Journal of Animal and Veterinary Advances 9 (1): 190-194, 2010
ISSN: 1680-5593

Comparison of Some Statistical Models for Describing Seedling Growth of *Lolium perenne* Plants in Early Period

Ufuk Karadavut
Faculty of Agriculture, University of Bingol, 12,000-Bingol, Turkey

Abstract: This study was carried out at Central Anatolian Region ecological conditions. In this study were aimed to compare some statistical growth models for describing seedling growth in early period. Quadratic, square root, exponential and weibull models were used to describe seedling growth. Coefficient of determination and mean square error were used as comparison criteria. As results, when 1000 seeds weight increased, germination rate decreased. Also, when germination rate decreased, leaf length at 25 days and dry weight plant^{-1} at 25 days decreased, but no of days for 1st tiller to appear increased. Quadratic model explained better than other models for seedling growth.

Key words: *Lolium perenne*, growth model, comparison, seedling growth, coefficient of determination, mean square error

INTRODUCTION

Marketed seeds must suit germination and purity standards. They must also be certified by the Ministry of Agriculture in Turkey. *Lolium perenne* is important agricultural grass species in Turkey. Very little information is available on the relationship between germination percentage and rate of seedling growth.

Lolium perenne propagates by seed. It is the best to use long-lived for long rotation or permanent pastures. Seeds from old permanent grassland consist of mostly long-lived leafy types and can be used in place of the improving pasture. Seeding rate varies according to the area, climate and purpose. Lewis (1989) pointed out that there was considerable mortality of seedling and that thin mortality rate increased as date of sowing was delayed after September. Culleton *et al.* (1991) reported that *Lolium perenne* was sown later the percentage germination and the rate of growth of the surviving seedling declined. Perry (1978) defined seedling vigor as follow; vigor is the sum of those properties performance seed during germination and seedling emergence. Seeds, which perform well are termed high vigor and those which perform poorly are called low vigor seeds. It is well established that rapid growth after germination can be critical to the seedling's survival (Naylor *et al.*, 1983). Late sowing prevented plant growth (Jaleel *et al.*, 2009). Because stress factors and some biologic and biochemical factors effect plant growth and development (Razmjoo *et al.*, 2008).

Model selection has considerably effected on estimating seedling growth. The selection of the most appropriate model for a particular cropping system is not obvious (Bock and Sikora, 1990; Angus *et al.*, 1993; Bullock and Bullock, 1994). Different models fitting on one data set can give comparable coefficient of determination (R^2), but it can vary to different seedling growth rates. Although, several statistical models are commonly used to describe to plant growing rates, the choice of one model over another is rarely explained.

The most studies based on statistical models for prediction optimal growth rate have been conducted several plants growth. Quadratic models have been very popular for describing plant growth. Several researchers used to this model on different plant growth and application of fertilization and irrigation (Hara, 1986; Neeteson and Wadman, 1987; Cerrato and Blacmer, 1990; Colwell, 1994; Belanger *et al.*, 2000; Fleming, 2001; Karadavut *et al.*, 2002, 2005; Reid, 2002). Exponential function also used to describe the crop response on growing periods. The square root model can also be a reasonable choice in many situations. The weibull model is the dynamic models and it can be used to describe growth (Colwell, 1994; Karadavut *et al.*, 2005).

In this study, we aimed to determinate seedling growth of *Lolium perenne* and to compare growth of plants with some statistical models.

MATERIALS AND METHODS

Seeds of *Lolium perenne* were sown at seven locations around Central Anatolian Region in 2006. At harvest, 1 kg sample of seeds was collected at random from 7 locations around the country. Germination percentages for these seed lots were determined using the procedures laid down by the International Seed Testing

Association (ISTA). Germination rates ranged from 95-85%. Thousand seed weight were also recorded for each seed.

