RESEARCH ARTICLE Legume Research- An International Journal, Volume 45 Issue 12: 1528-1531 (December 2022)

Prediction of Germination Percentage Through Electrical Conductivity in White and Coloured Coated French Bean (*Phaseolus vulgaris* L.)

Sıtkı Ermis

10.18805/LRF-704

ABSTRACT

Background: Rapid detection of seed germination will be a valuable tool for seed testing laboratories and commercial seed companies. The EC test has been accepted into ISTA rules for beans. The potential of the electrical conductivity test (EC) readings in predicting total and normal germination of nine white coated and nine coloured coated French bean cultivar seeds was examined.

Methods: Nine different white coated and nine coloured coated French bean (*Phaseolus vulgaris* L.) cultivars were obtained from different sources. EC measurements for predicting germination were carried out 2, 4, 6 and 8 h during soaking at 20°C. Germination test was conducted on three replicates of 50 seeds in between wet towel papers for 8 days at 25°C in the dark.

Result: Regression models were developed between EC and percentages of normal and abnormal seedlings in the germination test. EC readings at 2, 4, 6 and 8 hours were negatively related to percentage of total (R^2=0.717, 0.830 P<0.05) and normal germination percentages (R^2=0.762, 0.897 P<0.05). Results suggested that EC measurements carried out in between 2 and 8 hours soaking can be used for the estimation of seed germination in beans.

Key words: Beans, Electrical conductivity test, Germination test, Predicting germination.

INTRODUCTION

Bean, one of the pulses, is the most frequently grown and consumed crop worldwide (Boros and Waver, 2018). In Turkey, species from the Leguminosae family are commonly cultivated (Balkaya and Karaagac 2013). The most significant legume grown in Turkey is the French bean (*Phaseolus vulgaris* L.), with 580 thousand tonnes annually (Anonymous, 2021). This vegetable is a very lucrative cool season legume crop that is primarily grown for its dry beans and tender green pods. Since beans are grown by seed, they are an important tool for good crop health, genetic and physiological crop diversity potential. It is well recognized that an increase in crop production of at least 10% to 15% can be attributed to seed quality alone (Jhanavi *et al*., 2018; Negi *et al*., 2021).

Standard laboratory germination tests take several days, with duration varying between species. For beans (*Phaseolus vulgaris* L.), final counts of normal seedlings are made after eight days (ISTA, 2022). Methods that predict germinability in a shorter time are potentially advantageous for seed companies who have to make quick decisions about seed management and ease workload when a large number of seed lots are required to be tested.

The electrical conductivity test was initially allowed into the ISTA Rules in 2001 for vining peas (*Pisum sativum* L.) and later for *Glycine max* (L.) Merr., *Phaseolus vulgaris* L. and *Cicer arietinum* L. (ISTA, 2016). Recently, radish has been verified as a species to which the EC test can be applied (Powell and Mavi, 2016). Measures of the leakage of electrolytes from seeds into soak water (Matthews and Powell, 2006) is feasible seed quality test in various crop

Department of Horticulture, Faculty of Agriculture, Eskişehir Osmangazi University, Eskişehir-26160, Türkiye.

Corresponding Author: Sıtkı Ermis, Department of Horticulture, Faculty of Agriculture, Eskişehir Osmangazi University, Eskişehir-26160, Türkiye. Email: ermis@ogu.edu.tr

How to cite this article: Ermis, S. (2022). Prediction of Germination Percentage Through Electrical Conductivity in White and Coloured Coated French Bean (*Phaseolus vulgaris* L.). Legume Research. 45(12): 1528-1531. DOI: 10.18805/LRF-704.

Submitted: 17-06-2022 **Accepted:** 16-09-2022 **Online:** 21-09-2022

seeds. In this context, EC was proposed as a quick method for testing seed germination quality for international standardization by Matthews *et al*. (2012). Basically, leakage is higher for seed samples with low germination than for samples with high germination. The reason for that is the extent of seed ageing. Damage to cell membranes due to the seed ageing accelerates solute leakage into the surrounding water. EC accurately predicted total and normal germination of seed samples of diverse crop seeds as cabbage (Mirdad *et al*., 2006; Demir *et al*., 2008), leek (Demir *et al.,* 2012) cress (Ozden *et al*., 2017) and pea (Kaya, 2021). The objectives of the present work were to examine the relationship between EC of the seed soak water of bean cultivars and germination, measured as a percentage of total and normal seedlings.

