress factors show up, the dry matter transport and healthy life cycle of plant may be affected negatively. These results were advised us about plants life cycle and about whether under stress conditions or not during the generative period of corn. Field conditions in 2007 is really unsuitable for corn growth.

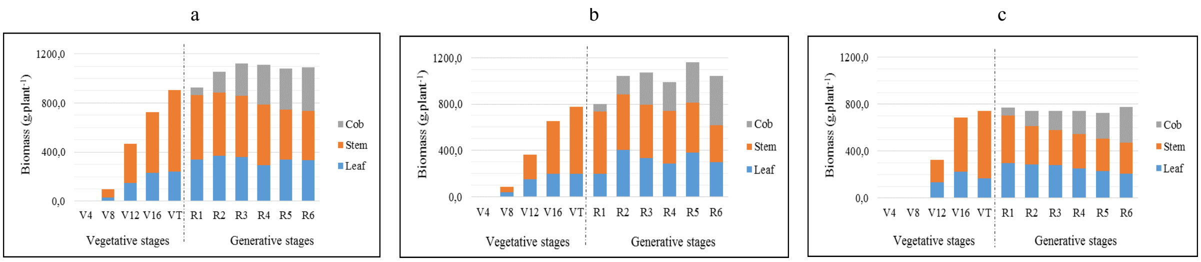

Fig. 2. Average of biomass at different phenological stages of corn in 2005 (a), 2006 (b) and 2007 (c).

In growth stages biomass change showed in all years of the experiment Figure 2. Maximum biomass values (g) during the growing season were measured in the first year of the experiment (2005) except V4, R5 and R6 phenological stages. It was indicated that biomass (g $plant^{-1}$) began with minimum value at seedling and smoothly increased till the silking (R1) stage in all years. After that, some phenological stages (R4 and R5 stages in 2005, R4 and R6 stages in 2006 and R2, R3 and R5 stages in 2007) were showed that biomass rate decreased. The change in biomass rate (decrease) was extremely appeared steam and leaf values in the three years. Ear biomass values were never decreased began R1 stage to R6 stage during all year.

Relative growth rate showed for growing stages in Figure 3. Generally, RGR were higher in the early stages of growth and it was nearly maintained until R1 stage. RGR value exhibited peak of maxima during R1 stage in the all years of the experiment. And then a pretty hard decline was appearance with the advancement of growing season (R2, R3, R4, R5 and R6 stages) in all years. It was indicated that in early stages of growth RGR of crop remained higher and it declined in advancement of age (Tan et al., 1978). At mature stage of corn (R6), it declined to a minimum value in all years of the experiment except 2007. Minimum RGR value raised during milk stage in 2007. RGR is the fundamental parameter, which provides one of the most ecologically significant and useful indices of plant growth (Talukder et al., 2001). Beside it is confirmed that importance of RGR in the adaptation of the plant to its environment (Burdon and Harper, 1980). Our result was compatible with those studies. Hence it was indicated that 2007 growing season had extremely unsuitable environmental factors for corn growing.

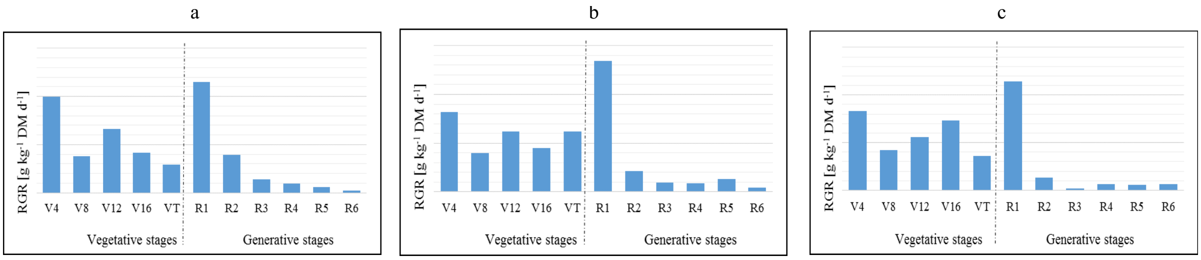

Fig. 3. Average of RGR values at different phenological stages of corn in 2005 (a), 2006 (b) and 2007 (c).

