Plant Knowledge Journal
ISSN: 2200-5390
EISSN: 2200-5404
2(2): 89-93 (2013)

Southern Cross Publishing Group
Australia

Laboratory tests for predicting emergence of soybean cultivars

Nabi Khaliliaqdam[1,*], Afshin Soltani[2], Naser Latifi[2], Farshid Ghaderi Far[2]

[1]Department of Plant Production, Non-Profit University of Baharan, Iran
[2]Department of Agronomy, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran

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

Abstract

Although many tests have been evaluated for the ability to predict soybean seed emergence, there is significant interaction between the test used, the cultivar, and the environmental conditions during seed emergence. Therefore, laboratory and field experiments were conducted to predict soybean emergence. Tests were conducted on three soybean cultivars (‘DPX’, ‘Sahar’, and ‘Williams’) in 2010 at the Seed Research Laboratory and Research Farm, Gorgan University of Agricultural Sciences and Natural Resources, Iran. Experimental cultivars were arranged in a completely randomized design for laboratory tests (standard germination, seedling growth, electrical conductivity) and randomized completely in blocks for field experiments. There were two sowing dates and four replications. A sub-sample of seeds from each cultivar was kept as control. The other sub-samples were artificially aged using the accelerated aging test at 41^0C for 72 h. Laboratory tests were then performed on aged and non-aged seeds. Results showed that from among all tests, the electrical conductivity (EC) test was most sensitive for ranking seed vigor in the different cultivars. The relationship between laboratory indexes and field emergence tests was significant, and the EC test had the highest R^2 (0.93^{**}). Germination rate did not show any dependence on field emergence. Aged seeds acted better than non-aged seeds for predicting field emergence. Overall, among all the laboratory indexes, EC showed seed vigor well, so the usage of the EC test for predicting field emergence could be suitable in agronomical programming.

Keywords: Laboratory test, Field emergence, Vigor, Soybean seed.
Abbreviations: CRD_ completely randomized design, RCB_randomized complete blocks, EC_electrical conductivity, AA_ accelerated aging, SG_ standard germination, SDW_ seedling dry weight, NS_ normal seedling, GR_germination rate, FE_field emergence, FER_field emergence rate.

Introduction

Seed vigor is one of the most important parameters of seed quality, and it has the potential to influence crop performance through seedling establishment, particularly under adverse environmental conditions (Ghassemi-Golezani et al., 2010). Measures of seed vigor on soybean [Glycine max (L) Merr.] showed that the evaluation of seed vigor related better to emergence in the field under stress conditions than did the results of the standard germination test. The results of vigor tests have also been shown to be excellent predictors of the storage capacity of soybean seeds (Egli and Tekrony, 1979). Relations between seed vigor, laboratory germination, field emergence, and yield have been the subjects of numerous studies. Prete et al. (1994) pointed to a highly significant negative correlation between the electrical conductivity evaluation and the field emergence of soybean seedlings. A detailed study on soybeans by Vieira et al. (1999) showed that significant correlations were detected between standard germination, accelerated aging, electrical conductivity, and seedling field emergence. In terms of the cultivar or the year, however, the degree of association among these parameters can change based on specific annual environmental conditions. Rapid emergence of seedlings from high vigor seed lots were reported for kenaf (Mentis and Smith, 2003), sorghum (Damavandi et al, 2007), safflower (Khavari et al, 2009), common bean (Kolasinska et al., 2000 corn(Mondo et al, 2012; Egili and Rucker, 2012), winter barley and wheat (Pedersen and Toy, 2001; Zamankhan et al, 2010), alfalfa, sudangrass, Siberian ryegrass, and purple vetch (Waes, 1995), and winter oil-seed rape (Ghassemi-Golezani et al., 2010). Seed vigor affects vegetative growth and is frequently related to yield in crops that are harvested at the vegetative stage or during early reproductive growth. There is usually no such relationship in crops harvested at full reproductive maturity, however, because seed yields at full reproductive maturity are usually not closely associated with vegetative growth; therefore the use of high-vigor seeds can be justified for all crops (Tekrony and Egli, 1991). There are two distinct factors whereby poor seed vigor could have an affect on crop yield. Firstly, it could reduce field emergence potential so that, even if the subsequent performance of the individual plants were unaffected, yield could be reduced through the establishment of a suboptimal plant-population density. Secondly, individual plants that subsequently emerge perform less well than those from a better-quality seed lot. In spite of these deleterious effects, seed vigor evaluation remains a good indicator of the rate of germination and early seedling growth (Khah et al., 1989; Ellis, 1992). Seed vigor has been reported to have had no relationship to yield in studies on soybean (Tekrony et al., 1987), onion (Rodo and Marcos-Filho, 2003), oilseed rape and pea (Larsen et al., 1998), spring and winter wheat (Pedersen and Toy, 2001), winter barley (Pedersen and Toy, 2001), and chick pea

Table 1. Results of variance of analysis (mean squares) for Standard germination (SG, %), Electrical conductivity (EC, $\mu s / cm.g$), Germination rate (GR, 1/h), AA-Seedling dry weight (AA-SDW, g), AA-Normal seedling (AA-NS, %), AA-Standard germination (AA-SG, %) and AA-Germination rate (AA-GR,1/h).

