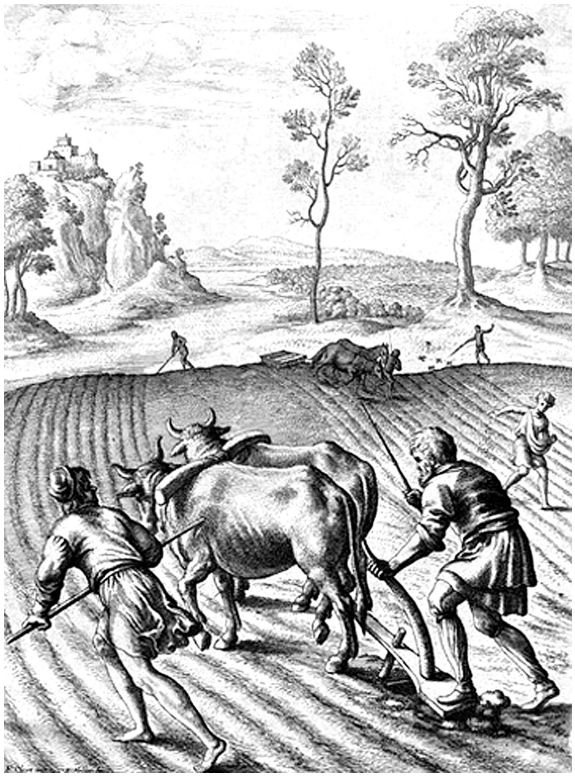
ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY



ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 3 (3): 179-183, 2004
ISSN 1680-8207

Modelling the Effect of Temperature on the Germination Speed in Some Legume Crops

Ahmet Balkaya
Department of Horticulture, Faculty of Agriculture, Ondokuz Mayis University, 55139, Samsun, Turkey

Abstract: In this research, the possibility of prediction of germination speeds of the seeds for some legume crops namely, green bean (Oz Ayşe 16, Dade, Tina and 4F-89 Cv.), red podded bean (Gitan and Sırık 97 Cv.), pea (Yaprak and Progres No:9 Cv.), cowpea (izmir orij. population and karagoz Cv.) and broad bean (Amasya orij. population) by mathematical models based on temperature was investigated. For this reason, a model ($D= a-b*T+c*T^2$) for predicting the time to emergence in relation to temperature for some vegetable crops was utilized. This model changed to ($D= a+b*T-c*T^2$) for germination speed of the crops tried. The prediction performance of this model with respect to the data used was highly acceptable. Values of regression coefficients (R^2) for each crop varied from 0.83 to 0.99 depending on the species. It was found that the new mathematical models obtained after adapting the present data to the above mentioned model could be used safely in predicting germination speed for some legume crops. In addition, optimum temperatures ($To=b/2*c$) for seed germination speed in the tried crops were calculated by using the coefficients obtained from the produced regression models.

Key words: Germination speed, modelling, temperature, legume vegetable crops

INTRODUCTION

Although all the factors affecting plant growth and development are at an optimum level, obtaining higher yield depends on seed quality[1]. For this reason, seed quality is very important in plant growing. The quality of seed means that, a stability about genetically structure, uniform germination in short period, high seed vigour and free from insects and diseases[2]. The seed quality is affected by many factors as ecologically and genetically[3]. Besides ecological factors, some seed characters are effective in legume crops growing in order to obtain a desirable yield and quality.

After seed sowing, a uniform germination and seedling emergence are desirable to the farmers. However, it has been determined that snap bean producers in Turkey have some problems due to the low germination and field emergence rates for some cultivars[4,5].

Germination experiments at laboratory conditions are carried out in order to determine the favorable characteristics of the seeds before sowing. Since germination speed is very important for about earliness in the plant growing and it can differ according to species, soil structures, sowing methods and especially temperature and soil moisture ratios[6].