4. Conclusions

The purpose of the study is determining to accurately predict yield of maize via biomass, dry matter and RGR values and some morphological characteristics such as plant height (cm), ear height (cm), blank tip of ear (cm) under the weather conditions in Mediterranean region which is dramatically changing from year to year. Firstly, our determination for maximum yield that it should be ideal air humidity value (approximately 60%) and monthly precipitation rate during growing season (by including January, February and March) rather than high daily air temperature and GDD values. Secondly ensuring optimal growing under favorable conditions that minimize environmental stress and allow yields to approach yield potential levels. And we were concluded on the basis of growth parameters such as dry matter, biomass and RGR data that this new material could support to increase seed size and seeds number per ear (decrease blank tip of ear) could be achieved. Especially three parameters came into prominence; rainfall amounts and air humidity of the years and determining the number of days when daily temperature rises above 37.5^{o}C during growth stages (especially in flowering and grain filling period) of corn. All yield parameters had the lowest value and blank tip of ear which determines the number of grains per ear had the highest value that effected yield adversely in 2007. Similarly, rainfall amounts and air humidity values are also examined the lowest air humidity and rainfall amount (especially in March and April) values than other two years. On the other hand, there was an increase at critical daily temperatures (totally upper 37.5^{o}C: 55 and critical 40^{o}C:16) in the last year of the experiment. These exorbitant temperatures basically effect flowering and grain filling periods of corn and as a result of this, low yield and high blank tip of ear values are obtained. Although GDD values which gives information about crop growth; were calculated highest result in 2007. Finally, the effect of GDD values for estimation yield has lower effect than other two parameters (critical temperatures and air humidity, rainfall amount).

Acknowledgements

This study was inspired from a part of the PhD thesis of Yakup Onur KOCA in Aydın location of Turkey and also was financed from BAP (project no: ZRF–6011).

References

Abendroth, L., Elmore, R., Boyer, M., Marlay, S., 2011. Corn growth and development. Iowa State University Extension, PMR 1009.

Açıkgöz, N., İlker, E., Gökçöl, A., 2004. Biyolojik Araştırmaların Bilgisayarda Değerlendirilmeleri. ISBN: 973-483-607-8 E.Ü. Tohum Teknolojisi Araştırma ve Uygulama Merkezi Yayın No:2 Bornova-İzmir.

Anonymous, 2013. Turkish Grain Board, Grain Bulletins in 2013. http://www.tmo.gov.tr/Upload/Document/raporlar/2013 hububatsektorraporu.pdf.

Anonymous, 2008. Pest and Crop (agronomy tips). http://extension.entm.purdue.edu/pestcrop /2008/issue19/.

Baroli, I., Dean Price, G., Badger, M., von Caemmerer, S., 2008. The contribution of photosynthesis to the red light response of stomatal conductance. Plant Physiol 146: 737-747.

Bean, B., Patrick, C., 2007. Corn Development and Key Growth Stages. Http://lubbock.tamu.edu/corn/pdf/corndevstages.pdf.

Beerling, D.J., Kelly, C.K., Salisbury, E.J., 1997. Stomatal density of temperature woodland plants over the past seven decades of CO2 increase: a comparison of Salisbury (1927) with contemporary data. Am. J. Bot. 84, 1572-1583.

Boccalandro, H.E., Rugnone, M.L., Moreno, J.E., Ploschuk, E.L., Serna, L., Yanovsky, M.J., Casal, J.J., 2009. Phytochrome B Enhances Photosynthesis at the Expense of Water-Use Efficiency in Arabidopsis. Plant Physiology, Vol. 150, p. 1083-1092.

Burdon, J.J., Harper, J.L., 1980. Relative growth rates of individual members of a plant population. Journal of Ecology 68: 953-957.

Coupe, S.A., Palmer, B.G., Lake, J.A., Overy, S.A., Oxborough, K., Woodward, F.I., Grayand, J.E., Quick, W.P., 2006. Systemic Signalling of Environmental Cues in Arabidopsis Leaves. Journal of Experimental Botany, Vol. 57, No. 2, p. 329-341.

Crafts-Brandner, S.J., Salvucci, E.M., 2002. Sensitivity of Photosynthesis in A C4 Plant, Maize, to Heat Stress. American Society of Plant Physiologists. 129 (4): 1773-1780.

Dadashi, F., Zaefarian, F., Abbasi, R., Bahmanyar, M.A., Rezvani, M., 2014. Response of leaf area and dry matter of crop, weeds and cover crops to competition and fertilizer resources. ActaagriculturaeSlovenica, 103 (1), pP: 27-36.

Edwards, J.T., Purcell, L.C., Vories, E.D., 2005. Light Interception and Yield Potential of Short-Season Maize (Zea mays L.) Hybrids in the Midsouth. Agron. J. 97, p: 225-234.

