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A New Approach to Determine Time and Temperature Combination for Electrical Conductivity Test in Sorghum

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ABSTRACT

This study was conducted to determine a suitable time and temperature combination for the electrical conductivity test to be used in sorghum seeds. Fifty seeds known initial seed moisture content and weight of fresh and dead seeds (105°C for 6h) of seven sorghum cultivars were used as material. The electrical conductivities of soaking water were measured using an EC meter in 20, 25 and 30°C for 4, 8, 12 and 24 h using 50 mL deionized water. The experimental design was three factor factorial (7 × 3 × 4) arranged in a completely randomized design; with four replications and 50 seeds per replicate. The results showed that increased time and temperature caused a remarkable increase in EC values of all of the cultivars. Temperature significantly affected the electrical conductivity values and the best results were obtained at 25°C. The cultivars with the lower germination percentage gave the higher electrical conductivity value. Dead seeds always gave higher electrical conductivity at 25°C for all periods. It was concluded that the temperature of 25°C and 24 h was the optimum combination for the electrical conductivity test in sorghum.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench), an important summer season cereal, has been usually cultivated for its grain or green fodder and it ranks fifth in the world production of cereals (Asgharipour and Heidari, 2011). It is adapted to semi-arid tropical regions and produces a reasonable yield under high temperatures, irregular rainfall, low soil fertility and water holding capacity. These conditions cause adverse effects on germination, emergence and seedling growth (Doggett, 1988; Mutava et al., 2011).

A simple, rapid and reliable method determining seed vigor is crucial for seed producers because the standard germination test generally overestimates emergence performance under field conditions. For this reason, several seed vigor tests such as accelerated aging, controlled deterioration, cold and cool test have been developed for predicting the emergence performance of the seed lots. The electrical conductivity (EC) test has been suggested as a method to evaluate seed vigor of pea and soybean (Hampton and TeKrony, 1995) while it has been usually performed for various crops in seed laboratories due to its simplicity and potential for rapid implementation (Panobianco1 et al., 2007; Milosevic et al., 2010). Its purpose is to indirectly assess the degree of cellular membrane injury due to seed deterioration. The seeds with lower viability leave a greater amount of electrolytes as a consequence of lower cellular membrane stability (Vieira et al., 1999). There is very limited research on the EC test in sorghum while Soares et al. (2010) found that the EC test was ineffective to distinguish seed lots of sorghum, expect for the lots with low vigor.

This study aimed to determine the optimum time and temperature combination for the electrical conductivity test to be used for sorghum seeds using comparison of fresh and dead seed values.

Materials and Methods

This study was conducted at the seed science laboratory of the Field Crops Department, Agricultural Faculty, Eskişehir Osmangazi University, Turkey. Seeds of *Sorghum bicolor* cultivars Aldarı, Akdarı, Beydarı, Gözde-80, Leoti and Rox, and a hybrid (*S. bicolor* x *S. sudanense*) cultivar cv. Greengo were harvested from the experimental fields at Eskisehir Osmangazi University in 2011. All of the seeds were stored at 4°C prior to the start of the experiment.

Germination test: Four replicates of 50 seeds from each cultivar were germinated on three rolled filter papers with 10 mL of distilled water. Each rolled paper was placed in a sealed plastic bag to prevent moisture loss. Seeds were allowed to germinate at 25 ± 1°C in the dark for 10 days. Seeds were considered to have germinated when the emerging radicle was at least 2 mm long. Germination percentage was recorded every 24 h for 10 days (ISTA, 2003).

Emergence test: Four replicates of 50 seeds from each cultivar were sown at 2 cm depths in sand in a seedling tray (30 × 20 × 7 cm) to determine the laboratory emergence percentage (EP). The seedlings were grown in an incubator at 25 ± 1°C for 10 days. The emerged seedlings (appearance of coleoptiles at the surface) were counted at 10 days after sowing.