The germination process requires moisture, oxygen and temperature ranges which are specific to particular crops. Seed germination is a complicated event including many reactions with different phases affected by temperature[7,8]. The temperature requirement of vegetable seeds for germination varies according to species. Some vegetable seeds germinate above a temperature tresh-hold of 0°C, some of the others can only begin to germinate at temperatures above 8 to 10°C for summer vegetable crops[9]. Minimum, optimum and maximum germination temperatures for winter vegetable crops are 0-4, 10-20 and 35-40°C, respectively. However, minimum, optimum and maximum germination temperatures for summer vegetable crops are 10-16, 20-30 and 40-45°C[10]. The higher temperature raised the faster will be the rate of chemical reactions in seed germination[1].

Germination speed can be different between species and also varieties[11]. Seed testa is also effective on the germination speed of seeds beside temperature. A highly significant negative correlation ($r = -0.7252^{**}$) between seed coat rate and germination speed in different cow pea genotypes were determined[12]. A thick testa is a negative effect for imbibition during germination. It was notified that in dwarf types of snap bean, colourfull seeds had higher germination and emergence rate than the white seeds[13]. In another research, it was found that there was a significant and negative relationship ($R^2=-0.7719^{*}$) between testa rate and germination power in coloured cultivars[14].

Corresponding Author: Dr. Ahmet Balkaya, Department of Horticulture, Faculty of Agriculture, Ondokuz Mayis University, 55139, Samsun, Turkey E-mail: abalkya@omu.edu.tr

Legume vegetable species show differences for temperature requirement during the germination. Green bean, red podded bean and cow pea seeds do not prefer low temperatures during germination. The snap bean seeds could be damaged due to heavy rain if they are sown in cool season and emergence problem in field is encountered. This situation are also clear for white colour seeds[14]. Şehirali[15] stated that germination rate of bean decreased at 10°C and 18-20°C was optimum. He also found that there was not any growth activity in bean seeds at over 35°C.

Germination speed of green bean seeds having less than 10 % moisture content was low for the temperatures below 15°C[16].

While Şehirali[15] and Günay[17] found that the minimum, optimum and maximum temperatures were 5-6, 30 and 35°C for germination of pea seeds, respectively. Lorenz and Maynard[18] found them as 5, 26 and 30°C, respectively. It was determined that soil temperature must be between 4 and 18°C for a normal germination of pea seeds[6]. Vural *et al.*[19] stated that the minimum and optimum temperatures for germination of cowpea seeds were 8-10 and 20-25°C, respectively.

Studies on broad bean germination showed that there were a great variation between temperature regimes. The minimum, optimum and maximum germination temperatures for broad bean seeds were 3, 20-25 and 30-35°C, respectively[15,16]. On the other hand, Abd-El Hamit[20] found that 18°C was an optimum temperature for the germination of broad bean seeds. Skjelvag[21] showed that the germination rate and time elapsing from sowing to emergence increased linearly in a controlled temperatures between 12-21°C.

The models have been used by many researchers to determine plant growth, development and yield in recent years[22]. Plant development includes the durations from seed sowing to preceding to reproductive stage and from this stage to maturity. Especially, temperature and light have an important effect on plant developmental phases[23]. The time elapsing from seed sowing to seedling emergence can be regarded as a parameter to the development of plants[24]. The changes in the seed quality affect especially field emergence and seedling periods[25].

In this research, the relationships between temperature and germination of legume vegetables such as green bean, red podded bean, pea, cowpea and broad bean were investigated at 15 different temperature regimes (5-40°C). Findings from this study have been used to determine germination speed by means of the mathematical model produced earlier by Uzun *et al.*[9]. On the other hand, the optimum temperatures for germination of the tried crops were also determined.

MATERIALS AND METHODS

This research was carried out in the seed laboratory of the Bafra High School of Profession of Ondokuz Mayıs University.