MATERIALS AND METHODS

This study was conducted in the Seed Science and Technology Laboratory of the Department of Horticulture, Faculty of Agriculture, Ankara University, Ankara during the period from October to December 2021. Nine different white coated (*Phaseolus vulgaris* L. cvs Ribera, Barcino, Efsun, Anemon, Voltran, Alala, Allegra, Bond, Gaudi) and nine coloured coated (cvs. Balca, Senem, Taylor, Balkiz, Garrafal Enana, Pedro, Serapis, Vermando, Roland) registered French bean cultivars were obtained from different seed companies. All samples were kept at 4°C before use. Initial seed moisture content was determined by using the high-temperature oven method (ISTA, 2022). Seeds were kept at 100% relative humidity over a night (16 h) before the germination test to avoid imbibitional injury. Seeds with cracks on the seed coat were eliminated from the lots. A germination test was conducted on three replicates of 50 seeds in between wet towel papers for 8 days at 25°C (ISTA, 2022) in the dark. Towel papers were placed in plastic bags and placed into the incubator. Total (2 mm radicle emergence) and normal (well-developed seedlings) germination percentages were evaluated after 8 days. Electrical conductivity of leachate measurements was done on two replicates of 10 weighed (0.001 g) seeds of each lot in 50 ml distilled water after 2, 4, 6 and 8 hours of soaking at 20°C in dark. Utilizing a conductivity meter, the electrical conductivity of the leachates from each replication was determined (Type CG 855). The results were expressed as $\mu Scm^{-1}g^{-1}$ to evaluate the variability in seed weight among French bean cultivars. Significant differences between experimental groups were assessed with one-way ANOVA, using the package for Social Sciences (IBM SPSS 21 package program) statistical program. Determination of coefficient (R^2) values were determined to assess the relation between EC and total and normal germination.

RESULTS AND DISCUSSION

Seed moisture content was changed between 13.0 and 15.7% in white, 13.1 and 14.7% in coloured cultivars. Changes in total and normal germination percentages and EC readings after 2, 4, 6 and 8 h were given in Table 1. Germination percentages and EC readings among the lots were changed significantly ($P<0.05$). Total germination percentages were above 93% in both white and coloured cultivars. Normal germination percentages ranged between 43 and 99% in white, 55 and 81% in coloured cultivars (Table 1). EC readings (μScm^{-1} g^{-1}) were found to in between 28.4 and 73.5 after 2 h, 39.1 and 86.5 after 4 h, 44.0 and 95.8 after 6 h, 62.3 and 112.4 after 8 h in white cultivars. In coloured cultivars, EC readings were lower than those of white cultivars and ranged between 9.7 and 42.8 after 2 h, 19.8 and 52.8 after 4 h, 26.6 and 61.3 after 6 h, 31.8 and 69.2 after 8 h. Solute leakage was gradually increased as soaking time is extended in all seed lots. Lot 9 in white and lot 1 in coloured ones had lost the lowest amount of leakage but lot 6 in white and lot 7 had lost the maximum amount of solute leakage in coloured cultivars (Table 1). This was the same in all different EC reading hours.

There were close relationships between EC readings of seed lots and the percentages of total and normal germination percentages of white and coloured seed lots after all four EC reading hours (Fig 1 and 2). Significances in between EC readings and total germination ranged between R^2= 0.728- 0.814, $P<0.005-0.001$ in white, R^2=0.717-0.830 $P<0.05-0.01$ in coloured cultivars (Fig 1). Significances in between normal germination and EC readings ranged between 0.762 and 0.897 ($P<0.05-0.01$) in white and 0.800 and 0.848 ($P<0.01$) in coloured cultivars.

Table 1: Changes in total (TG) and normal seed germination (NG) percentages and the EC ($\mu Scm^{-1}g^{-1}$) after 2, 4, 6 and 8 h of 9 white and 9 coloured French bean seed cultivars.