Firstly, seed germination rate at 15°C germination rate was established by counting the numbers that germinated each day over a 15 days period. Secondly, involved placing 4 replications (each replication consisting of 100 seeds selected at random from each seed lot) of each seed outdoors in trays filled with soil on September 20, 2006. The soil had low fertility. The equivalent of 50 kg ha^{-1} of N (as a form urea) and P was applied 60 kg ha^{-1} as TSP (Triple Super Phosphate).

When 70% of seeds had emerged, five plants were selected at random and labeled (Culleton *et al*., 1991). Leaf lengths were recorded for seeds 25 days after emergence. The number of days to first tiller appearance was also recorded. Dry weight per plant was recorded by selecting five plants at random in each pot and cutting them off at 25 and 35 days after emergence. Maturated plants were dried at 105°C and 24 h. And then, dry weights were recorded. The used model is shown:
The quadratic model is:

$$Y = a + bX + cX^2$$

The square root model is:

$$Y = a + bX^{\frac{1}{2}} + cX$$

The exponential model is:

$$Y = a + b\exp^{cX}$$

The weibull model is:

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

For statistical model:
Y = Plant height and dry matter
t = Time
a-c = Parameter of model

The coefficients of determination (R^2) were computed from the analysis of variance provided as:

$$R^2 = \frac{RSS}{TSS}$$

Where:
RSS = Residual Sum Squares
TSS = Total Sum Squares

Mean Square Error (MSE) of total growth and dry matter for the model was calculated according to the equation:

$$MSE = \frac{\sum_{i=1}^{n}(Y_O - Y_P)^2}{n}$$

Where:
Y_O = The observed growth and dry matter
Y_P = The predicted growth and dry matter
n = The number of observations. For statistical analysis, we used the STATISTICA 6.0 V statistical program

RESULTS AND DISCUSSION

While there were some significant differences in seed weights between the seeds while, there was no correlation between seed size and germination percentage. The rates of germination in the low germination seeds were slower than in the high germination of the total germinated seeds. About 87.6 and 92.8% of seeds had germinated after 5 and 10 days, respectively (Table 1). In the high viability seeds, germination rate after 5 and 10 days were 79.8 and 85.1%, respectively. A similar observation was reported by Culleton *et al*. (1991).

The results of relationship between germination percentage and various seedling parameters are given in Table 2. As the percentage germination declined, so the rate of growth the surviving seedlings also declined. Total leaf length 25 days was 132.6 mm in the high germination seed lot, compared with 111.2 mm in the low germination seed lot. Number of days taken for tillering to commence increased steadily as the rate of germination declined. The implication of these results are that seeds with high germination should be used, especially when sowing is carried out in adverse conditions, be it sowing late in autumn, sowing into poor seed bed or direct drilling seeds into exiting pasture.

The quadratic model explained a small proportion of the variability as indicated by coefficient of determination

Table 1: According to 1000 seeds weight germination rates of various samples of *Lolium perenne* seeds

	Rate of germination (%)	
Seed weight 1000 (g)	After 5 days	After 10 days
1.96	87.6	92.8
2.06	83.4	88.6
2.13	79.8	85.1
LSD (p<0.05)	3.6	1.9

Table 2: Relationship between germination percentage and various seedling parameters in experiment

Germination (%)	Leaf length at 25 days	Dry weight $plant^{-1}$ (mg)		No. of days for 1st tiller to appear
		25 days	35 days	
95	132.6	3.5	7.0	30
90	121.8	3.2	6.5	32
85	111.2	2.8	6.2	35
LSD (p<0.05)	15	1.8	1.5	1.1

Table 3: The criteria of model selection

Statistical models	Comparison criteria	Leaf length (25 days)			Dry weight plant (25 days)			Dry weight plant (35 days)		
		95%	90%	85%	95%	90%	85%	95%	90%	80%
Quadratic	R^2	99.81	99.720	99.16	99.680	99.430	99.080	99.430	99.430	99.420
	MSE	2.88	10.810	26.77	0.006	0.115	0.456	0.056	0.929	0.526
Square root	R^2	98.23	98.250	97.42	98.550	98.090	97.680	98.450	97.950	98.780
	MSE	3.01	9.365	18.65	0.008	0.152	0.621	0.098	1.125	0.983
Exponential	R^2	96.74	96.880	96.55	96.640	96.180	95.980	96.440	97.030	96.420
	MSE	4.20	10.650	20.61	0.011	0.234	0.866	0.154	1.381	1.412
Weibull	R^2	94.26	95.050	94.85	95.160	95.420	95.630	94.220	94.080	94.470
	MSE	5.12	13.550	26.30	0.064	0.315	1.045	0.238	1.341	1.684

