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Comparison of Relative Growth Rates in Silage Corn Cultivars

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Abstract: This study was carried out, in Konya Bahri Dagdas International Agricultural Research Institute's practice and research land. In the study, silage corn varieties growth analyses were made which depending on time. Relative Growth Rates (RGR) were measured all cultivar and times. While these analysis making 5 plants were taken from each plot and measured on these plants. Richards, Logistic, Weibull and Gompertz growth models were used for evaluating. At the models comparing determination coefficient (R^2), mean square error were used. As a result this showed that RGR is different from growth features. Weibull function explained RGR better than other models for all of cultivars.

Key words: Growth models, relative growth rate, comparative criteria

INTRODUCTION

Analyzing the mean relative growth rate of seedlings is one method used to compare growth differences that arise from experimental treatments and the growth analysis takes in account: the increase of biomass per unit mass per day (RGR). Relative Growth Rate is affecting by three factors: the leaf area per unit leaf dry mass or Specific Leaf Area (SLA); the allocation of mass to leaves (light capture per unit plant mass) (LMF); the increase in biomass per unit leaf per day (unit leaf rate) (Hunt, 1982; Barbosa *et al*., 2009). Relative growth rate is an important characteristic of particular conditions of genotypes. A growth function for estimating RGR is an important part. Relative growth rate has been used as a measure of growth for young plants. RGR is defined as the ratio of growth of an organism and seedlings of plants were affected by conditions of day length, temperature, irradiance, relative humidity and mineral nutrient supply (Mahmoud and Grime, 2006).

Relative Growth Rate is an important character. It shows and describes the performance of whole plants systems under controlled or uncontrolled conditions. Because of that, it should be determined all plants. Especially, RGR should be used in plant breeding studies. RGR gives very important data about plant growth. RGR has been used to examine growth as affected by differing levels of fertilizers (Van Den Driessche, 1982), weed control (Brand, 1991), shading (Kolb and Steiner, 1990), soil moisture (Frederickson *et al*., 1993), carbon dioxide (Samuelson and Seiler, 1993), sulfur dioxide (Jensen, 1983) and ozone (Laurence *et al*., 1993). Relative Growth Rate is also used to compare differences due to genotype (Kolb and Steiner, 1990) and planting stock size (Haase and Rose, 1993). This technique is particularly viewed as useful when comparing seedlings that differ in size (Kozlowski *et al*., 1991). To examine relative growth rates is to determine which seedlings are more efficient (Brand, 1991). Today, many still believe that relative growth rate is the most important index of productivity (Radosevich and Osteryoung, 1987).

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Crop physiologists and geneticists like to quantify the two traits to characterize genotypic variation in response to growth environments, thereby assisting breeders in the design of crop varieties for target environments (Yin *et al*., 2003). In plant simulation modeling, modelers often wish to quantify the dynamics of growth, enabling the ultimate weight at the end of the growing cycle (Read *et al*., 2002). With the life cycle of an organ or a crop, the total growth duration can be divided into three sub-phases; an early accelerating phase; a linear phase and a saturation phase for ripening (Goudriaan and van Laar, 1994). Therefore, the growth pattern typically follows a sigmoid curve. It is the best way to use a curvilinear equation which gives a gradual transition from one phase to the next. RGR shows sigmoid curve in growth period of plants. Less is known, however, about the underlying mechanisms driving RGR differences among plant species. Understanding of RGR is critical for effective management for future. A mathematical analysis of the changes in plant relative growth rates necessary to increase aboveground production following growing was conducted.

The aim of the present study is to comparison RGR growth of some silage corn cultivars with sigmoid growth functions.

MATERIAL AND METHODS

This research was conducted in 2004-2005 growing seasons in Konya centre. In the research, three silage corn cultivars (TTM 813, ADA 9510 and ANT) were tested in completely randomized block design with four replications. These cultivars were cultivated Bahri Dağdaþ International Agricultural Research Institute experimental areas. Each plot was 3.0×5.0 m = 15 m^2. Planting distance was 0.75 m between rows and 0.25 m between plants and a plant population of 53 333 plants ha^{-1}. Single-row plots were used for the root pulling experiments while four-row plots were used for data collection on all other traits.