In the study green bean (Oz Ayşe16, Dade, Tina and 4F-89 cultivars), red podded bean (Gitan and Sırık 97 cultivars), pea (Yaprak and Progres No. 9 cultivars.), cowpea (Izmir orij. population and karagoz cultivars) and broad bean (Amasya orij. population) seeds produced in 2001 were used as seed materials.

Seed germination experiments were carried out in germination cabins. The seeds were placed on a moistured filter paper (Watman No.1) kept in glass made containers as 100 seeds for each replication and closed with the drying paper. The study was performed in germination cabins adjusted to 15 different temperatures (5, 8, 10, 13, 15, 18, 20, 23, 25, 28, 30, 33, 35, 38 and 40°C, respectively). Each treatment was repeated four times for each temperature values. The seeds left for germination were observed daily and the seeds having radicle 1 cm long for the criteria of the seed germination[26].

The evaluation of germination results were analysed according to the International Seed Testing Association for determining germination speed rate (%) for each temperature value[1,27].

In predicting the germination speed of tried seeds belonging to some legume crops (as percentage) with different temperatures regimes, the model ($D = a-b*T + c*T^2$) produced by Uzun *et al.*[19] in order to predict the time elapsing from sowing to emergence for some vegetable crops was adapted to the data obtained from the present study by carrying out multi regression analysis. In this model:

$$D = a-b*T + c*T^2.$$

Where:

D: The time elapsing from seed sowing to emergence as days

T: Mean temperature (°C)

a, b, c are coefficients of the parameters

Furthermore, these stages of the model by taking into consideration, optimum germination for the seeds of tried crops were determined as well as obtaining standard equation predicting germination speed for each crop. Hence the equation changed to $To = b/2*c$.

For model evaluation, the data obtained from the present study were analysed by multi regression analysis method and the analysis were continued until the least

sum of squares and the highest regression coefficients (R^2) were obtained. The Excel 7.0 package programme was used for the analysis.

RESULTS AND DISCUSSION

In determining the adapted models for each tried species, multi regression analysis were carried out until the lowest standard errors of independent variables, namely T and T^2 values and the highest R^2 (regression coefficients) values of the equations were obtained.

After following the modeling procedure, it was found that the model adapted to the data obtained from the present study showed that the model changed from $D= a-b*T + c*T^2$ to $D= a + b*T-c*T^2$ (Table 1) for the tried legume crops.

The regression coefficients (R^2) of the new produced equations for germination speed in the tried plant species changed between 0.83 (green bean) and 0.99 (broad bean) as a result of model adaptation. In addition to the results, the regression coefficients changed in each plant varieties for germination speed, namely 0.83 (Dade Cv.)–0.97 (Öz Ayşe 16 Cv.) in the green bean varieties, 0.91 (Gitan and Sırık 97 Cv.) in the red podded bean varieties, 0.88 (Yaprak Cv.) – 0.98 (Progres No. 9) in the pea varieties, 0.95 (Karagöz Cv.) –0.98 (Izmir orig. pop.) in the cowpea varieties and 0.99 in Amasya originated broad bean genotype.

The results showed that the effect of temperature on germination speed was much more important than the other possible effective parameters since 83 to 99% of the variation in germination speed was explained by temperature depending on the plant species and varieties.

The regression coefficients of the equations belonging to the other species was found generally high. At this stage, it can say that very reliable equations have been obtained in the present study for predicting speed of germination (%) as affected by temperature. On the other hand, it would be possible to determine optimal temperatures (°C) for germination speed by using the coefficients of independent variables (b and c) obtained from the equations belonging to the speed of germination for each species and varieties (Table 1).

High temperatures had a negative effect on the germination speed. In this study , optimum temperature requirement of green bean varieties were found between 23.0 –24.6°C. These values were similar as for red podded bean and cowpea varieties (Table 1). Pea and broad bean seeds germinated between 16.7-18.3°C and these germination values were found lower to be compared to other legumes crops. In this research, it was determined that both germination period derived with higher temperatures and germination speed decreased at the same conditions.