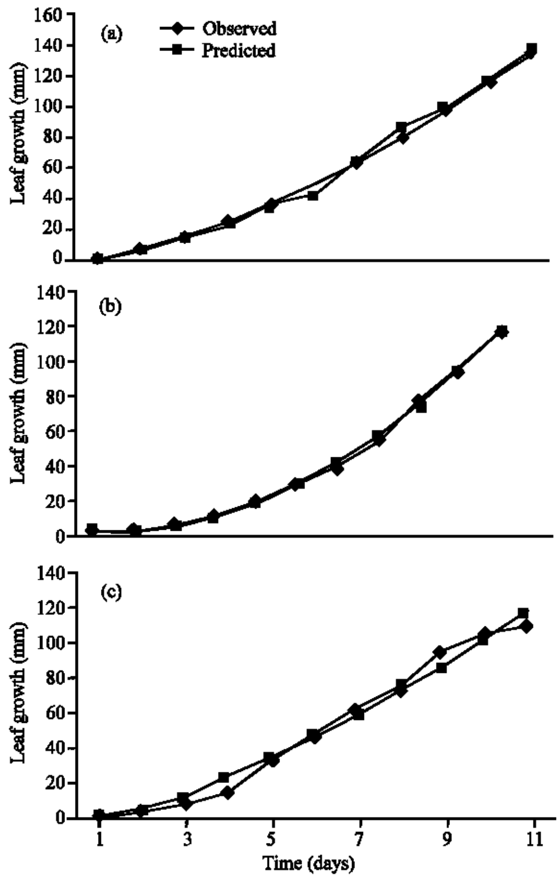

Fig. 1: Leaf length growth (25 days) in different germination percentage (According to Quadratic model), a) 95% leaf growth, b) 90% leaf growth, c) 85% leaf growth

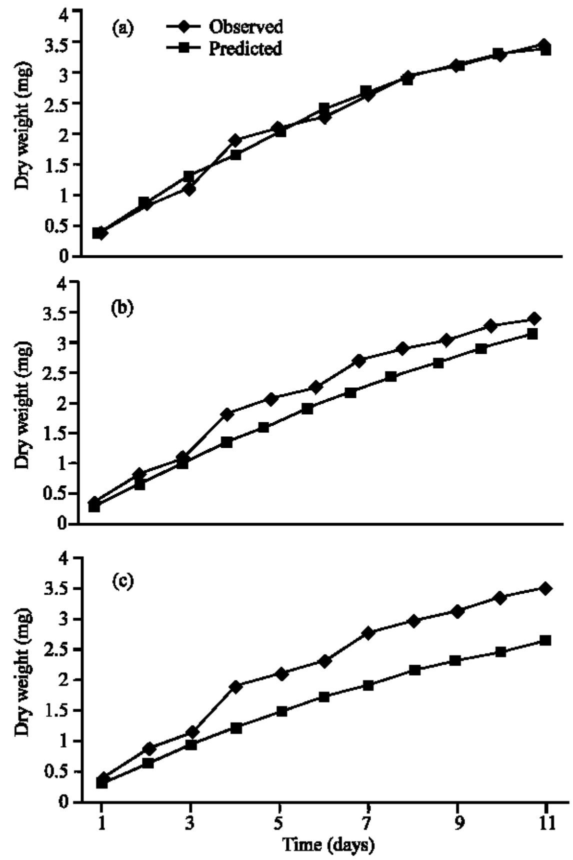

Fig. 2: Dry weight of plants (25 days) in different germination percentage (According to Quadratic model), a) 95% dry weight (25 days), b) 90% dry weight (25 days), c) 85% dry weight (25 days)