Electrical conductivity (EC) test: The electrolyte leakage was measured for four replicates of 50 weighed seeds from fresh and dead seeds which were killed at 105°C for 6h. Both fresh and dead seeds were immersed in 50 mL deionized water at 20, 25 and 30°C for 4, 8, 12 and 24 h. The electrical conductivity of soak water was measured using a conductivity meter (Model WTW Cond 314i, Germany). The results were expressed in $\mu S\ cm^{-1}\ g^{-1}$ to take into account any variability in seed weight among the seed lots. To determine the optimum time and temperature combination for the electrical conductivity test, differences between EC values of dead and fresh seeds were calculated as EC value of dead seeds minus EC values of fresh seeds.

The experiment was arranged in a completely randomized design (CRD) with four replicates and 50 seeds per replicate. Germination percentage data were subjected to arcsine transformation before an analysis of variance was performed using the MSTAT-C program (Michigan State University). The differences among the means were compared using the Duncan Multiple Range Test values ($P \leq 0.05$).

Results and Discussion

The germination rate, emergence rate and 1000 seed weight of sorghum cultivars were significantly different ($P \leq 0.05$), while seed moisture content was not changed (Table 1). The lowest germination rate was obtained in Gözde-80 (89.0%), while the highest value was found in Aldarı and Leoti with 100%. Minimum emergence rate was detected in Gözde-80 with 79%. The heavier seed weight was measured in Rox, Greengo and Akdarı followed by Aldarı, Leoti, Beydarı and Gözde-80, respectively.

The minimum electrical conductivities of fresh seeds were measured at 20°C for 4 h. The highest EC value was determined in Gözde-80 followed by Greengo (Table 2). Dead seeds gave lower EC values for 4 and 8 h while they possessed higher EC values as duration was extended. Prolonged time resulted in an increase in EC values of sorghum cultivars except for Gözde-80 and Greengo. As shown in Figure 1A, the differences between EC values of dead and fresh seeds were very prominent in Beydarı. The EC values of fresh seeds of Gözde-80 and Greengo were higher than that of dead seeds. These results agree with those reported by Santipracha et al. (1997) in corn and Cisse and Ejeta (2003) in sorghum; furthermore, they confirm that genetic differences may play an important role in determining seed vigor.

Measurement of EC at 25°C showed that Gözde-80 and Greengo had the highest EC value while the lowest was recorded in Beydarı (15.0 $\mu S\ cm^{-1}\ g^{-1}$) and Rox (19.7 $\mu S\ cm^{-1}\ g^{-1}$). Increased time clearly improved the EC values of sorghum cultivars; consequently, the highest EC values were detected at 24 h (Table 3). Dead seeds presented higher EC values compared to fresh seeds. Hampton and TeKrony (1995) reported that the seed lots with lower germination percentages had lower emergence percentages but, higher electrical conductivity values. A positive difference between fresh and dead seeds of the investigated cultivars was illustrated in Figure 1B.

Table 1 Seed viability and seed characteristics of the investigated sorghum cultivars.

Cultivars	Germination rate (%)	Emergence rate (%)	1000 seed weight (g)	Seed moisture content (%)
Akdarı	98.0^{a}	88^{bc}	23.5^{ab}*	10.0
Aldarı	100.0^{a}	98^{a}	22.8^{b}	9.6
Beydarı	96.5^{a}	92^{ab}	20.4^{c}	10.2
Gözde-80	89.0^{b}	79^{d}	20.3^{c}	9.2
Greengo	99.0^{a}	84^{cd}	23.8^{a}	9.2
Leoti	100.0^{a}	94^{ab}	20.9^{c}	9.1
Rox	98.0^{a}	91^{b}	24.0^{a}	9.3

*Means followed by the same letter(s) in each column are not significantly different at $P \leq 0.05$

Table 2 The electrical conductivities ($\mu S\ cm^{-1}\ g^{-1}$) of soak water of the fresh and dead seeds at 20°C for 4, 8, 12 and 24 hours.

