Seed Science and Biotechnology ©2011 Global Science Books

The Appropriate Laboratory Tests for Predicting Field Emergence and Performance of Chickpea

Mahjoobeh Esmaeilzade-Moridani • Morteza Eshraghi-Nejad • Farshid Ghaderi-Far*

Department of Agronomy, Gorgan University of Agricultural Science and Natural Resources, Gorgan, Iran

Corresponding author: * **akranghaderi@yahoo.com**

ABSTRACT

Investigation of the relationships between laboratory tests and seedling emergence of chickpea cultivars in field and determination of the appropriate laboratory test were essential for archive the good establishment and reasonable yield. For this propose an experiment was carried out with five cultivars in Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran. Laboratory tests including standard germination test (SG), germination rate (GR), electrical conductivity (EC), accelerated ageing test (AA) (41°C for 48, 72, 96 and 120 h), seedling growth rate (SGR) and seedling length (SL) were carried out in a completely randomized design. Field study was conducted at three sowing dates. Correlation coefficients were used to determine the appropriate test for estimating field emergence. Results showed that standard germination test has not good correlation with field emergence at all sowing dates, but vigor tests have higher correlations at all sowing dates than SG. The results indicate that SL ($r \geq 0.73$), AA72 ($r \geq 0.86^{ns}$), and EC ($r \leq -0.52^{ns}$) were closely associated with field emergence at sowing dates. Thus SL, AA72 and EC were the most successful in predicting the emergence potential of the chickpea seeds.

Keywords: accelerated aging, electrical conductivity test, seedling length, vigor test

Abbreviations: AA, accelerated ageing test; **EC**, electrical conductivity; **GR**, germination rate; **SG**, standard germination test; **SGR**, seedling growth rate; **SL**, seedling length

INTRODUCTION

Legume grains comprise an important part of the human diet in developing countries in tropical and subtropical areas (Ramalho Ribeiro and Portugal Melo 1990). Chickpea (*Cicer arietinum* L.) is the world's third most important grain legume after beans and peas (FAO 1993). It is cultivated mainly in Algeria, Ethiopia, India, Mexico, Morocco, Myanmar, Pakistan, Spain, Syria, Tanzania, Tunisia, Turkey, and Iran (Naghavi and Jahansouz 2005).

The standard germination test is the world's best-known methodology for evaluating physiological quality of a seed lot (Hampton and TeKrony 1995). Since the standard germination test gives information concerning the capacity of seeds to produce normal seedlings under optimum conditions (Egli and Tekrony 1995; Artola and Castaneda 2005; Noli *et al*. 2008), at different unfavorable field conditions such as temperature (Kamkar *et al*. 2008; Soltani *et al*. 2008; Eshraghi *et al*. 2009; Kamkar *et al*. 2009) and salinity (Kamkar *et al*. 2009) stress that affects on seed germination rate and percentage, it tends to overestimate field performance (Delouche and Baskin 1973). Therefore, much effort has been given to develop a test or group of tests that can determine seed vigor accurately (Makkawi *et al*. 1999).

Seed vigor testing is widely used by the seed industry (Van de Venter 2001) and is defined by the international seed testing association (ISTA) as the sum total of those properties of the seed which determine the level of activity and performance of the seed or seed lot during germination and seedling emergence (Hampton and TeKrony 1995). High seed vigor is important for good crop establishment, maximizing yields and/or quality of crops (Artola *et al.* 2004). In order to achieve this, it is necessary to have the methodology, which will allows estimating the planting value of seed lots (Perry 1982) and selecting high quality seed lots (Artola and Castaneda 2005). The results obtained from previous studies showed that vigour tests could provide better results for ranking the quality and for indicating planting value of seed lots than the standard germination test. However, the correlation coefficients between germination, vigour, and seedling emergence varied according to species, vigour test methods, and the field sowing conditions (Wang *et al.* 1996).

