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Seed Academy

Bulk Electrical Conductivity Test V.062021 | *Jensina Davis & Tim Gutormson*

OVERVIEW & HISTORY

First proposed in 1925, the electrical conductivity (EC) test measures the biochemical characteristics of a seed lot to determine potential seed vigor characteristics. Less vigorous or aged seeds repair their internal membranes at a slower rate, resulting in more solutes leaking from the seed in comparison to more vigorous seeds with faster membrane repair processes. In the field, these solutes can attract and promote pathogen growth. These solutes include inorganic cations, and sugars among other biological compounds (Marcos-Filho, 2015). Fessel et al. (2006) found that the primary leachate is potassium ions. Sucrose, starch, oils, and complex proteins either are uncharged or tend not to be readily soluble in H_2O within the 24-hour test and hence do not contribute to conductance. A high percentage of leaches come out of the seed in the first 6 hours of the test as the seed rapidly imbibes water (Hoegemeyer and Gutormson, 2000). Leakage is thought to be due to more permeable cell walls related to seed deterioration caused by frost events or aging of seed. Aging can occur when seed corn is being dried, especially when high moisture ear corn begins heating in the dryer, and is often due to poor ambient drying conditions or lack of air flow to keep the mass of ear corn cool. Seed size, soaking temperature and period, as well as mechanical damage can impact results (Fessel, 2006). Ratio of seeds to water cited varies between 1.2 ml water/seed (Hussein), 1.5ml/seed (Sena et al., Fessel et al.), 2 ml/seed (Aliloo & Shokati, Goggi et al.) and 5ml/seed (Ocvirk et al.). Gotardo et al. (2001) evaluated imbibition time and temperature and found that 18–24 hours at 25°C was the optimal test conditions for the maize bulk EC.

Good sampling is key for accurate EC results, as variation between replications can be large (Goggi et al., 2008). SoDak Labs utilizes four replicates of 50 seeds, 75ml water, at 25°C for a 24 hour incubation period as listed for corn (Zea mays L.) in Table 4.15 of the AOSA Seed Vigor Handbook (2009).

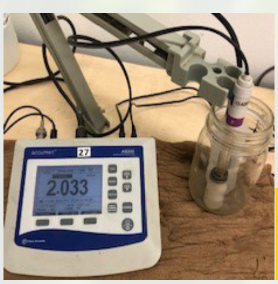

FIGURE 1. EC meter probe soaking in standard solutions.

RELATIONSHIP TO VIGOR TEST, QUALITY AND FIELD EMERGENCE

In the Sena et al. (2017) study, the EC had significant correlations with the cold test and the low temperature germination test used (germination at 18°C). Ocvirk et al. (2014) also found EC to be significantly correlated with the coleoptile length in the cold test and the standard germination. Aliloo & Shokati (2011) found EC to be significantly correlated with field emergence. Hussein et al. (2012) found that as maize seed was aged via an accelerated aging process, the electrical conductivity increased, indicating that the EC test is capable of detecting deterioration due to aging and storage. In a study regarding storage temperature and seed deterioration, Fessel et al. (2006) found that the EC did detect seed deterioration in maize; however, it was not as sensitive as the cold test or accelerated aging to the decline in vigor during storage. This study did not observe significant deterioration in any of the test results in the 10°C storage treatment with any of the vigor tests used.

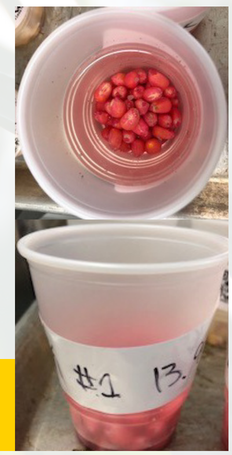

FIGURE 2. 50 corn seeds soaking in 75 ml of deionized water.

RANKING SEED QUALITY USING BULK EC AS A VIGOR TEST

Sena et al. (2017) found that EC had the potential to be an efficient test to stratify and rank maize seed lots. Though it ranked lots slightly differently than the cold test, the rankings were similar to the field emergence test they performed.

At SoDak Labs, we routinely run Bulk EC tests on seed corn and data from 2016–2020 is presented in Table 1. Bulk EC quality ranges of 0–15, 16–20, 21–25, and 26–30 $\mu S\ cm^{-1}\ g^{-1}$ seed show good relation to seed quality as measured by warm germination at 25°C and tray cold tests. As EC value increases above 30 $\mu S\ cm^{-1}\ g^{-1}$, a drop occurs in tray cold test results from 91% to 87%, suggesting that 30 $\mu S\ cm^{-1}\ g^{-1}$ may be a level that indicates a seed quality concern.

TABLE 1. Four Bulk EC quality ranges of seed corn and corresponding quality responses for warm germination and tray cold tests. Results are averages for the quality range. Electrical conductivity results are expressed in µS cm^{-1} g^{-1}, and warm germination and tray cold results are percentages. Tests dates from 09/2016 to 06/2021 and electrical conductivity results from 4,924 tests..

Electrical Conductivity Range (µS cm^{-1} g^{-1} seed)	# Tests per Quality Range	Electrical Conductivity	Warm Germination	Tray Cold	
			Strong Normal Seedlings	Strong Normal Seedlings	UV/Slow Normal Seedlings
0 – 15	4157	10	98	95	0
16 – 20	493	18	97	93	1
21 – 25	200	23	97	93	1
26 – 30	58	28	97	92	1
31 – 35	14	33	96	89	1
>36	2	39	94	83	1

TABLE 2. Table 2 – Quality responses of 681 farmer submitted (2021) seed corn lots tested across three vigor tests and one mechanical damage test.

Electrical Conductivity Range (µS cm^{-1} g^{-1} seed)	# Tests per Quality Range	Percent of total samples	Average Electrical Conductivity (µS cm^{-1} g^{-1})	NPK Cold Tray Test %		Saturated Cold %				Pericarp Damage %		
				Normal	Slow Normal	Normal	Slow Normal	Abnormal	Dead	Severe & Medium	Light	None
0 – 15	350	51	10	94	0	87	8	2	3	6	13	81
16 – 20	177	26	18	92	1	83	10	2	5	10	16	74
21 – 25	103	15	23	91	0	79	11	2	8	10	14	76
26 – 30	41	6	28	89	1	72	11	3	14	12	13	75
31 – 35	9	1	33	84	0	75	9	2	14	6	12	82
>36	1	0	39	87	2	70	7	4	19	17	32	51

In 2021, SoDak Labs analyzed 681 corn lots for electrolyte leakage or membrane permeability (EC), pericarp damage (PD), and seedling vigor using a saturated cold test and NPK cold test. NPK cold utilizes imbibitional chilling at aerobic conditions, and a "salt solution" similar to a starter fertilizer within the moistening agent. We grouped and averaged the data across five quality ranges to determine if there is a relationship between these seed quality indicators (Table 3). As EC values increased, the percent NPK Cold and saturated cold strong normal decreased.

TABLE 3. Bulk EC levels and seed corn quality levels.

uS cm^{-1} g^{-1} (leakage of charged ions)	SoDak (2021) Quality (based on comparisons in Table 2 above)	Sena et al. (2017) Quality Rating
0 – 15	Very High	High
16 – 20	High	High – Medium
21 – 25	High	Low
26 – 30	Medium	Low
31 – 35	Low	Low
>36	Low	Low

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