To conclude, considering that there have been a marked interest by many researchers in modelling plant growth and development in recent years, the equations

Table 1: The coefficients, their standard errors and R^2 values of the new produced equations predicting germination speed ($D= a + b*T-c*T^2$ for some legumes vegetable crops

Species	Varieties	Co-efficients a	b	c	R^2	Predicted optimum temperature (°C)
Green bean	Ö.Ayşe 16 (10-40°C)[1]	-27.06 (8.81)**	10.56(0.76)***	0.23(0.015)***	0.97***	23.0
	Dade (10-40°C)	-71.42 (26.86)**	12.58 (2.3)***	0.27(0.045)***	0.83***	23.3
	Tina (10-40°C)	-88.7 (22.05)***	13.26 (1.9)***	0.27 (0.03)***	0.85***	24.6
	4F-89 (13-40°C)	-60.94 (21.52)**	11.7 (1.74)***	0.24 (0.03)***	0.89***	24.4
Red podded bean	Gitan (13-38 °C)	-46.61 (19.54)*	10.86 (1.6)***	0.24 (0.032)**	0.91***	22.6
	Sırık-97 (10-40°C)	-46.61 (19.54)*	10.86 (1.6)***	0.24 (0.032)**	0.91***	22.6
Pea	Yaprak (5-35°C)	+42.96 (7.19)**	5.49 (0.8)***	0.15 (0.02)***	0.88***	18.3
	Progres No:9 (5-35°C)	+33.57 (2.7)***	4.43 (0.23)***	0.13(0.056)***	0.98***	16.7
Cowpea	Izmir orij. population (5-40°C)	-54.46 (5.34)***	11.55(0.53)***	0.25(0.01)***	0.98***	23.1
	Karagöz (5-40°C)	-104.42(10.2)***	14.12(0.88)***	0.28(0.017)***	0.95***	25.2
Broad bean	Amasya orij. population (5-33°C)	-11.26 (4.21)*	10.88(0.47)***	0.30(0.011)***	0.99***	18.2

*, **, ***: Significant at the level of P≤0.05, 0.01, 0.001, respectively. [1]: Temperature variations used for regression analysis

produced in the present study may be used in this field. In some plant species, many models were found to be useful for predicting germination speed, germination power and germination period or field emergence speed, emergence power and field emergence period by some researchers in Turkey[19,28]. These kind of models such as those predicting days to germination or optimum temperatures could be used for adjusting a proper time for seed sowing according to different regions and utilising the vegetation period of these regions more productively. The temperature limits (5 to 40°C), used in the present study also enable us to use these models for predicting.