Various vigor tests used to assess seed physiological quality aim to correlate the performance of the seed lots in the laboratory with their performance in the field or evaluate seed vigor (Schuab *et al*. 2006; Dutra and Vieira 2006). A list of laboratory tests for estimating of seed vigor of various species was given in Handbook of Vigor Test Methods (Hampton and TeKrony 1995). Over the years, many seed vigor tests have been developed and evaluated. The third edition of the Handbook of Vigour Test Methods (ISTA 1995) (Hampton and TeKrony 1995) contains detailed instructions on the procedures of the most commonly used seed vigor tests (Van de Venter 2000). However, studies for evaluating seed vigor in chickpea seeds are scarce. Thus, the present study was carried out to investigate different vigor tests, to examine the correlation between these vigor tests and field emergence and to identify a vigor test which could predict field emergence in chickpea.

MATERIALS AND METHODS

This study was carried out on five chickpea (*Cicer arietinum* L.) cultivars include 'ILC' (lot 1), 'Jam' (lot 2), 'Arman' (lot 3), 'Hashem' (lot 4), and 'Beauvanij' (lot 5) at the seed laboratory and the Research farm of the Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran. The cultivars were from Kabuli type of chickpea with large, smooth coated, beige seeds that cultivated in north and west of Iran. Laboratory tests include standard germination, germination rate, seedling growth rate (seedling dry weight and seedling length), electrical conductivity

Received: 3 March, 2011. Accepted: 5 June, 2011.

Original Research Paper

(EC), accelerated ageing test were conducted. In order to investigation of seed vigor tests performance field experiments were conducted at three sowing dates (5 January, 5 February and 5 March, 2010). The field soil was clay loam with pH = 7.6 and EC = 1.3 dS m^{-1}.

Standard germination (SG)

Seed samples were sown on moistened rolled paper and kept at a temperature of 20°C ± 0.5 in the dark and on the eighth day, normal seedlings were counted and data were expressed as percentage.

Germination rate (GR)

Seed germination was tested in moistened rolled paper at a temperature of 20°C. Seeds were observed twice daily and considered germinated when the radicle was approximately 2 mm long or more. GR (R_{50}, h^{-1}) was then calculated as Soltani *et al*. (2001):

$$R_{50} = 1/D_{50} \quad (1)$$

where D_{50} is the estimation of time taken for cumulative germination to reach 50% of maximum where interpolated from the germination progress curve versus time.

Seedling growth rate (SGR)

Seed samples were sown as for the SG test and normal seedling length and dry weight were measured after 8 days.

Electrical conductivity (EC)

The test was carried out according to the methodology proposed by Hampton and TeKrony (1995) using 250 ml deionized water and 20°C for 24 h. The conductivity of the leachate was then measured and results were expressed as µS cm^{-1} g^{-1}.

Accelerated ageing test (AA)

The accelerated ageing test was conducted according to the procedure described by Hampton and TeKrony (1995). 100 seeds were placed on a wire mesh tray and placed in the box holding 40 ml of water. Seeds were aged at 41 ± 0.5°C for 48, 72, 96 and 120 h. Following ageing, seed samples were sown on moistened rolled paper and kept at a temperature of 20± 0.5°C in the dark. On the eighth day, normal seedlings were counted and data were expressed as percentage.

Field experiments

Field experiments were conducted to compare emergence with laboratory test results at three sowing dates. Seeds of each cultivar were hand sown in rows 2.0 m long, 0.35 m apart and 0.05 m deep. Soil moisture was kept sufficiently wet for germination. The percentage of emerged seedling was counted until 20 days after sowing.

Table 1 Seed moisture contents and 100-seed weight of chickpea cultivars.

Seed lots/Cultivars	Seed moisture content (%)	100-seed weight (g)
1. ILC	8.72	22.34
2. Jam	8.60	42.33
3. Arman	11.95	28.56
4. Hashem	8.56	28.02
5. Beauvanij	8.48	23.92

Statistical analysis

All experiments were conducted with the use of a completely randomized design with four replications. The data were subjected to analysis of correlation using CORR procedures and LSD test was used using GLM procedures in Statistical Analysis System (SAS) for significantly different at $P \leq 0.05$ between treatments (SAS Institute 1989).