	Seed lot	TG (%)	NG (%)	EC ($\mu Scm^{-1}g^{-1}$)			
				2 h	4 h	6 h	8 h
White	1	93^{bc}	60^{e}	62.5^{b}	67.9^{c}	79.6^{c}	87.2^{d}
	2	95^{ab}	77^{bc}	43.1^{f}	59.3^{e}	67.0^{f}	80.3^{e}
	3	95^{ab}	65^{de}	50.8^{d}	57.2^{f}	68.1^{e}	76.9^{f}
	4	95^{ab}	68^{de}	58.9^{c}	72.3^{b}	85.3^{b}	96.6^{b}
	5	95^{ab}	72^{bc}	49.7^{e}	57.5^{f}	68.5^{e}	77.0^{f}
	6	88^{c}	43^{f}	73.5^{a}	86.5^{a}	95.8^{a}	112.4^{a}
	7	96^{ab}	69^{cd}	51.2^{d}	64.6^{d}	76.6^{d}	89.7^{c}
	8	99^{ab}	80^{b}	32.5^{g}	41.9^{g}	49.4^{g}	65.6^{g}
	9	100^{a}	99^{a}	28.4^{h}	39.1^{h}	44.0^{h}	62.3^{h}
Coloured	1	100^{a}	81^{a}	9.7^{g}	19.8^{g}	26.6^{g}	31.8^{h}
	2	100^{a}	72^{ab}	16.0^{f}	28.9^{ef}	39.3^{d}	51.8^{f}
	3	93^{cd}	67^{b}	31.3^{b}	39.1^{b}	52.9^{b}	59.9^{b}
	4	95^{bcd}	64^{bc}	29.9^{b}	35.2^{d}	47.1^{c}	55.1^{d}
	5	96^{abc}	71^{ab}	23.7^{d}	30.0^{e}	39.0^{e}	51.2^{f}
	6	97^{abc}	73^{ab}	30.2^{b}	39.2^{b}	46.4^{cd}	54.3^{e}
	7	91^{d}	55^{c}	42.8^{a}	52.8^{a}	61.3^{a}	69.2^{a}
	8	99^{ab}	75^{ab}	18.7^{e}	27.7^{f}	33.4^{f}	41.0^{g}
	9	96^{abc}	69^{ab}	26.2^{c}	37.5^{c}	45.3^{de}	55.8^{cd}

Values with different letters in the same column are significantly different at the 5% level.

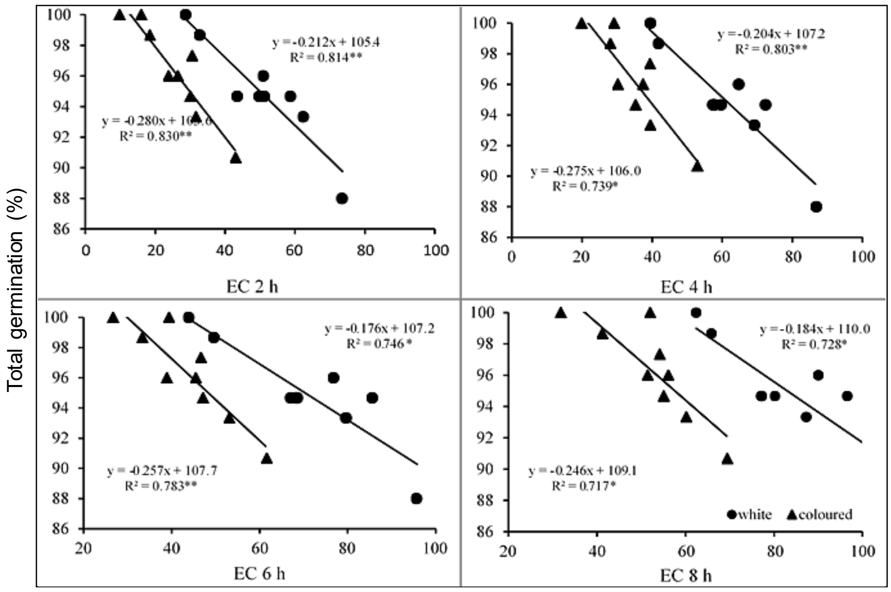

Fig 1: The relationship between EC and the total seed germination percentages of white (•) and coloured (▲) French bean cultivars. Significance: *:0.05, **:0.01.

