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Effects of Seed Storage Periods on Electrical Conductivity of Seed Leakage, Germination and Field Emergence Percentage in Common Bean (*Phaseolus vulgaris* L.)

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This study was carried out to determine the effects of seed storage at + 4 °C for 8, 20, 32 and 44 months on electrical conductivity of seed leakage, germination and field emergence percentages in common bean (*Phaseolus vulgaris* L.). The seeds of common bean cvs Karacasehir-90, Sahin-90 and Yunus-90 were used in present investigation. Field experiments were conducted under three diverse environmental conditions (E1, E2 and E3) for soil texture, seedbed moisture content at sowing time, soil and air temperature during the seedling emergence and also total rainfall at pre- and post-sowing periods in Samsun and Sinop provinces, Turkey, in year 2004. In addition, germination speed (GS) and germination power percentage (GP), the length of seedling emergence periods (SEP) and electrical conductivity (EC) of seed leakage were determined. Environments showed significant differences for field emergence (FE) ($p < 0.05$) and SEP ($p < 0.01$). In E1, unfavourable environmental conditions at the germination and seedling emergence stage significantly reduced FE percentage (60.11 %) and extended SEP (14.07 d), when compared with E2 (81.00 % and 8.64 d) and E3 (61.78 % and 8.36 d). Bean cultivars were not different in terms of GS, GP and the length of SEP, while they were different for FE and EC values. GS, GP, FE and EC ranged from 89.69-94.06 %, 91.88-96.56 %, 63.12-72.12 %, 26.72-36.42 µS cm^{-1} g^{-1} among cultivars, respectively. GS, GP, FE, EC and SEP were affected by the storage periods. Lower GS, GP and FE ($p < 0.01$) were determined in seeds stored for 44 months than that in the others due to reduction in seed viability with the extending time of storage. In addition, seed storage of 44 months had the longest SEP and highest EC values. Strong relationships were found between EC and GS (r = -0.9316**), EC and GP (r = -0.9186**), EC and FE (r = -0.7660**). Study results showed that common bean seeds could be stored safely at + 4 °C up to 32 months without a significant reduction occurred in their viability.

Key Words: Common bean, *Phaseolus vulgaris*, Storage period, Electrical conductivity, Environmental conditions, Germination speed, Germination power, Field emergence.

INTRODUCTION

The first step for the successful crop production is to use high yielded and quality seeds. Changes in seed quality have important effects on emergence and seedling and plant development[1]. Timing of emergence often determines whether a plant competes successfully with its neighbors, is consumed by herbivores, infected with diseases and whether it flowers, reproduces and matures properly by the end of the growing season[2]. Vigor may be reduced by damage to the embryo or seed coat during harvesting and processing. Other factors affecting vigor include environment and nutrition of the parent plant, stage of maturity at harvest, seed size, senescence caused by long storage and pathogens[3]. Seeds of many species of legumes are capable of retaining germinability for many years in storage[4]. However, seeds should be stored in a favourable storage conditions to minimize the loss of viability throughout storage period. Adequate storage is a significant agricultural problem because of the need to maintain seed viability and vigor[5], particularly in tropical regions with a high humidity[6]. The time of storage, type of seed stored and storage environment (temperature, relative humidity and oxygen levels) influence seed vigor[7]. Symptoms of vigor loss are reductions in germination rate and uniformity, reductions in tolerance to environmental stress and inferior seedling emergence and growth[8].

Many researchers have reported significant correlation coefficients between field emergence and standard laboratory germination tests, but they have also reported inconsistencies and difficulties with the prediction of field emergence. Germination test results can be used to compare the quality of different seed lots[9]. The germination percentage indicates the potential of a seed lot to establish seedlings under good field conditions[3]. High germinating seed lots with low electrolyte leakage are considered to be high in vigor and better able to withstand stressful conditions[10].

When seeds aged, the seed membrane becomes more permeable, so many substances in seeds such as sugars, free amino acids, organic acids and various elements leach out in the presence of water. The concentration of leakages is normally measured either by the electrical conductivity or by chemical methods[11]. The conductivity test has been developed into a routine vigor test to predict field emergence of garden pea (*Pisum sativum* L.) and is also used for soybean, French bean (*Phaseolus vulgaris* L.), mung bean (*Phaseolus aureus* Roxb) and field bean[12].

