Evaluating Electrical Conductivity as a Predictor of Kabuli Chickpea (*Cicer arietinum*) Seed Vigor

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Abstract

Electrical Conductivity (EC) is a vigor testing method recommended for use to predict the emergence of Kabuli Chickpea (*Cicer arietinum*) seeds. However, there is no standardization in methodology or interpretation of results. Seven Varieties with eight lots of Kabuli Chickpea were characterized and subjected to laboratory germination tests, field emergence evaluations, and EC tests. Water to seed ratios and soaking periods were examined for the lots, which had varying ages and seed conditions. EC values from adequate collection methods were compared to field emergence data points. It was concluded that EC can predict general trends in vigor but should not be used alone in seed evaluation.

Introduction

Seed vigor is difficult to analyze quantitatively, as it is not a single measurable trait, but a concept describing several characteristics associated with various aspects of a seed's ability to germinate, grow, and establish as a seedling in unfavorable conditions.[1] Vigor is affected by seed age, seed coat integrity, insect damage, pathogens, and storage conditions.

As a globally grown and consumed crop, Chickpeas are considered one of the earliest cultivated vegetables on earth. Due to their long growing season, they are planted into unfavorable growing conditions such as cool moist soil, leaving low vigor seeds at a disadvantage for emergence and establishment. Kabuli types, have larger seeds with paper-thin testa, seed coats, which leave them susceptible to harvest damage, with subsequent susceptibility to pathogen, and imbibition damage.[2] However, high vigor seeds with adequate germination percentages, can emerge and establish well in adverse conditions.

EC can be used as a measure of Chickpea vigor and is one of two tests recommended by the ISTA .[3] EC measures the concentration of ions that remain after the seeds are soaked in deionized water (DI) during the beginning stages of imbibition. As seeds begin to take in water, the cellular membranes begin to reorganize and repair damage. Until those processes cease, sugars, ions, and other metabolites leak through a Chickpea's permeable membrane. Higher vigor seeds can reorganize their membranes more rapidly, and repair damage to a greater extent, than low vigor seeds,[3] resulting in lower conductivity levels. Knowledge of solute leakage levels can also be helpful, as when planted into soil, the leaked solutes can increase the activity of fungi, which can hinder the development of seedlings, especially at lower temperatures.[4]

A review of current literature revealed that several different methodologies are used to obtain EC values, with no guidelines for the interpretation of the values. Additionally, ratio of seed to water is not considered in the methodology guidelines, leaving room for variation of results for seeds of different size, as EC is a measure of concentration. The objective of this experiment was to gain insight into a standardized methodology for measuring and interpreting the EC of Kabuli Chickpeas that could quickly and accurately assess the vigor and quality of seed batches..

Name/Variety	Source	Lot Number	Age (years)	Storage Condition	Observations
Breeding Line	USDA, Pullman WA	1	4	RT, Plastic	Insects present
CA179000	WSU Spillman Agronomy Farm	2	1	RT, Paper	Some seed coat splitting, but overall uniform
Dwelley	USDA, Pullman WA	3	4	RT, Plastic	Some dark almost black seeds
Dwelley	WSU Spillman Agronomy Farm	4	1	RT, Paper	
Frontier	USDA, Pullman WA	5	4	RT, Plastic	Smallest seeds
Sawyer	USDA, Pullman WA	6	4	RT, Plastic	Insects present
Sierra	WSU Spillman Agronomy Farm	7	1	RT, Paper	Less split coats than CA but more halved seeds
UC-5	USDA, Pullman WA	8	4	RT, Plastic	Highly damaged and seeds varied in size

Table 1. Characterization of Seed Lots

Methods

<u>Materials</u>

Eight separate lots of Chickpea were sourced from two locations, the Washington State University (WSU) Spillman Agronomy Farm and a USDA location in Pullman WA. The lots were characterized (Table 1.)

<u>Methods:</u>

Thousand Seed Weight was calculated following AOSA Guidelines,[5] and average weight for a single seed was derived from that.

Germination protocols were carried out following the AOSA guidelines for *Cicer arietinum* with four reps of 100 seeds.[5] Each lot was monitored for pathogen development. Average germination % was calculated for each lot.

EC was taken following the ISTA guidelines[6] and expressed in µS.cm-1.g-1 . The effects of both soaking time and mL amount were examined with five treatments as follows: A=100mL, B=125mL, C=150mL, D=175mL, E=200mL. The leachate was measured from hours 18-32 in two-hour intervals.

Field Emergence was carried out with a replicated complete block design (RCBD) mid-March. Four reps of 100 seeds per lot were planted 1.5-2" deep into tilled soil. Emergence counts, soil temperature readings, and soil moisture readings were taken daily for thirty-five days. Field Emergence % and an Emergence Speed Index (ESI) were calculated for each lot.