Cultivar	4h		8h		12h		24h	
	Fresh	Dead	Fresh	Dead	Fresh	Dead	Fresh	Dead
Akdarı	21.8^{e}	18.5^{ef}	25.5^{f}	23.2^{f}	27.5^{f}	26.3^{f}	33.7^{g}	35.3^{g}*
Aldarı	20.1^{ef}	17.5^{f}	24.4^{f}	24.9^{f}	27.8^{f}	29.9^{f}	33.6^{g}	42.9^{f}
Beydarı	21.0^{ef}	22.4^{e}	23.0^{f}	30.4^{e}	26.5^{f}	35.9^{e}	34.5^{g}	49.7^{e}
Gözde-80	52.2^{a}	43.3^{b}	62.9^{a}	55.3^{b}	68.6^{a}	61.1^{b}	80.6^{a}	73.7^{b}
Greengo	36.7^{c}	30.6^{d}	45.0^{c}	37.4^{d}	49.3^{c}	41.6^{d}	61.8^{c}	56.3^{d}
Leoti	22.3^{e}	21.8^{e}	26.8^{ef}	27.5^{ef}	30.0^{f}	30.9^{f}	36.5^{g}	37.4^{g}
Rox	20.2^{ef}	18.7^{ef}	24.7^{f}	25.7^{f}	28.5^{f}	29.9^{f}	36.7^{g}	43.6^{f}

*Means followed by the same letter(s) in each exposure time are not significantly different at $P \leq 0.05$

Table 3 The electrical conductivities (µS cm^{-1} g^{-1}) of soak water of the fresh and dead seeds at 25°C for 4, 8, 12 and 24 hours.

Cultivar	4h		8h		12h		24h	
	Fresh	Dead	Fresh	Dead	Fresh	Dead	Fresh	Dead
Akdarı	20.4^{g}	26.3^{ef}	24.6^{fg}	33.8^{d}	28.3^{gh}	38.0^{ef}	33.1^{h}	52.0^{f}*
Aldarı	22.2^{fg}	24.3^{efg}	26.4^{efg}	33.6^{d}	31.1^{gh}	43.4^{de}	42.4^{g}	59.8^{ef}
Beydarı	15.0^{h}	33.8^{cd}	21.6^{g}	43.1^{c}	26.1^{h}	52.0^{bc}	35.3^{gh}	72.5^{bc}
Gözde-80	39.2^{b}	53.9^{a}	50.4^{b}	64.7^{a}	57.1^{b}	71.4^{a}	67.8^{cd}	83.7^{a}
Greengo	38.1^{bc}	41.3^{b}	46.5^{bc}	50.0^{b}	52.7^{bc}	56.7^{b}	64.0^{de}	76.1^{ab}
Leoti	22.0^{fg}	33.4^{cd}	27.9^{ef}	41.4^{c}	32.2^{fg}	48.0^{cd}	39.2^{h}	62.8^{de}
Rox	19.7^{g}	28.2^{de}	25.7^{efg}	30.7^{de}	29.9^{gh}	42.2^{de}	38.8^{gh}	60.7^{de}

*Means followed by the same letter(s) in each exposure time are not significantly different at $P \leq 0.05$

Table 4 The electrical conductivities (µS cm^{-1} g^{-1}) of soak water of the fresh and dead seeds at 30°C for 4, 8, 12 and 24 hours.

Cultivar	4h		8h		12h		24h	
	Fresh	Dead	Fresh	Dead	Fresh	Dead	Fresh	Dead
Akdarı	20.0^{j}	28.1^{ef}	25.5^{h}	35.9^{d}	30.0^{h}	40.9^{de}	38.2^{e}	41.9^{e}*
Aldarı	24.0^{ghij}	25.0^{fghi}	30.1^{efg}	33.6^{def}	36.3^{efg}	41.1^{d}	51.0^{d}	62.2^{c}
Beydarı	23.8^{ghij}	31.9^{de}	29.4^{fgh}	41.9^{c}	35.7^{fg}	50.9^{c}	52.0^{d}	79.7^{a}
Gözde-80	44.6^{b}	49.1^{a}	53.0^{b}	57.6^{a}	59.3^{b}	64.6^{a}	72.1^{b}	78.6^{a}
Greengo	38.6^{c}	35.8^{cd}	50.3^{b}	44.8^{c}	57.6^{b}	52.4^{c}	71.9^{ab}	75.4^{ab}
Leoti	22.3^{hij}	26.5^{fg}	27.6^{gh}	34.1^{de}	32.3^{gh}	39.7^{def}	42.7^{e}	55.8^{d}
Rox	21.4^{ij}	25.7^{fgh}	26.9^{gh}	34.5^{de}	31.7^{gh}	44.1^{d}	43.7^{e}	70.4^{b}