RESULTS

Seed moisture contents of the seed lots ranged between 8.56 and 11.95% and 100 seed weight ranged between 22.34 and 42.33 g (**Table 1**).

There were considerable variations in meteorological parameters among three sowing dates (5 January, 5 February and 5 March) (**Table 2**). The variations of meteorological parameters, especially temperature, can be affects on emergence at field condition (Eshraghi-Nejad *et al*. 2009). First sowing date with low mean temperature (8.42°C) was less favorable for emergence than the second and third sowing date (10.65 and 11.31°C, respectively). This sowing date used to increase the chance of encountering stress condition during emergence. Because of unfavorable conditions for emergence at first sowing date, differences between cultivars was clearly sensible and emergence percent was lower than the other sowing dates (**Table 3**). At second and third sowing dates, almost all seed lots of cultivars emerged more than the previously, because of favorable conditions (**Table 3**).

Post ANOVA analysis showed that there were significant differences between cultivars in AA after (41°C in 48, 72, 96 and 120 h), EC, GR, SG, SGR and SL (**Table 3**). SG showed that cultivars have partly high germination present (> 85%) (**Table 3**). In germination rate test, seed lot 2 has the highest and seed lot 3 has the lowest germination rate (0.039 and 0.026 h^{-1}, respectively). According to EC test, seed lots 5 and 2 have the highest and lowest leakage (45.68 and 19.98 µS cm^{-1} g^{-1}, respectively). Seed lots 2 and 5 have the highest (8.25 mg d^{-1}) and lowest (4.72 mg d^{-1}) seedling growth rate, respectively. According to seedling growth rate test, seed lot 1 has the most length (22.57 Cm) and seed lot 5 was shortest (16.82 Cm). Seed lot 2 has acceptable ger-

Table 2 The quantity of maximum and minimum temperatures, precipitation and relative humidity at three sowing dates.

Sowing date	Max temperature (°C)	Min temperature (°C)	Mean temperature (°C)	Precipitation (mm)	Relative humidity (%)
5 January	12.48	4.37	8.42	6.51	74.08
5 February	15.20	6.11	10.65	7.01	77.09
5 March	15.20	7.43	11.31	3.25	81.11

Table 3 Standard germination (SG), germination rate (GR), electrical conductivity (EC), seedling dry weight (SDW), seedling length (SL) germination after accelerated aging (AA) and field emergence (FEM) for chickpea cultivars.

Seed lots/ Cultivar	SG (%)	GR (h^{-1})	EC (µS $cm^{-1}g^{-1}$)	SGR		Germination after AA (%)				Germination after AA (%)		
				SGR ($mg.day^{-1}$)	SL(cm)	48 h	72 h	96 h	120 h	5 January	5 February	5 March
1. ILC	98.3	0.035	25.66	6.29	22.57	91.2	76.2	23.3	0.0	59.6	55.0	96.2
2. Jam	91.7	0.039	19.98	8.25	21.12	73.5	80.0	43.2	21.5	71.7	85.0	86.2
3. Arman	90.0	0.026	31.69	6.53	22.07	77.5	83.7	25.5	0.0	75.0	81.2	96.2
4. Hashem	90.0	0.028	23.99	6.26	21.26	77.5	88.7	36.2	0.0	84.6	95.0	97.5
5. Beauvanij	85.0	0.031	45.68	4.72	16.82	48.7	5.0	0.0	0.0	16.7	18.7	23.7
LSD $_{(0.05)}$	12.237	0.0041	3.9587	0.7932	2.3051	14.331	14.593	22.05	12.374	14.124	19.323	17.696

Table 4 Correlation coefficients between laboratory tests and field emergence at chickpea cultivars.