The objective of this work was to determine the effects of seed storage at + 4 °C constant temperature for 8, 20, 32 and 44 months on electrical conductivity of seed leakage, laboratory germination, field emergence percentage and the length of seedling emergence period in common bean (*Phaseolus vulgaris* L.) cvs Karacasehir-90, Sahin-90 and Yunus-90.

EXPERIMENTAL

Seeds of common bean (*Phaseolus vulgaris* L.) cvs Karacasehir-90, Sahin-90 and Yunus-90 stored at + 4 °C constant temperature for 8, 20, 32 and 44 months in darkness within the airtight polyethylene bags to prevent moisture absorption were used in the study. Cold storage depot of Faculty of Agriculture, University of Ondokuz Mayis was used to store experimental seed materials.

Experiments were separated into two main parts as field and laboratory experiments. Field emergence (FE) experiments were carried out under three diverse environmental conditions differing in soil texture, seedbed moisture content at sowing time, soil and air temperature during the seedling emergence and also total rainfall at pre- and post-sowing periods. Each one of the field experiment sites was assumed as a different environment (E1, E2 and E3) from another one because of the differences in soil and air conditions. Sowing of field experiments were performed on May 14 in E1, May 24 in E2 and June 29 in E3 in 2004. Soil moisture content at the depth of sowing was excessive and temperature of seedbed was lower than that for optimum seedling emergence through 20 d after sowing in E1. On the contrary, seedbed physical conditions and temperature were optimum for germination and seedling emergence in E2. Soil texture in both E1 and E2 were clayey and clayey-loam in E3. Two of field trials in E1 and E2 was carried out in Samsun province (41° 17' N, 36° 19' E, 120 m asl) of Turkey, while the third one in E3 was set in Sinop (42° 12' N, 35° 9' E, 18 m asl) province.

Field emergence experiments were arranged in a split plot design in randomized complete blocks with 3 replications. Bean cultivars were allocated to main plots and storage periods to subplots. Seeds were sown in 3-4 cm soil depth by hand in 2 row plots, 25 seeds for each of them, with 0.5 m between the rows and 0.10 m between plants on the same row. Field emergence was recorded as the percentage of seedling emerged from the soil at the end of the 15th d after sowing.

Laboratory experiments were containing germination and electrical conductivity tests. Germination speed (GS) and germination power (GP) were determined at the end of the 5 and 9th days by counting the number of normal seedling[13]. The electrolytes leaking from bean seeds, stored at + 4 °C for different periods, into the seed soaking water were measured at the end of the 24 h using the electrical conductivity meter according to Hampton *et al.*[14].

Data on germination and electrical conductivity tests were subjected to an analysis of variance according to completely randomized plots. Statistical analyses were performed using MSTATC programme. Duncan's multiple comparison procedure was used for comparison of means showing statistical significance.

RESULTS AND DISCUSSION

Germination speed and power percentages of seeds stored at + 4 ºC for different periods in common bean are presented in Table-1.

TABLE-1
GERMINATION SPEED AND GERMINATION POWER PERCENTAGES (%) OF COMMON BEAN SEEDS STORED FOR DIFFERENT PERIODS

	Cultivars	Storage periods (months)				
		8	20	32	44	Mean
Germination speed (%)	Karacasehir-90	98.75a**	98.75a	100.00a	73.75c	92.81
	Sahin-90	95.00ab	100.00a	96.25ab	85.00bc	94.06
	Yunus-90	100.00a	98.75a	100.00a	60.00d	89.69
	Mean	97.92a**	99.17a	98.75a	72.92b	–
Germination power (%)	Karacasehir-90	100.00a**	100.00a	100.00a	73.75b	93.44
	Sahin-90	97.50a	100.00a	96.25a	92.50a	96.56
	Yunus-90	100.00a	100.00a	100.00a	67.50b	91.88
	Mean	99.17a**	100.00a	98.75a	77.92b	–

**Significant at 0.01 level, means of cultivars and storage periods followed by the same letters within the same column or same row are not significantly different according to Duncan's multiple range test.