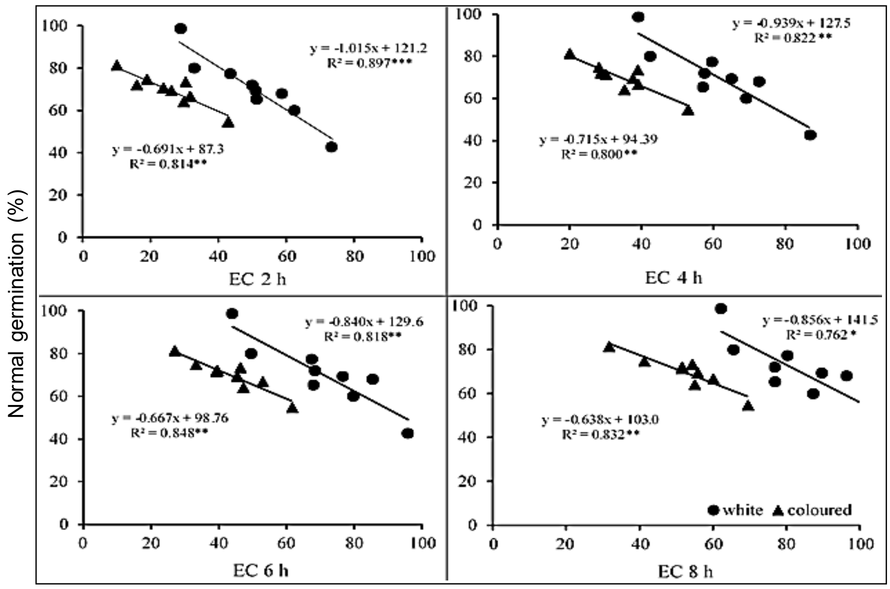

Fig 2: The relationship between EC and the normal seed germination percentages of white (•) and coloured (▲) French bean cultivars. Significance: *: 0.05, **: 0.01, ***: 0.001.

The high and significant correlation between EC values and germination percentages of total and normal seedlings suggests that conductivity readings can be an alternative to the germination test which requires 8 days in bean. Information about germination levels of commercial bean cultivars can be obtained within as short as two hours. Our results are in agreement with the prediction of germination by bulk conductivity in artificially aged cabbage and cauliflower (Mirdad *et al*., 2006; Demir *et al*., 2008), leek (Demir *et al*., 2012) and cress (Ozden *et al*., 2017) seeds. They concluded that seed ageing results in the loss of cell membrane integrity inducing an increase in solute leakage and reduced germination percentages. Khajeh Hosseini *et al*. (2010) reported that EC averages of single oilseed rapeseed at 24 hours of soaking were 4.9 µS cm^{-1} g^{-1} in seeds which produced normal seedlings. In legumes and maize seeds, results confirmed that EC of single seed leachate can be taken as a physiological index of seed germination (Steere *et al*., 1981; Davidson *et al*., 1994). Obviously, different seed weights may result in different leakage measurements. Weighing seeds prior to EC assessment and referring this measure to seed weight expressed in grams is a generally accepted experimental procedure (Hepburn *et al*., 1984). White French bean cultivars resulted in higher electrolyte leakage than those of coloured ones which are in agreement with earlier findings in this crop (Powell *et al*., 1986; Demir, 1996).

CONCLUSION

In conclusion, the EC test has a quick, cheap and simple method of detecting the germination potential of bean seed cultivars with various germination. This method may help the seed industry to decide the renewal time of seed lots during storage. EC assessment may be also used as a routine test in checking the germination quality of unsold seeds produced in previous years before marketing.

ACKNOWLEDGEMENT

The author expresses gratitude to Turkish and Global Seed Companies for providing seed samples of French bean varieties as well as to Prof. Dr. İbrahim Demir, Ankara University, Faculty of Agriculture, Department of Horticulture, for enabling the use of his laboratory in this work.

Conflict of interest: None.

REFERENCES

Anonymous (2021). Statistical Data of Turkey. Turkish Statistical Institute. https://biruni.tuik.gov.tr.

Balkaya, A., Karaağaç, O. (2013). General Status of Leguminous Vegetable Genetic Resources in Turkey. The European Journal of Plant Science and Biotechnology. 7(1): 1-6.