Parameters	df	SG	EC	GR	SDW	AA-NS	AA-SG	AA-GR
Cultivar	2	226.33**	43.05**	0.0001**	0.0451**	1404**	2029**	0.00003*
Error	9	7.0	0.723	0.00001	0.0044	58.22	46.11	0.000007
CV		2.78	3.41	6.76	14.7	16.23	8.65	10.35

** and * Significantly probability in 0.01 and 0.05 respectability.

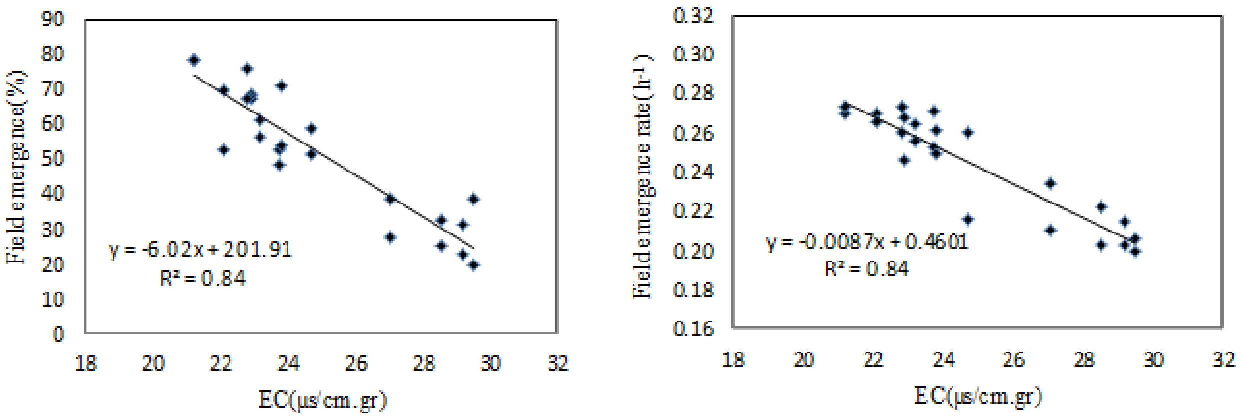

Fig 1. Relations between Field emergence and field emergence rate to Electrical conductivity.

(Kanouni et al., 2009). Plant establishment, growth and final yield are affected by many factors, such as plant densities and environmental influences. Obviously, the effect of seed vigor on crop performance is complex; therefore, it may be difficult to find a general relationship between the results of a vigor test and actual crop performance (Larsen et al., 1998). Laboratory tests have been extensively evaluated for the ability to predict soybean seed emergence; however, no such study has been done on conditions in Gorgan, which is the most important soybean producing area in the country of Iran. Since there is a significant interaction between the test used, the cultivar, and the environmental conditions during seed emergence, such a study will provide more information.

Results and Discussion

Quality of cultivar seed evaluated by different tests

Analysis of the results from all the emergence trials and the electrical conductivity (EC) test showed that there were highly significant differences *(P*<0.01) between the cultivars (Table 1). When seed lots of a cultivar were compared, SG between the cultivars was found to be significantly different. For example, standard germination (SG) of the Williams cultivar seeds was lower than that of the DPX and Sahar seeds (*P*<0.05); consequently they had more EC (Table 2). Accelerated aging (AA) revealed variable statistics between the cultivars. For AA-seedling dry weight (SDW) and AA-normal seedling (NS), the differences between DPX and Sahar cultivars were not significant (Tab.2). The highest AA-germination standard was observed in cultivars which had higher SDW and NS and lower EC (as the DPX and Sahar cultivars). The Williams cultivar's score in the germination rate (GR) was lowest (0.0229 h^{-1}). It also scored lower in seed vigor, but the difference between the two other cultivars was not significant (*P*<0.05). Ghassemi-Golezani et al. (2010) achieved results similar to ours. Their tests showed that in canola, three seed lots for cultivars (Okapi and Licord) had different levels of vigor. Similarly, safflower seed from 'Zarghan279' had the lowest quality with no difference in seed quality among the other cultivars (Khavari et al., 2009). In most cases, vigor has a genetically or physiological basis, although sometimes it may include the effects of seed-borne disease. That means seeds can retain a high quality for some time; thereafter theybegin to deteriorate on the mother plant or during storage, losing viability and vigor (Ellis and Peta-Filho, 1992; Ghassemi-Golezani and Hossenzade-Mahotchi, 2009). Differences in vigor between species or cultivars within species, however, especially hybrids, have a genetic basis.