Laboratory germination test results revealed that bean cultivars were not differed for GS and GP. GS varied between 89.69 % in Yunus-90 and 94.06 % in Sahin-90, while GP were 91.88 % in Yunus-90 and 96.56 % in Sahin-90 (Table-1).

GS and GP percentages were not affected by storage periods until 32 months, but storage of seeds for 44 months reduced both GS and GP ($p < 0.01$) (Fig. 1). Pandita and Nagarajan[15] determined that germination percentage reduced from 97.5 to 87.0 % as the aging process progressed from 8 to 32 months in Arkel and Bonneville garden pea cultivars. Cultivar × storage period interaction for GS and GP was highly significant ($p < 0.01$). The lowest GS and GP were found when seeds of Yunus-90 cv. stored for 44 months (Table-1).

Environments showed significant differences ($p < 0.05$) regarding field emergence percentages. The percentages of emerged seedlings in E2 (81.00 %) were higher than that in E1 (60.11 %) and E3 (61.78 %). A significant ($p < 0.05$) interaction was found between environment and cultivar, environment and storage period in terms of field emergence (not shown in Tables).

Seeds with low viable can be able to germinate under favourable condition, but all of them can't be able to emerge from the soil[16]. In the present study, bean cultivars differed for field emergence percentages ($p < 0.05$) (Table-2). The lowest field emergence (63.12 %) was determined in Sahin-90 among cultivars. Although bean cultivars showed high performance for

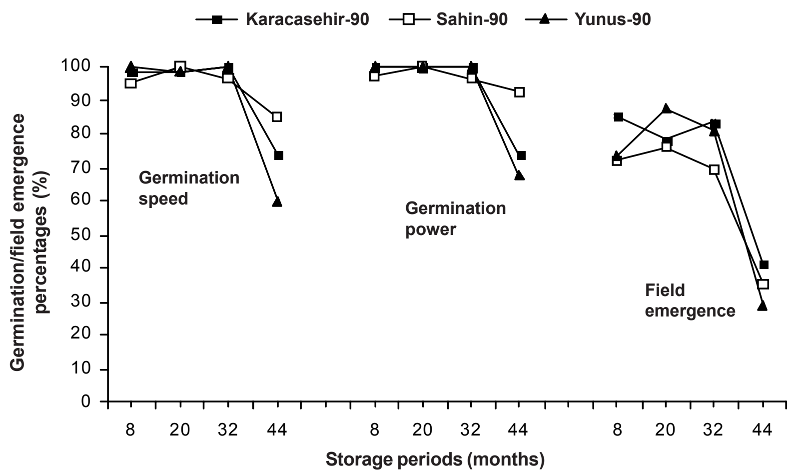

Fig. 1. Changes in germination speed, germination power and field emergence percentages depending on seed storage periods in common bean

TABLE-2
FIELD EMERGENCE PERCENTAGES (%) OF COMMON BEAN SEEDS STORED FOR DIFFERENT PERIODS

Cultivars	Storage periods (months)				Mean
	8	20	32	44	
Karacasehir-90	85.32	78.24	83.56	41.32	72.12a*
Sahin-90	72.00	76.00	69.32	35.12	63.12b
Yunus-90	73.32	87.56	80.88	28.88	67.68ab
Mean	76.88a**	80.60a	77.92a	35.11b	–

*Significant at 0.05 level; **Significant at 0.01 level, means of cultivars and storage periods followed by the same letters within the same column or same row are not significantly different according to Duncan's multiple range test.

GS and GP (89.69 % and over) under favourable laboratory conditions (Table-1), they didn't give the same performance under field conditions due to uncontrolled environmental factors causing negative effects on seed germination and seedling emergence. Scully and Waines[17] reported that seed germination and emergence were affected by soil temperature and optimum soil temperature for germination was 20-30 °C for common bean. Germination percentages of 39 bean seed samples at 10 °C were found[18] below 60 %.