	FEM1	FEM2	FEM3
SG	0.44^{ns}	0.26^{ns}	0.69^{ns}
SL	0.84^{*}	0.73^{ns}	0.97^{**}
AA48	0.74^{ns}	0.63^{ns}	0.92^{**}
AA72	0.97^{**}	0.86^{*}	0.98^{**}
AA96	0.87^{*}	0.65^{ns}	0.78^{ns}
AA120	0.21^{ns}	-0.13^{ns}	0.10^{ns}
GR	-0.15^{ns}	-0.49^{ns}	-0.06^{ns}
EC	-0.79^{ns}	-0.52^{ns}	-0.83^{*}
SGR	0.69^{ns}	0.37^{ns}	0.65^{ns}

mination percent in all AA tests (21.5-80%) while seed lot 5 has the least germination percent (0-48.7%).

The results of field experiments showed that the emergence percent at first sowing date (5 January) differs between 16.7 - 84.6%. These range varied between 18.7 - 95% and 23.7 - 97.5% at 5 February and March, respectively. Seed lot 4 has the highest emergence percent (ranged between 84.6 - 97.5%) at the all sowing dates that there was no significant difference with seed lots 3 (75.0 - 96.2%) and 2 (71.7 - 86.2%); while seed lot 5 has the lowest emergence percent (16.7 - 23.7) at the all sowing dates (**Table 3**).

The correlation between the laboratory tests and field emergence are presented in **Table 4**. These results showed that there were significant correlations between some of the laboratory tests and field emergence. The correlation of the standard germination test with field emergence was not significant (r = 0.26 - 0.69).

SGR, GR, and AA120 tests have no significant correlations with field emergence at three sowing dates (**Table 4**). AA72 has significant correlations with field emergence at three sowing dates (range: r = 0.86 - 0.98), while AA48 and AA96 had no good correlation with field emergence at all sowing dates (**Table 4**). SL had a good correlation with field emergence at three sowing dates ($r = 0.84^{*}$, 0.73^{ns} and 0.97^{**}, respectively). A seed lot with longer seedling has a higher percent emergence in field conditions at all sowing dates. EC had a good negative correlation with field emergence at all sowing dates ($r = -0.79^{ns}$, -0.52^{ns} and -0.83^{**}, respectively). A seed lot with more leachate has the least percent of emergence at field conditions at all sowing dates.

DISCUSSION

The non-significant correlation of the standard germination test with field emergence indicated that the standard germination test gave mean values higher than that of field emergence especially in 5 January (the unfavorable sowing date). Wang *et al.* (1996) reported that the standard germination test and the germination index did not show any significant correlation with seedling emergence in any glasshouse or field trial. These overestimates caused by differences between laboratory and field conditions. Lovato and Cagalli (1993) reported that the standard germination test was less well correlated with field emergence under sever environmental conditions. SG has significant correlation with field emergence at third sowing date. This result was agreed with Egli and TeKrony (1995). They worked on soybean and showed that SG have good predicts of seed vigor when seedbed conditions were ideal and similar to laboratory conditions.

Khavari *et al.* (2009) reported that SGR and GR have no significant correlations with field emergence of safflower (*Carthamus tinctorius* L.) that supported our results, while Makkawi *et al.* (1999) showed that these tests have significant correlations with emergence at field in lentil (*Lens culinaris* Medikus). They worked two experiments two investigate the relationship between various physical, physiological and biochemical tests and their associations with field emergence. Results showed that speed of germination, seedling dry weight and electrical conductivity provided the best correlation with field emergence in both clay and silty loam soils.

Happ *et al.* (1993) and Ghaderi-Far *et al.* (2010) reported that accelerated ageing was one of the effective tools in identifying the quality of ryegrass (*Lolium perenne* L.) and sesame (*Sesamum indicum* L.) seed. Ghaderi-Far *et al.* (2010) were investigated the effect of combination of temperature and time for the AA using five lots of sesame. They concluded that combination, 47°C/72 h, could be used to evaluate the seed vigor of sesame seeds. Demir *et al.* (2005) reported that AA is preferable test for predicting the emergence potential of the aubergine (*Solanum melongena* L.) seed lots. Egli and TeKrony (1995) at his study on 26 fields in 10 years concluded that planting soybean (*Glysin max*) seed with an AA ≥ 80% or SG ≥ 95% will ensure adequate performance in many field environments. Our results confirmed that the favorable durations of AA test for chick-pea were 72 and 96 h at 41°C. Makkawi and Gastel (2007) reported that accelerated ageing was found to cause a progressive reduction in seed and viability.