R^2>0.95 in most cases (Table 3). According to germination percentage, quadratic growth curves were (Fig. 1-3). In generally, there were little differences between R^2-values obtained by three germination percentage (95, 90 and 85%) with similar R^2-values however, a large variation leaf length and dry weights of plants with three germination percentage. The coefficient of determination is therefore, poor criteria for selection a model identifying growth and dry weight because it is a nonlinear model (Seber and Wild, 1989). Greater R^2 values of dry weight were observed with 95% germination at average 99.68% (25 days). It was 99.43% (90% germination and 25 and 35 days) and 99.42% (85% germination and 35 days).

For quadratic model, the mean square error of the estimate varied greatly among germination percentage (Table 3). In generally, MSE varied between 0.006 and 26.77.

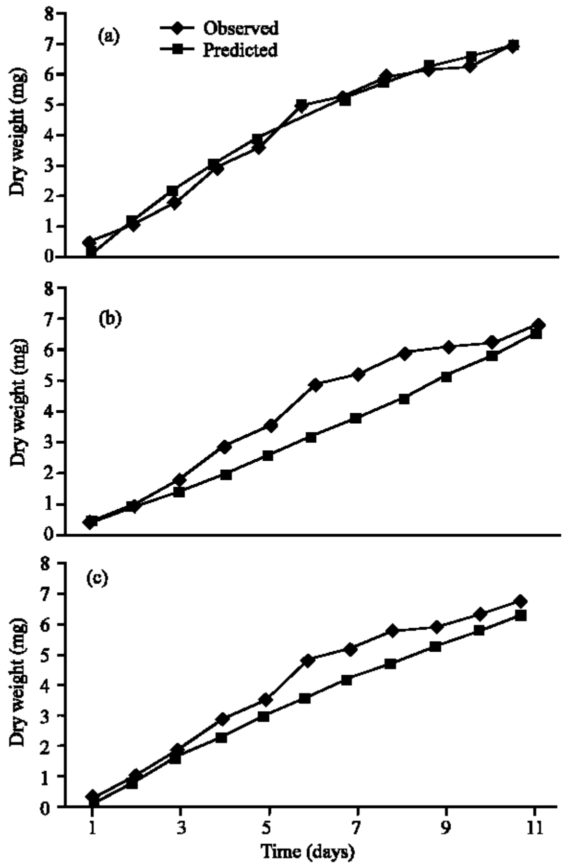

Fig. 3: Dry weight of plants (35 days) in different germination percentage (According to Quadratic model); a): 95% dry weight (35 days), b): 90% dry weight (35 days), c): 85% dry weight (35 days)

It varied between 2.866 and 26.77 (in plant height), between 0.006 and 0.456 (in dry weight of plant 25 days) and between 0.056 and 0.526 (in dry weight of plants 35 days).

The quadratic model explained a similar proportion of the variability in the dry weight, however leaf length had been calculated by model varied greatly, but Weibull model fitted the data very well. We conclude that the quadratic model is good suited to describe the dry matter accumulation in seedling growth of *Lolium perenne*. It is suggested that to be reliable, models should not have any systematic bias. Therefore, the regression residuals should have a normal distribution. An example of analysis of regression residues is shown for the some germination percentage.

According to a statistical test (Anderson Darling Normality Test), in dry weight (25 days) didn't distribute normality. And other hand others distribute normally. As results, while germination rate of seeds decreased, describing of quadratic model decreased gradually.

When 1000 seeds weight increased, germination rate decreased. Also, when leaf length, dry weight/plant and dry weight/plant at 25 days decreased, no of days for 1st tiller to appear increased. Weibull growth model showed the smallest determination for describing early seedling growth of *Lolium perenne*. We think, early seedling growth varied speedily each growth stage. In this reason, Weibull growth model may be not to determinate its growth.