The effects of seed storage periods on field emergence were found significant ($p < 0.01$). Field emergence percentages determined for 8, 20 and 32 months stored seeds (76.88, 80.60 and 77.92 %, respectively) were not statistically different, but very high reductions occurred in field emergence when seeds stored for 44 months (35.11 %) (Table-2, Fig. 1).

The length of seedling emergence period (SEP) determined in E1 (14.07 d) was longer ($p < 0.01$) when compared with E2 (8.64 d) and E3 (8.36 d) because of unfavourable environmental factors mentioned above at the seedling emergence period. Interactions between environment and cultivar, environment and storage period regarding the length of SEP were significant ($p < 0.05$) (not shown in Tables).

No significant differences were found among common bean cultivars in terms of SEPs. SEP of common bean cultivars varied between 10.17 d in Yunus-90 and 10.49 d in Sahin-90 (Table-3). Emergence period has been found 8 to 9 d in common bean under Samsun ecological conditions by Zeytun and Gulumser[19]. Cortelazzo *et al.*[6] determined that germination began 24 h later in seeds stored at 8 °C for 12 years and reached 86.8 %, which wasn't significantly different from that of fresh beans (96.0 %).

TABLE-3
THE LENGTH OF SEEDLING EMERGENCE PERIODS (DAYS) DETERMINED FOR SEEDS OF COMMON BEAN STORED FOR DIFFERENT PERIODS

Cultivars	Storage periods (months)				Mean
	8	20	32	44	
Karacasehir-90	10.00	10.00	10.11	11.56	10.42
Sahin-90	9.78	9.89	10.33	11.94	10.49
Yunus-90	9.89	9.44	10.00	11.33	10.17
Mean	9.89b**	9.78b	10.15b	11.61a	–

*Significant at 0.01 level, means of cultivars and storage periods followed by the same letters within the same column or same row are not significantly different according to Duncan's multiple range test.

The length of SEPs wasn't different for seeds stored up to 32 months, while it was longer in seeds stored for 44 months due to their reduced viability (Tables 1 and 2) and increased electrical conductivity values (Table-4). These results were in agreement with Peksen *et al.*[20] stated that days to emergence prolonged with increases in electrical conductivity values in garden pea.

Changes in electrical conductivity values depending on cultivars and seed storage periods are given in Table-4. Electrical conductivity values showed significant differences ($p < 0.01$) among bean cultivars and varied between 26.72 $\mu S\ cm^{-1}\ g^{-1}$ in Sahin-90 and 36.42 $\mu S\ cm^{-1}\ g^{-1}$ in Karacasehir-90. Although, the effects of seed storage for 8, 20 and 32 months on electrical conductivity were not different, electrical conductivity values determined for 44 months stored seeds were two times higher ($p < 0.01$) than that for the other storage periods. Cultivar × storage period interaction was found highly significant ($p < 0.01$) (Table-4).

TABLE-4
ELECTRICAL CONDUCTIVITY (µS cm^{-1} g^{-1}) OF COMMON BEAN SEEDS STORED FOR DIFFERENT PERIODS

Cultivars	Storage periods (months)				Mean
	8	20	32	44	
Karacasehir-90	30.56cde**	32.19cd	33.22cd	49.72b	36.42a**
Sahin-90	26.28cde	24.67cde	21.15de	34.77c	26.72b
Yunus-90	18.47e	24.08cde	22.68cde	66.17a	32.85a
Mean	25.10b**	26.98b	25.68b	50.22a	

**Significant at 0.01 level, means of cultivars and storage periods followed by the same letters within the same column or same row are not significantly different according to Duncan's multiple range test.

Fig. 2 clearly shows that there were no significant changes regarding germination power, field emergence and electrical conductivity when seeds were stored up to 32 months. However, significant increases in electrical conductivity values and reductions in germination power and field emergence percentages occurred in seeds stored for 44 months with decreasing seed viability.