REFERENCES

1. Şehirali, S., 1997. Seed and Seed Technology. In Turkish, Istanbul, pp: 422.
2 Mavi, K. and T. Sermenli, 2002. The effect of fruit position on the mother plant on seed quality in eggplant. In Turkish. Türkiye 1. Tohumculuk Kongresi, Izmir, pp: 289-294.
3. Robani, H., 1992. Quality assurance program to ensure a continuous supply of high quality seed. Hort. Technol., 2: 335-336.
4. Demir, I., R. Yanmaz and A. Günay, 1994. Seed moisture content as a determining factor of seed harvest time of Snap bean Cv. 4F-89. In Turkish. Bahce Dergisi, 23: 59-66.
5. Balkaya, A., R. Yanmaz, H. Bozoglu and A. Gulumser, 1999. Determination of bean growing situation of Samsun. In Turkish. The Black Sea Region Agriculture Semp., 1: 51-62.
6. Bayraktar, K., 1976. Vegetable Growing. Vol . III. Vegetable Seed Production. In Turkish. Ege Üniv. Ziraat Fakültesi Yayınları, No. 244. Izmir.
7. Sağsoz, S., 1990. Seed Science. In Turkish. Atatürk Üniv. Yayınları. No:677. Ziraat Fak. Yayınları. No:302, Ders Kitapları Serisi. No. 54, pp: 273.
8. Kevsereoğlu, K. and O. Çalışkan, 1995. Effect of different temperature degrees on germination of some industry plants seeds. Turk. J. Fac. Agric. O.M.U., 10: 23-31.
9. Uzun, S., D. Marongoz and F. Özkaraman, 2000. Modelling the time elapsing from seed sowing to emergence in some vegetable crops. Pak. J. Biol. Sci., 4: 442-445.
10. Günay, 1992a. Vegetable Growing. Vol: 1. 2. Baskı. In Turkish. Ankara.
11. Elçi, Ş., O. Kolsarıcı and H.H. Geçit, 1987. Field Crops. In Turkish. Ankara Üniv. Ziraat Fak. Yayın. No.1008, Ankara, pp: 170.
12. Pekşen, E., A. Pekşen, H. Bozoğlu and A. Gülümser, 2000. Determination of some seed characteristics in different cowpea (*Vigna ungiculata* L. Walp) genotypes. Turkish. J. Fac. Agric. O.M.U., 15: 65-72.
13. Deakin, J.R., 1974. Association of seed colour with emergence and seed yield of snap beans. J. Am. Soc. Hort., 99: 110-114.
14. Balkaya, A. and S. Odabaş, 2002. Research on the determination of the seed characteristics in some significant snap bean varieties grown in Samsun, Turkey. Pak. J. Biol. Sci., 5: 1-6.
15. Şehirali, S., 1988. Grain legume crops. In Turkish. Ankara Univ. Ziraat Fak. Yayin: 1089. Ders Kitabi: 314. Ankara.
16. Sepetoğlu, H., 1994. Grain legume crops. In Turkish. Ege. Univ. Ziraat Fak. Yayinlari. Ders Notlari: 24. Izmir.
17. Günay, 1992b. Special Vegetable Growing. Vol: IV. In Turkish. Ankara.
18. Lorenz, A.O. and D.N. Maynard, 1980. Vegetable Growers. John Wilay and Sons. Inc. Canada, pp: 390.
19. Vural, H., D. Eşiyok and I. Duman, 2000. The Culture Vegetables (Vegetable Growing). Turkish Izmir, pp: 440.
20. Abd-El Hamit, N.H.H., 1982. Effect of germination on the chemical, nutritional and technological properties of some cereals and legumes. Nile Valley Faba Bean Abst. No: 493
21. Skjelvag, A.O., 1981. Effects of climatic factors on the growth on the development of field bean (*Vicia faba* L. var. minor). I. Pheneology, height, growth and yield in a phytotrone experiment. Acta Agric., Scandinavia, 31: 358-371.
22. Uzun, S., 1997. The effects of temperature and light on the plant growth, development and yield (I. Growth). Turkish. J. Fac. Agric. O.M.U., 12: 147-156.
23. Uzun, S., 1996. The quantitative effects of temperature and light environment on the growth, development and yield of tomato and aubergine (Unpublished Ph.D Thesis). The Univ. Reading, England.
24. Ellis, R.H., P. Hadley, E.H. Roberts and T. Summerfield, 1990. Quantitative Relations Between Temperature and Crop Development and Growth. In: Climatic Change and Plant Genetic Resources. Belhaven Press, London and New York.
25. Demir, I. and A. Günay, 1994. The effects of seed quality on germination, emergence and subsequent seedling development in cucumber (*Cucumis sativus* L.). Bahce Dergisi, 23: 27-32.

26. Samimy, C.A.G., A.G. Taylor and T.J. Kenny, 1987. Relationship of germination and vigour tests to field emergence of Snap bean (*Phaseolus vulgaris* L.). J. Seed Technol., 11: 23-24.
27. Anonymous, 1985. International rules for seed testing. Seed Sci. Technol., 13: 299-355.
28. Kevseroğlu, K., S. Uzun and O. Çalışkan, 2000. Modelling the effect of temperature on the germination percentage and days to germination in some industry plants. Pak. J. Biol. Sci., 3: 1424-1426.