*Means followed by the same letter(s) in each exposure time are not significantly different at $P \leq 0.05$

Table 5 Correlation coefficients between germination, emergence and exposure time in each temperature for the electrical conductivity test.

	20°C		25°C		30°C	
Duration	Germination	Emergence	Germination	Emergence	Germination	Emergence
4 h	-0.806^{*}	-0.884^{**}	-0.505	-0.785^{*}	-0.668	-0.813^{*}
8 h	-0.778^{*}	-0.876^{**}	-0.587	-0.823^{*}	-0.612	-0.804^{*}
12 h	-0.782^{*}	-0.867^{**}	-0.593	-0.818^{*}	-0.591	-0.780^{*}
24 h	-0.766^{*}	-0.880^{**}	-0.569	-0.756^{*}	-0.555	-0.687

* and ** significant at 0.05 and 0.01 levels of probability, respectively

Compared to fresh seeds of sorghum cultivars, dead seeds exhibited higher EC values except for Greengo. As expected, extended exposure time caused an increase in EC values of sorghum cultivars. The maximum EC value was observed in dead seeds of Beydarı with 79.7 µS cm^{-1} g^{-1} and Gözde-80 with 78.6 µS cm^{-1} g^{-1} (Table 4). The difference between dead and fresh seeds was very prominent and all of the differences were positive except for Greengo for 4, 8 and 12 h (Figure 1C). In general, the greatest difference was recorded at 24 h. Soares et al. (2010) reported that the electrical conductivity test should only be used if the seed lots with low vigor have been identified. Also, they stated that EC test should be performed at 16 h or above.

Simple correlations calculated between the germination, emergence rate and exposure times indicated that germination and emergence were negatively correlated with electrical conductivity (Table 5). Significant negative correlation coefficients were found between emergence and exposure time at 20°C while the highest correlation ($r=-0.884^{**}$) was observed in exposure time of 4 h at 20°C. But, the dead seeds showed lower EC value in the time and temperature combination; indicating that higher correlation would constantly predict the seed vigor of sorghum and the previous researcher could not estimate correctly the seed vigor of sorghum using electrical conductivity test (Soares et al., 2010)

In conclusion, to determine the effective time and temperature combination for the electrical conductivity test in sorghum seeds, fresh and dead seeds were used in the study. The differences between EC values of both seed lots were evaluated as a seed vigor selection criterion. An apparent difference among the temperatures was observed because all of the sorghum cultivars at 25°C presented positive results; suggesting that the EC values of dead seeds were high. Also, higher EC values were obtained at measurement of 24 h. It was concluded that 25°C for 24 h was the optimum combination for the electrical conductivity test to be used for a reliable indicator of sorghum seed vigor.