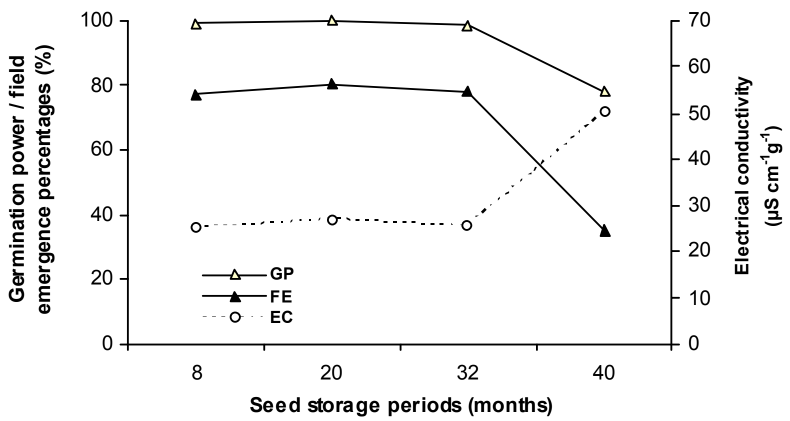

Fig. 2. Changes occurred in germination power (GP), field emergence (FE) percentages and electrical conductivity (EC) values with seed storage periods over means of all genotypes

Kolasinska *et al.*[18] found that the electrical conductivity of 39 bean samples ranged from 7 to 45 µS cm^{-1} g^{-1} and the conductivity test could be used to predict seedling emergence in the field irrespective of soil temperature at sowing. Powell and Matthews[21] informed that a decline in seed vigor of pea, 13 seed lots from six cultivars of peas from commercial warehouses following up to two years storage, was indicated by an increase in the leaching of electrolytes from the seeds and reduced vital staining with increased time in storage, although viability was still maintained at a level above the minimum standard (80 %). However, the decline in vigor of the seed lots in the warehouses did not occur at the same rate. The present results are in agreement with the results of Powell and Matthews[21] and also Pandita and Nagarajan[15] stated that electrical conductivity values of pea seeds increased from 16.7 to 24.3 μS cm^{-1} g^{-1} with the extension of seed ageing from 8 to 32 months.

Deterioration and loss of seed viability may occur as a result of seed aging. Following ageing, chromatid-type aberrations (in particular single fragments) were most frequently observed in the surviving seeds of both pea cultivars and landraces[22]. Adebisi and Ajala[23] determined that both the storage periods and genotypes had highly significant effects on germination percentage and seedling vigor in soybean. After two months storage, a decline occurred in germination percentage of NARC 2 soybean cultivar's seeds with high (9.8 %) and medium (7.7 %) moisture content at all temperatures (-20, 5, 25, 37 and 50 °C). There were no viable seed after two months storage at 37 °C in all moisture levels[24]. It was reported that the rate of seed deterioration increased with the increase in storage temperature and storage period in garden pea. Varietals differences were observed among pea varieties for seed deterioration by Shakeel *et al.*[25].

Electrical conductivity values determined in the present study were negatively and highly significantly related to GS (r = -0.9316**), GP (r = -0.9186**) and FE (r = -0.7660**). In some preceding studies on food legumes, close relationships were found between electrical conductivity of seed leakage and germination or field emergence percentages. A negative and strong relationship was determined between electrical conductivity and field emergence in coloured seeded bean cultivars by Balkaya and Odabas[26]. Peksen *et al.*[27] found that electrical conductivity was a reliable test to predict field emergence potential of white seeded cowpea genotypes under field conditions before sowing. It has been reported that electrical conductivity values showed negative and highly significant correlation with laboratory germination and field emergence percentages and also days to emergence prolonged with increases in electrical conductivity in garden pea[20]. The present results are in agreement with Balkaya and Odabas[26] and Peksen *et al.*[20,27], but contrast with Peksen[28] stated that electrical conductivity readings determined at both 24 and 48 h weren't significantly related to GS, GP and FE percentages in faba bean.

Present study results showed that bean cultivars were not different in terms of GS, GP and SEP, but FE and EC were affected by both cultivars and environmental conditions. In addition, it was found that storage periods had significant effects on all investigated characters.