EC was negatively correlated with seed vigor (Vieira *et al.* 1999). They worked on eleven soybean cultivars in two years and concluded that the electrical conductivity test is negatively correlated with the seedling field emergence. Our results were confirmed by other researches (Makkawi *et al.* 1999; Vieira *et al.* 1999; Khavari *et al.* 2009). Makkawi *et al.* (2008) concluded that low quality seeds tended to have higher conductivity values as aging increased.

Our findings showed that SL has good correlation with field emergence that was against to other findings (Makkawi *et al.* 1999; Khavari *et al.* 2009). Khavari *et al*. (2009) used SG, AA, SGR, EC tests on safflower to study relationship between laboratory tests and field emergence. Results of their experiment revealed that AA and EC tests provided better separation of safflower seed vigor levels than SG and SGR. They suggested that AA and EC were the most successful in predicting the emergence potential of the safflower seeds. Kim *et al.* (1994) reported that hypocotyl length provided a good estimate of vigor in soybean. However, Makkawi *et al.* (1999) found that the correlation of shoot and root length with field emergence have not significant with field emergence.

CONCLUSION

These results showed that, standard germination test has not good correlation with field emergence, and vigor tests have higher correlations at all sowing dates than SG in chickpea. Seed vigor tests were generally better predictors than traditional standard germination. This indicates that SL, AA72 and EC were closely associated with field emergence at sowing dates and would be appropriate tests for mea-suring seed vigor in chickpea cultivars seeds for planting and also for comparing the performance of different seed lots under various planting conditions.

REFERENCES

Artola A, Carrillo-Castañeda G, García de los Santos G (2004) A seed vigor test for *Lotus corniculatus* L. based on vacuum stress. *Seed Science and Technology* **32**, 573-581

Artola A, Carrillo-Castañeda G (2005) The bulk conductivity test for birds-foot trefoil seed. *Seed Science and Technology* **33**, 231-236

Delouche JC, Baskin CC (1973) Accelerated ageing techniques for predicting the relative storability of seed lots. *Seed Science and Technology* **1**, 427-452

Demir I, Ermis S, Okçu G, Matthews S (2005) Vigour tests for predicting seedling emergence of aubergine (*Solanum melongena* L.) seed lots. *Seed Science and Technology* **33**, 481-484

Dutra AS, Vieira RD (2006) Accelerated ageing test to evaluate seed vigor in pumpkin and zucchini seeds. *Seed Science and Technology* **34**, 209-214

Egli DB, Tekrony DM (1995) Soybean seed germination, vigor and field emergence. *Seed Science and Technology* **23**, 595-607

Eshraghi-Nejad M, Kamakr B, Soltani A (2009) Cardinal temperatures and required biological days from sowing to emergence of three millet species (common, foxtail, pearl millet). *Journal of Agricultural Science and Technology* **3**, 36-43

FAO (1993) FAO Yearbook Production, Rome, Italy: *FAO* **46**, 105-115

Gaderi-Far F, Bakhshandeh E, Ghadirian R (2010) Evaluating seed quality in sesame (*Sesamum indicum* L.) by the accelerated ageing test. *Journal of Seed Technology* **32**, 69-72

Hampton JG, TeKrony DM (1995) *Handbook of Vigour Test Methods*, International Seed Testing Association, Zurich, Switzerland, 117 pp

Happ K, McDonald M, Danneberger TK (1993) Vigour testing in perennial ryegrass (*Lolium perenne* L.). *Seed Science and Technology* **21**, 375-381