Boros, L., Wawer, A. (2018). Seeds quality characteristics of dry bean local populations (*Phaseolus vulgaris* L.) from National Center for Plant Genetic Resources in Radzików. Legume Research. 41(5): 669-674. DOI: 10.18805 /LR-382.

Davidson, K.G.V., Moore, F.D., Roos, E.E., Nath, S. and Sowa, S. (1994). Comparison of seed-quality indices resulting from single-seed electroconductivity measurements. Hort Science. 29: 1158-1163.

Demir I. (1996). The effects of testa colour, temperature and seed moisture content of occurrence of imbibition damage in beans. Turkish J. Agri Forest. 20: 295-298.

Demir, I., Cebeci, C. and Guloksuz, T. (2012). Electrical conductivity measurements to predict germination of commercially available radish seed lots. Seed Science and Technology. 40: 229-237.

Demir, I., Mavi, K., Kenanoglu, B.B. and Matthews, S. (2008). Prediction of germination and vigour in naturally aged commercially available seed lots of cabbage (*Brassica oleracea* var. *capitata*) using the bulk conductivity method. Seed Science and Technology. 36: 509-523.

Hepburn, H.A., Powell, A.A. and Matthews, S. (1984). Problems associated with the routine application of electrical conductivity measurements of individual seeds in the germination of testing of peas and soybeans. Seed Science and Technology. 12: 723-734.

Jhanavi, D.R., Patil, H.B., Justin, P., Hadimani, H.P.R., Mulla, S.W.R. and Sarvamangala, C. (2018). Genetic variability, heritability and genetic advance studies in French bean (*Phaseolus vulgaris* L.) genotypes. Indian J. Agric. Res. 52(2): 162-166.

ISTA (2016). International Rules for Seed Testing, Edition International Seed Testing Association, Bassersdorf, Switzerland.

ISTA (2022). International Rules for Seed Testing, Edition International Seed Testing Association, Bassersdorf, Switzerland.

Kaya, G. (2021). The relationship between seed vigor and germination performance under various chloride salts in pea. Legume Research. 44(7): 793-797. DOI: 10.18805/LR-559.

Khajeh-Hosseini, M, Nasehzadeh, M. and Matthews, S. (2010). Rate of physiological germination relates to the percentage of normal seedlings in standard germination tests of naturally aged lots of oilseed rape. Seed Science and Technology. 38: 602-611.

Matthews, S. and Powell, A.A. (2006). Electrical conductivity vigour test: Physiological basis and use. Seed Testing International. 131: 32-35.

Matthews, M., Noli, E., Demir, I., Khajeh-Hosseini, M. and Wagner, M.H. (2012). Evaluation of seed quality: From physiological to international standardization. Seed Science Research. 22: 69-73.

Mirdad, Z., Powell, A.A. and Matthews, S. (2006). Prediction of germination in artificially aged seeds of *Brassica* spp. using the bulk conductivity test. Seed Science and Technology. 34: 273-286.

Negi, S., Bharat, N.K. and Kumar, M. (2021). Effect of seed biopriming with indigenous PGPR, *Rhizobia* and *Trichoderma* sp. on growth, seed yield and incidence of diseases in French bean (*Phaseolus vulgaris* L.). Legume Research. 44(5): 593-601. DOI: 10.18805/LR-4135.

Ozden, E., Memis, N., Kapcak, D., Durmus, E., Ozdamar, C., Ozdemir, M., Demir, I. (2017). Electrical Conductivity Relates Seed Germination in Cress. 2nd International Balkan Agriculture Congress. Tekirdag Turkey. pp. 476-481.

Powell, A.A., Oliveira, M. De A. and Matthews, S. (1986). The role of imbibition damage in determining the vigour of white and coloured seed lots of dwarf French Beans (*Phaseolus vulgaris*). Journal of Experimental Botany. 37(178): 716-722.

Powell, A.A. and Mavi, K. (2016). Application of the Radicle Emergence Test to Radish (*Raphanus sativus*) Seed. In: Method Validation Reports. International Seed Testing Association, Bassersdorf. pp. 65-72.

Steere, W.C., Levengood, W.C. and Bondie, J.M. (1981). An electronic analyzer for evaluating seed germination and vigour. Seed Science and Technology. 9: 567-576.