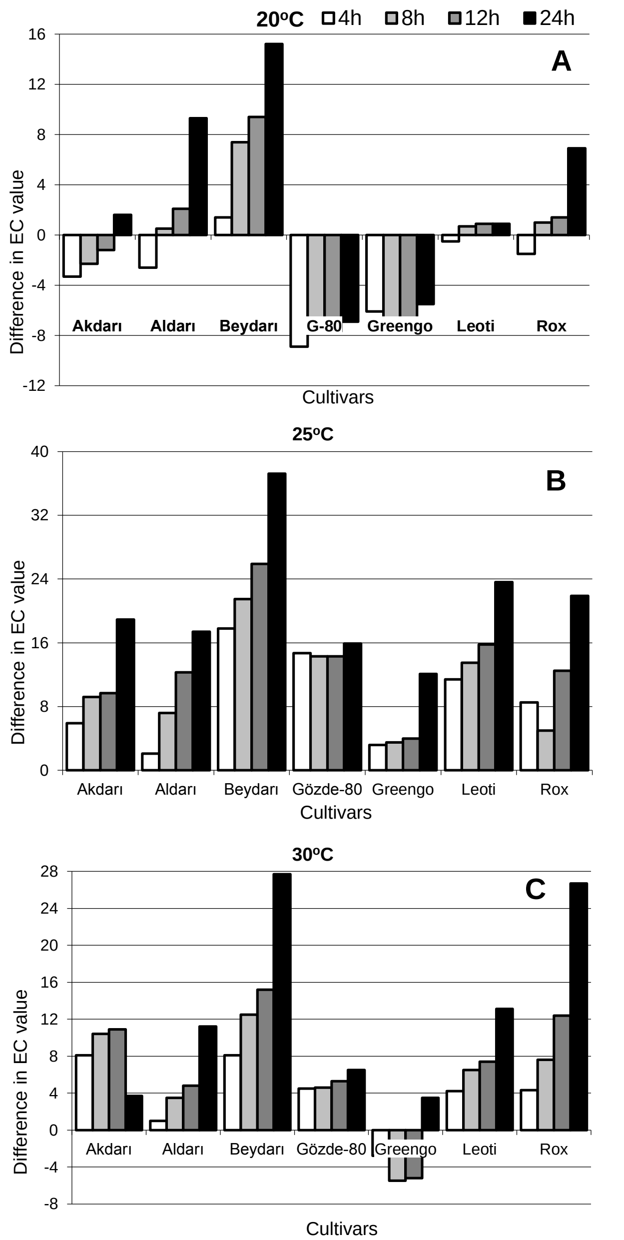

Figure 1. The difference between EC values of the dead and fresh seeds of sorghum cultivars at 20°C (A), 25°C (B) and 30°C (C) for 4, 8, 12 and 24 h.

References

Asgharipour MR, Heidari M. 2011. Effect of potassium supply on drought resistance in sorghum: Plant growth and macronutrient content. Pakistan Journal of Agricultural Science, 48: 197-204.

Cisse ND, Ejeta G. 2003. Genetic variation and relationships among seedling vigor traits in sorghum. Crop Science, 43: 824-828.

Doggett H. 1988. Sorghum. 2nd Ed. John Wiley and Sons Inc. New York.

Hampton JG, Tekrony DM. 1995. Handbook of vigour test methods. 3rd Ed. International Seed Testing Association, Zurich.

ISTA 2003. Handbook on seedling evaluation. 3rd Ed. International Seed Testing Association, Zurich.

Mutavaa RN, Prasada PVV, Tuinstrab MR, Kofoidc KD, Yua LJ. 2011. Characterization of sorghum genotypes for traits related to drought tolerance. Field Crops Research, 123: 10-18.

Milosevic M, Vujakovic M, Karagic D. 2010. Vigour tests as indicators of seed viability. Genetika, 42: 103-118.

Panobianco M, Vieira RD, Perecin D. 2007. Electrical conductivity as an indicator of pea seed aging of stored at different temperatures. Scientia Agricola, 64: 119-124.

Santipracha W, Santipracha Q, Wongvarodom V. 1997. Hybrid corn seed quality and accelerated aging. Seed Science and Technology, 25: 203-208.

Soares MM, Conceicao PM, Dias DCFS, Alvarenga EM. 2010. Vigor tests in sorghum seeds with emphasis to electrical conductivity. Ciência Agrotechnica, 34: 391-397.

Vieira RD, Paiva A, Perecien DJA. 1999. Electrical conductivity and field performance of soybean seeds. Seed Technology, 21: 15- 24.