Egly, D.B., Guffy, R.D., 1997. Factors associated with reduced yields of delayed planting of soybean. Agronomy Journal, 159: 176-185.

Ferris, R., Nijs, I., Beaeghe, T., Impens, I., 1996. Elevated CO2 and temperature have different effects on leaf anatomy of perennial ryegrass in spring and summer. Ann. Bot. 78, 489-497.

German, A.B., Donald, G.B., Steven, E.H., 1996. Soil Temperature and Planting Date Effects on Corn Yield, Leaf Area, and Plant Development. Agronomy Journal 88: 385-390.

Hunt, R., Causton, D.R., Shipley, B., Askew, A.P., 2002. A Modern Tool for Classical Plant Growth Analysis. Annals of Botany 90: 485-488.

Kassem A.S.M., 2013. Effect of nutrient limitation on physiological and morphological plant traits related to growth and quality of tomato. PhD thesis, Humboldt University in Berlin, Faculty of Agriculture and Horticulture.

Lawson, T., Oxborough, K., Morison, J.I.L., Baker, N.R., 2002. Responses of Photosynthetic Electron Transport in Stomatal Guard Cells and Mesophyll Cells in Intact Leaves to Light, CO2, and Humidity.Plant Physiol. Vol. 128, p. 52-62.

Mallet, J., 2008. Hybridization, ecological races and the natureof species: empirical evidence for the ease of speciation. Philos. Trans. R. Soc. Lond. B 363: 2971-2986.

Min, Y., 2012. Analysis of Yield and Major Agronomic Characteristics of Hybrid Corn from Regional Trials in Guizhou Province. Guangxi Tropical Agriculture, Vol: 6, P: 513.

Miyazawa, S.I., Livingston, N.J., Turpin, D.H., 2006. Stomatal development in new leaves is related to the stomatal conductance of mature leaves in poplar (Populustrichocarpa x P. deltoides). J Exp Bot 57: 373-380.

Ozores-Hampton, M., McAvoy, G., 2010. “What causesblossom drop in tomatoes?” The Tomato Magazine 14(4): 4-5.

Ozturk, A., Demirsoy, L., Demirsoy, H., 2014. The Effect of Shading on Net Assimilation Rate and Relative Growth Rate in Strawberry. Anadolu J. Agr. Sci., 2014, 29(3): 167-173.

Perry, L.J., Compton, W.A., 1977. Serial Measures of Dry Matter Accumulation and Forage Quality of Leaves, Stalks and Ear of Three Corn Hybrids. Agronomy Journal 69: 751-755.

Sharifi, R.S., Pirzad, A., 2011. Study of Physiological Growth Indices in Maize (*Zea mays* L.) Hybrids under Different Plant Densities Application. Intl. J. Agric: Res & Rev. Vol., 1 (1), P: 26-32.

Sharifi, R.S., Raei, Y., Weisany, W., 2014. Study of physiological growth indices in maize (*Zea mays* L.) hybrids under different plant densities. International Journal of Biosciences. Vol. 5(3), p. 100-109.

Sharifi, R.S., Zadeh, N.N., 2012. Effects of plant density and row spacing on biomass production and some of physiological indices of corn (*Zea maize* L.) in second cropping. Journal of Food, Agriculture & Environment Vol.10 (3&4): 795-801.

Tabor, J., 2000. Prediction, Impact and Control Variables for Field Research Evaluation. For Food Aid Management, 300 I Street, NE, Suite 212, Washington, D.C.

Talukder, F.A.H., Chanda, S.C., Golam, S.A.K.M., Bhander, P.K., Islam, M.N., 2001. Early vegetative growth and fibre yield in Tossa Jute (Corchorusolitorius L.). Pakistan J. Biol. Sci. Vol. 4(6). P. 665-667.

Tan, G.Y., Tan, W.K., Walton, P.D., 1978. Effects of Temperature and Irradiance on Seedling Growth of Smooth Bromegrass. Crop Science, Vol.: 18/1, p. 133-136.

Van Hout, R., Chamecki, M., Brush, G., Katz, J., Parlange, M., 2008. The influence of local meteorological conditions on the circadian rhythm of corn (Zea mays L.) pollen emission.Agr.Forest Meteorol. 148, 1078-1092.

Wiersma, J.J. 2002. Determining an optimum seeding rate for spring wheat in Northwest Minnesota. Crop Management 18:1-7.

Willmer, C., Fricker, M., 1996. Stomata. In: Black, M., Charlwood, B. (Eds.), Topics in Plant Functional Biology. II. Chapman and Hall, London, p. 95-125.