At planting P in the form of single super phosphate was applied at 80 kg ha^{-1} each; N was applied at 150 kg ha^{-1} in the form of urea. The N fertilizer was applied in two equal splits; 75 kg N ha^{-1} at planting and the other half 10 weeks after planting. Weed control were practiced two times by hand when plants reached to 15-20 and 35-40 cm. The data were gathered every week. For each measure, 5 leaves of plant that were randomly selected were used.

Plants were observed and measured every week for RGR. To comparison GRG growth of cultivars was used following growth models (Seber and Wild, 1989);

Logistic Function

$$Y = \frac{a}{1 + be^{-ct}}$$

where, y is mass, a upper asymptote, b and c are constants that determine the curvature of the growth pattern, t is times, the RGR is c/2.

Richards Function

$$Y = \frac{a}{[1 + be^{-ct}]^{1/d}}$$

where, y is mass, a upper asymptote, b and c are constants that determine the curvature of the growth pattern, t is times and RGR is c/(1+d). d is inflexion point parameter.

Gompertz Function

$$Y = ae^{-be^{-ct}}$$

where, y is mass, a upper asymptote, b and c are constants that determine the curvature of the growth pattern, t is times and RGR is equal to c.

Weibull Function

$$Y = a - be^{-ct^d}$$

where, a upper asymptote, b and c are amprical constants, defining the shape of the response. t; times RGR is k/a. d is inflexion point parameter.

Models were compared with determination of coefficient and mean square error. These criteria are given below:

$$\text{Determination of coefficient } (R^2) = 1 - \frac{\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2}{\sum_{i=1}^{n}(Y_i - \bar{Y}_i)^2}$$

$$\text{Mean Squares Error (MSE)} = \frac{\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2}{n}$$

Statistical analyses were done the STATISTICA V5 software package program.

RESULTS AND DISCUSSION

Estimated values of RGR varied among the tree genotypes (Table 1). For TTM 813 cultivar, weibull model had the highest RGR (0.062), for ADA 9510 cultivar, Richards model had the highest RGR (0.066) and for ANT 90 cultivar, weibull model had the highest RGR

Table 1: Estimated values of RGR varied among the tree genotypes

Cultivar	Model	RGR	R^2	MSE
TTM 813	Logistic	0.043	98.45	2.612
	Richards	0.051	98.59	2.059
	Gompertz	0.054	98.52	2.851
	Weibull	0.062	98.60	1.967
ADA 9510	Logistic	0.055	98.36	2.923
	Richards	0.062	98.44	2.694
	Gompertz	0.054	97.86	3.155
	Weibull	0.059	98.56	2.113
ANT 90	Logistic	0.047	98.05	3.104
	Richards	0.058	98.15	2.957
	Gompertz	0.061	96.12	5.632
	Weibull	0.066	98.16	2.430

(0.066) values. But, logistic model had the lowest values of RGR at the all cultivars (0.043, 0.055 and 0.047, respectively). All growth models were capable of describing the dynamics in RGR of growing grains. Weibull function gives better estimation of RGR than other models.

Values of growth model parameters fitted to the data (Voisin *et al*., 2002; Yin *et al*., 2003). Illustration of fitting RGR were shown Fig. 1. Gompertz equation predicted an appreciable lower than other equations for all cultivar. Richards function resulted more higher than Logistic and Gompertz function about RGR. However, Weibull function had significant variation. Zeide (1993) reviewed 12 equation, including such as Logistic, Gompertz, Richards and Weibull equation. Growth results gave that environmental resistance and ageing restricted growth. Karadavut and Tozluca (2005) investigated Logistic, Gompertz, Richards and Weibull equation about rye (*Secale cereale* L.) growth. Weibull model was the best explaining growth. The expansion part is driven by plant size and the decrease part by age. Growth functions assume a certain initial value at the beginning of growth. This is reasonable for crops or plants because a crop or plant does have a small initial weight at emergency (Yin *et al*., 2003). Karadavut *et al*. (2009) explained that Relative growth rate varied according to growth of cultivars. While Leaf Area Rate increased significantly with times, Leaf Area Index (LAI), Relative Leaf Growth Rate (RLGR) and Crop Growth Rate (CGR) declined with times. In this study, RGR also varied according to cultivars. If we consider phylogenetic relationships between species, the differences in RGR of cultivars were not clear for many of the growth components studied. Therefore, corn cultivars with a low RGR could be more successful in occupying resource-poor (water and/or nutrient) habitats.