From the germination and field experiments, it can be concluded that common bean seeds could be stored safely at + 4 °C up to 32 months without a significant reduction occurred in their viability. Use of stored seeds for 44 months or more periods might be resulted in poor seedling emergence, lower plant density and also lower seed yield in field conditions due to loss of seed viability through the long storage period.

REFERENCES

1. I. Demir, R. Yanmaz and A. Günay, *Bahce*, **23**, 59 (1994).
2. F. Forcella, R.L.B. Arnold, R. Sanchez and C.M. Ghersa, *Field Crops Res.*, **67**, 123 (2000).
3. W.J. van der Burg, in eds.: J.P. Srivastava and L.T. Simarski, Seed Production Technol., ICARDA, Aleppo, Syria, pp. 82-87 (1986).
4. A.M. Mayer and A. Poljakoff-Mayber, Germination of seeds, Pergamon Pres, Oxford, New York, edn. 4, pp. 38-43 (1989).
5. M. Zhang, M. Yoshiyama, T. Nagashima, Y. Nakagawa, T. Yoshioka and T. Esashi, *Plant Cell Physiol.*, **36**, 1189 (1995).
6. A.L. Cortelazzo, J. Coutinho and P.A. Granjeiro, *Braz. J. Morphol. Sci.*, **22**, 121 (2005).
7. L.O. Copeland and M.B. McDonald, Principles of Seed Science and Technology, New York, USA, p. 321 (2001).
8. J.G. Hampton, Seed vigour: Its importance and application. http://www. nzsti.semec.ws/semec/seedvigourintroduction.htm. (2000).
9. International Seed Testing Association (ISTA), Supplement to *Seed Sci. Technol.*, **21**, 1 (1993).
10. J.G. Hampton, in eds.: J.G. Hampton and D.M. TeKrony, International Seed Testing Association, Zurich, Switzerland, pp. 10-27 (1995).
11. P.K. Agrawal, in eds.: J.P. Srivastava and L.T. Simarski, Seed Production Technol. ICARDA, Aleppo, Syria, pp. 190-198 (1986).
12. International Seed Testing Association (ISTA), in ed.: H.A. van de Venter, Seed Vigour Testing Seminar, Copenhagen, Zurich (1995).
13. International Seed Testing Association (ISTA), *Seed Sci. Technol.*, **27**, 340 (1999).
14. J.G. Hampton, K.A. Johnstone and V. Euaumpon, *Seed Sci. Technol.*, **20**, 677 (1992).
15. V.K. Pandita and S. Nagarajan, *Indian J. Agric. Sci.*, **72**, 213 (2002).
16. H. Ilbi and H. Geren, TOTEM, ISBN 975-483-671-X, 975-483-672-8, Bornova, Izmir, pp. 381-425 (2005).
17. B. Scully and J.G. Waines, *Agron. J.*, **79**, 287 (1987).
18. K. Kolasinska, J. Szyrmer and S. Dul, *Crop Sci.*, **40**, 470 (2000).
19. A. Zeytun and A. Gulumser, *J. Agric. Fac. Ondokuz Mayis Univ.*, **3**, 83 (1988).
20. E. Peksen, A. Peksen, H. Bozoglu and A. Gulumser, *J. Agron.*, **3**, 243 (2004).
21. A.A. Powell and S. Matthews, *Acta Hort.*, **83**, 133 (1978).
22. H.O. Sivritepe and A.M. Dourado, *Turk. J. Bot.*, **22**, 223 (1998).
23. M.A. Adebisi and M.O. Ajala, *J. Tropical Forest Resour.*, **16**, 126 (2000).
24. S. Nasreen, B.R. Khan and A.S. Mohmand, *Pak. J. Biol. Sci.*, **3**, 2003 (2000).
25. A.J. Shakeel, M. Afzal, S. Nasim and R. Anwar, *Pak. J. Biol. Sci.*, **4**, 1490 (2001).
26. A. Balkaya and M.S. Odabas, *Pak. J. Biol. Sci.*, **5**, 382 (2002).
27. A. Peksen, E. Peksen and H. Bozoglu, *Pak. J. Bot.*, **36**, 311 (2004).
28. E. Peksen, *Asian J. Chem.*, **19**, 3178 (2007).

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