Kamkar B, Ahmadi M, Soltani A, Zeinali E (2008) Evaluating non-linear regression models to describe response of wheat emergence rate to temperature. *Seed Science and Biotechnology* **2**, 53-57

Kamkar B, Vakili S, Mirizadeh A (2009) Effects of salinity and temperature on germination of three millet varieties. *Journal of Seed Science and Biotechnology* **2**, 35-39

Khavari F, Ghaderi-Far F, Soltani E (2009) Laboratory tests for predicting seedling emergence of safflower (*Carthamus tinctorius* L.) cultivars. *Journal of Seed Technology* **31**, 189-193

Kim SH, Choe ZR, Kang JH, Copeland LO, Elias SG (1994) Multiple seed vigour indices to predict field emergence and performance of barley. *Seed Science and Technology* **22,** 59-68

Lovato A, Cagalli S (1993) Sugar beet (*Beta vulgaris* L.) seed vigour compared in laboratory and field tests. *Seed Science and Technology* **21**, 61-67

Makkawi M, El Balla M, Bishaw Z, van Gastel AJG (2008) Electrical conductivity in lentil seed leachates using a single-seed analyzer. *Journal of New Seeds* **9**, 267-283

Makkawi M, van Gastel AJGM (2007) Effect of accelerated ageing on germination and vigor in lentil (*Lens culinaris* Medikus) seed. *Journal of New Seeds* **8**, 87-98

Makkawi M, El Balla M, Bishaw Z, Van Gastel AJG (1999) The relationship between seed vigour tests and field emergence in lentil (*Lens culinaris* Medikus). *Seed Science and Technology* **27**, 657-668

Naghavi MR, Jahansouz MR (2005) Variation in the agronomic and morphological traits of Iranian chickpea accessions. *Journal of Integrative Plant Biology* **47**, 375-379

Noli, E, Casarini E, Urso G, Conti S (2008) Suitability of three vigour test procedures to predict field performance of early sown maize seed. *Seed Science and Technology* **36**, 168-176

Perry DA (1982) The concept of seed vigour and its relevance to seed production techniques. In: Hebblethhwaite PD (Ed) *Seed Production*, Butterworths and Co. Ltd., London, pp 585-592

Ramalho Ribeiro JMC, Portugal Melo IM (1990) Composition and nutritive value of chickpea. *Options Mediterranean's - Serie. Seminaires* **9**, 107-111

Schuab SRP, Braccini AL, Scapim CA, Franca-Neto JB, Meschede DK, Ávila MR (2007) Germination test under water stress to evaluate soybean seed vigour. *Seed Science and Technology* **35**, 187-199

Soltani A, Zeinali E, Galeshi S, Latifi N (2001) Genetic variation for and interrelationships among seed vigor traits in wheat from the Caspian Sea coast of Iran. *Seed Science and Technology* **29**, 653-662

Soltani E, Galeshi S, Kamkar B, Akramghaderi F (2008) Modeling seed aging effects on the response of germination to temperature in wheat. *Journal of Seed Science and Biotechnology* **1**, 32-36

Van de Venter A (2000) What is seed vigour? *Journal of New Seeds* **2**, 67-72

Van de Venter A (2001) Seed vigor testing. *Journal of New Seeds* **2**, 51-58

Vieira RD, Paiva-Aguero JA, Perecin D, Bittencourt SRM (1999) Correlation of electrical conductivity and other vigor tests with field emergence of soybean seedlings. *Seed Science and Technology* **27**, 67-75

Wang YR, Yu L, Nan ZB (1996) Use of seed vigour tests to predict field emergence of lucerne (*Medicago sativa*). *New Zealand Journal of Agricultural Research* **39**, 255-262

Yaklich RW, Kulik MM, Anderson JD (1979) Evaluation of vigor tests in soybean seeds: Relationship of ATP, conductivity and radioactive tracer multiple criteria laboratory tests to field performance. *Crop Science* **19**, 806-810