Logistic function is symmetrical around t. The Richards function is flexible and has often been used to describe various asymmetrical growth patterns. Gompertz and Weibull functions have also predicted asymmetrical growth (Yin *et al*., 2003). Under certain conditions, small increases in relative growth rate will lead to increased aboveground production. Temporal variation effected mainly to variation in RGR. The lack of differences in RGR between deciduous and evergreens was due to the higher leaf mass ratio (LMR, leaf dry biomass/total dry biomass) for the evergreens. Under other conditions, very large increases in relative growth rate can occur without production being increased over. Plants growing at nearly their maximum potential relative growth rate have little opportunity to respond positively to growth and potentially can sustain less growth rates far below maximum. Plants with high relative growth rates at the time of growing require large increases in growth rate while slow growing plants require only small increases. Speed growing intensities are least likely to increase production and speed growing frequencies require

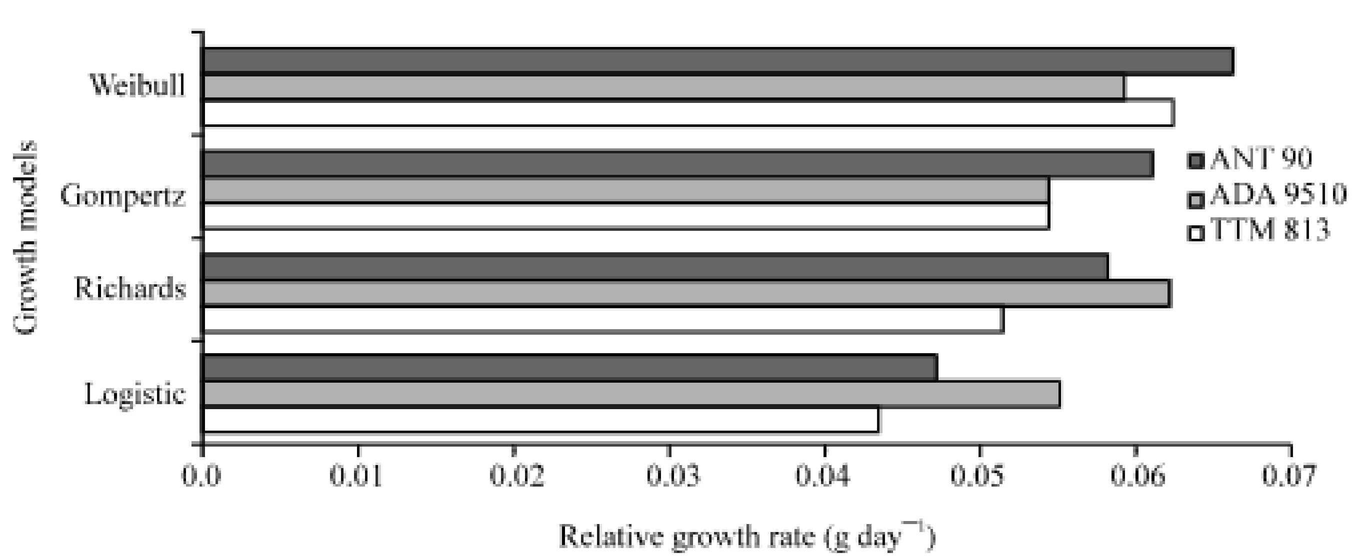

Fig. 1: According to cultivars, determination rate of models of RGR

greater responses than infrequent growing events. The RGR was not uniform through the study period. What caused these changes over time? We found that the temporal changes in RGR were mainly due to variation in Net assimilation rate. This can be partly explained by an increase in the photoperiod of about 16% during the period in which the experiment was carried out between April and September. Therefore, the temporal changes in cultivars could be determined by a higher CO_2 fixation due to increasing length of photoperiod.

CONCLUSION

Variation in RGR among corn cultivars was due mainly to differences in morphological parameters such as leaf area ratio (LAR, whole plant area/whole plant dry weight) and SLA (Specific leaf area). A faster RGR is not consistently associated with the deciduous habit. The faster growth of the deciduous leaf could be explained by their higher LAR and higher SLA relative to evergreens. We suggest, RGR, could be an important parameter in determining adaptive advantages of corn cultivars. RGR was explained Weibull growth function better than other growth models for all of cultivars. Weibull growth model should be considered for estimating RGR.

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