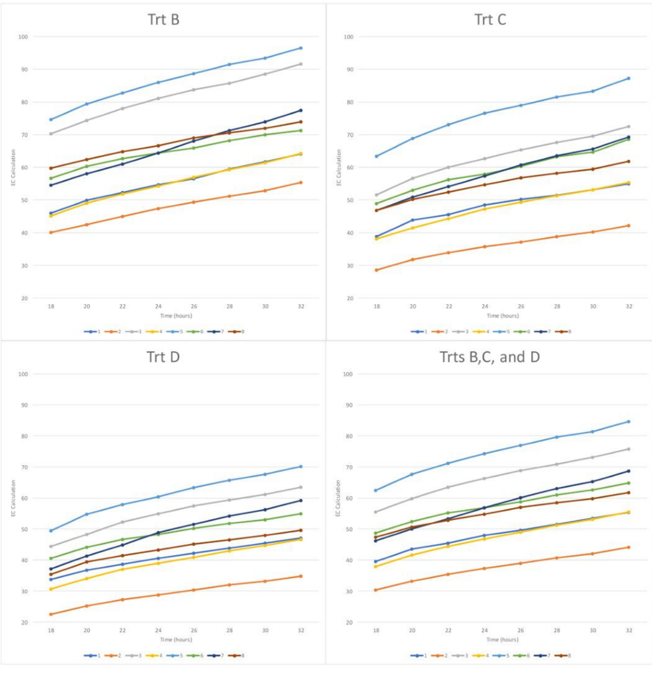
<u>Statistical Analysis</u>

A completely randomized experimental design was used for the field emergence. The data was submitted to general linear model for analysis of variance and the means were compared by the Tukey test at 5% of probability.

Results

Lot	Age	Average Germ %	Pathogens	Average Seed Weight (g)	Average FE %	Average ESI	Average Days to First Emergence
1	4	93	F	0.316	32	7.9	21
2	1	85	F	0.495	36	9.9	23
3	4	91	F,B	0.485	18	3.7	24
4	1	93	F	0.495	21	3.5	25
5	4	97	F	0.338	44	14.9	21
6	4	92	F,B	0.419	22	5.9	22
7	1	96	F,B	0.546	16	4.5	22
8	4	95	F	0.487	19	4.1	24

Table 2. Results for Germination %, Pathogen presence during germination testing (B=Bacterial, F=Fungal), Average Seed Weight, Field Emergence % (FE %), Field Emergence Speed Index (ESI), and Days to First Emergence.



Figures 1-4. Fig 1, 2, and 3 show the Average EC values for each individual treatment over time for each lot. Fig 4 shows the averages of all three treatments combined.

Results Cont.

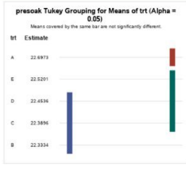


Figure 5. SAS Tukey Grouping For Presoak Weight with Treatment

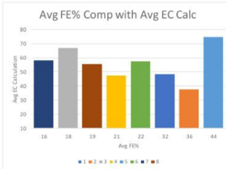


Figure 6. Average FE% and Age of Each lot Compared to Average EC Readings from Treatments B-D

Discussion

Each lot, regardless of age and condition, showed sufficient germination rates. All lots displayed fungal growth during the germination tests, while only lots 3, 6 and 7 displayed bacterial.

None of the lots showed good field emergence levels at the end of the collection period, as an adequate field emergence would be considered between 80-100% of a lot's germination rate. All lots evaluated fell below this level, indicating that none of them have high vigor rates. This may have been influenced by weather variation as on days seven and eight after sowing, the soil temperature dropped from a daytime average of 10°C to 0°C. That large temperature fluctuation may have affected germinating seeds. A second field planting was done early April to potentially control for the effects of soil temperature. Comparing EC readings to FE% and ESI, there are general correlations for every lot, except 5, showing that a higher EC value tends to lead to lower FE% and ESI. However, lot 5 had both the highest EC rates and FE%. This could be contributed to potential unexplored genetic components contributing to seed vigor and emergence, as seed size is not known to play a direct role in chickpea seed emergence rates.[8]

Treatment A, resulted in the larger seeded lots not being fully covered during the soaking period. The 100mL resulted in a very concentrated leachate, and difficulty with the physical measurements and thus was not a good method for EC measurements. Treatment E with 200mL led to more diluted leachates, which for the smaller seeded varieties, was not sufficient for differentiation. Thus, treatments B-D with mL amounts between 125-175 would be sufficient for EC testing.

While Lot 5 was an outlier, the overall trends in EC otherwise do follow expected predictions. However, if EC alone was used to test the vigor of the seeds, this would not be known. Comparing Lots 1 and 4, they have nearly identical EC values, however their FE% are not identical. This indicates that EC may not be sensitive enough to make exact distinguishments between vigor levels. Similarly, Lots 6, 7, and 8 were all ranking similarly in their EC readings. For EC reading methods, the time of measurement did play a role. The difference of a few hours, could have one lot ranking above another. Yet if the EC was to be measured two or four hours later, it could be lower in rank with comparison to another. Comprehensively, there is not enough data present to make a recommendation for the interpretation for EC readings for chickpeas. This is largely due to vigor's complexity. In this experiment, EC is being compared to field emergence rates, however field emergence can also be influenced by outside factors such as animal activity and extreme weather events.

Conclusions

The timing and set up for collection does affect how EC results would be interpreted. 125-175 mL of DI would be sufficient for groups of 50 seeds. Depending on the hour of the reading, one lot could appear to have variable EC readings that skew interpretations when comparing between lots. The ratio of seed to water does influence the results as if the water does not fully cover the seeds throughout soaking, levels will likely be altered. EC alone will not provide a comprehensive vigor rating, as exhibited by lot 5.

In the future, Accelerated Aging tests could be used to investigate the impact of cellular deterioration on EC readings. Additionally, genotypes could be examined for possible variation. As temperature plays a large role in field emergence, a second planting will be analyzed in the future, to see if temperature variation influenced the FE data.

However, as a rapid seed vigor test, EC does have potential. More testing would need to be performed to give a ranking of EC values for low medium, and high vigor seeds. Seed size may also play a role, as the seed to water ratio effects the dilution of leachate which the EC is read

References

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