CONCLUSION

The cells of the plants embryo begin to increase in number by division for growing. And than seed form soon the tiny shoot. This is known popularly as the sprout and by botanists as the hypocotyl. If the seed is not properly placed, this first growth will make a curve before the rounded point extends downward. If environment is suitable, shoot will growth. All seeds start the root or hypocotyl downward prior to the starting of the plumule upward to be exposed to the air and sun. Determination of this growth is vey important. Because, plants growth very quickly. This study showed that quadratic model explained seedling growth well.

REFERENCES

Angus, J.F., J.W. Bowden and B.A. Keating, 1993. Modeling nutrient responses in the field. Plant Soil, 155, 156: 57-66.

Belanger, G.R. Walch, J.E. Richards, P.H. Milburn and N. Ziadi, 2000. Comparison of three statistical models description potato yield response to nitrogen fertilizer. Agron. J., 92: 902-908.

Bock, B.R. and F.J. Sikora, 1990. Modified quadratic/plateau model for description plant response to fertilizer. Soil Sci. Soc. Am. J., 54: 1784-1789.

Bullock, D.G. and D.S. Bullock, 1994. Quadratic and quadratic-plus-plateau models for predicting optimal nitrogen rate of Corn: A comparison. Agron. J., 86: 191-195.

Cerrato, M.E. and A.M. Blacmer, 1990. Comparison of models for describing corn yield response to nitrogen fertilizer. Agron. J., 82: 138-143.

Colwell, J.D., 1994. Estimating fertilizer requirements. A quantities approach. CAB International, Wallingford, UK.

Culleton, N., V.Mc Carthy and D. McGilloway, 1991. A note on the germinability and early seedling growth of *Lolium perenne*. Irish J. Agric. Res., 28: 194-196.

Fleming, R.A., 2001. The weibull model and an ecological application: Describing the dynamics of foliage biomass on Scotty pine. Ecol. Model, 138: 309-319.

Hara, T., 1986. Growth of individuals in plant populations. Ann. Bot., 57: 55-68.

Jaleel, C.A., M. Paramasivam, A. Wahid, M. Farooq, H.J. Al-Juburi, F. Somasundaram and R. Panneerselvam, 2009. Drought stress in plants: A review on morphological characteristics and pigment compositions. Int. J. Agric. Biol., 11: 100-105.

Karadavut, U., A. Genc, A. Karakoca and A. Sinan, 2002. A study for the determination of growth curves in Broad beans (*Vicia faba* L.). VI. Turkey Biostatistics Congress, Sep. 2002. Diyarbakir, Turkey, pp: 312-317.

Karadavut, U., A. Genc, A. Karakoca, A. Sinan, C. Palta and S. Aksoyak, 2005. Model selection determining growth curves of Dagdas wheat plants. V. Turkey Statistical Research Symposium, May 2005. Antalya, Turkey, pp: 512-518.

Lewis, G.C., 1989. Factors influencing the effects of fungicide treatment on seedling emergency of perennial grass (*Lolium perenne*). Grass and Forage Sci., 44: 417-424.

Naylor, R.E.L., A.H. Marshall and S. Matthews, 1983. Seed establishment in directly drilled sowing. Herbage Abst., 53: 73-91.

Neeteson, J.J. and W.P. Wadman, 1987. Assessment of economically optimum application rate of fertilizer. N on the basis of response curves. Fert. Res., 12: 37-52.

Perry, D.D., 1978. Report of the vigor test committee 1974-1977. Seed Sci. Technol., 6: 159-181.

Razmjoo, K.P. Heydarizadeh and M.R. Sabzalian, 2008. Effect of salinity and drought stresses on growth parameters and essential oil content of *Matriaria chamomile*. Int. J. Agric. Biol., 10: 451-454.

Reid, J.B., 2002. Yield response to nutrient supply across a wide range of conditions. I. Model deviation. Field Crops Res., 77: 161-171.

Seber, G.A.F. and C.F. Wild, 1989. Nonlinear Regression. John Wily and Sons, New York, USA, pp: 325-365.