Relationship between laboratory tests and field emergence

Two sowing dates (20th May and 1st July) were used to ensure the plants would encounter stress conditions during the vegetative stage. This strategy was only partially successful. Field emergence (FE) and field emergence rate (FER) produced significant differences among cultivars at the two sowing dates (Table 3). The Sahar cultivar had a significantly higher FE than the Williams cultivar at both sowing dates (*P*<0.05).The Sahar cultivar also appeared to have the highest FER at both sowing dates, but the difference between Sahar and DPX was not significant. The first sowing date was expected to produce the upper FE and higher FER (Table 4), because environmental conditions at the first sowing date were better than the second sowing date. In this study, laboratory indexes were evidently significantly related to field emergence (Table 5). Standard germination had a significant positive relation with FE and field emergence rate, but it seems that the SG test scored higher than field emergence (Tables 2 and 4). Values of AA-SDW and AA-NS both had a significantly positive relation *(P*<0.01) to FE and FER (Table 4). For GR, relationships with all indexes were not significant, which showed that GR cannot be a suitable index for predicting field emergence, because soil temperature and the time to emergence can influence germination rate and uniformity (Egli and Rucker, 2012). FE and FER decreased with a high gradient as EC diminished (-

Table 2. Results of mean comparison laboratory indexes for soybean cultivars.

Cultivars	Standard germination (%)	Electrical conductivity ($\mu s / cm.gr$)	Germination rate (1/h)	AA-Seedling dry weight(g)	AA-Normal seedling (%)	AA-SG (%)	AA-Germination Rate (1/h)
DPX	99 a	23.87 b	0.0431 b	0.251 a	53 a	92 a	0.0275 a
Sahar	100 a	22.26 c	0.053 a	0.302 a	62 a	91 a	0.0280 a
Williams	86.5 b	28.57 a	0.0496 a	0.098 b	26 b	52.5 b	0.0229 b
LSD(0.05)	4.23	1.36	0.0053	0.107	12.205	10.86	0.0043

Table 3. Results of variance of analysis (mean squares) for field emergence (FE, %) and field emergence rate (FER, 1/h) at two sowing dates (20th May,1st -July).

Parameters	df	Sowing date			
		20th May		1st -July	
		FE	FER	FE	FER
Rep.	3	58.81	0.0003	15.75	0.0001*
Cultivar	2	1510.93**	0.0031**	1904.81**	0.0039**
Error	6	20.65	0.0001	60.54	0.000008
CV		8.03	4.93	16.34	1.19

** and * Significantly probability in 0.01 and 0.05 respectability

0.62 %/µs/cm^2 and -0.0082 h^{-1}/µs/cm^2 respectively) (Fig.1). On the other hand, the deterioration of seeds between cultivars caused reductions in viability percentage and seedling establishment; therefore, because of poor vigor rate, field emergence declined. In wheat, Zaman Khan et al. (2010) indicated that among all tests, germination index (GI), accelerated aging (AA), and electrical conductivity (EC) provided the best estimate of seed vigor. Mondo et al. (2013) revealed that plants originating from high-vigor seeds had a dominant effect on those originating from low-vigor seeds and had no compensatory effects. In another study, the lower establishment of soybean seedling with lower vigor was observed in field conditions (Khaliliaqdam et al., 2012a; Viera et al., 1999). The relationships among SG, vigor, and FE for all cultivars are listed in Table 5. Although all laboratory indexes except GR had a significant relationship with FE, the accuracy of the EC test was evidently the most accurate in predicting FE (r=0.91**); thus the EC test contributed to the prediction of FE and FER better than other tests did. The result of the experiment reported here demonstrated that seed vigor is an important component of seed quality. One which cannot be ignored is seed testing. Zaman Khan et al. (2010) concluded that all laboratory test results significantly correlated with FE except the SG and germination indices. Data from previous research on soybean similarly demonstrated that cultivars had different levels of vigor between laboratory indexes, such as SG, AA-normal seedling percentage, and AA-seedling dry weight. The EC test was most sensitive and allowed for the differentiation of levels of physiological quality in seeds and an estimation of the potential FE of a seedling, although the degree of association among these parameters for soybean can change based on environmental conditions (Hampton and Tekrony, 1995; Khaliliaqdam et al., 2012a,b; Vieira et al., (1999), for aubergine (Demir et al., 2005), for four forage species (purple vetch, alfalfa, sudangrass and Moench subsp.) (Waes, 1995) and for kenaf (Mentis and Smith, 2003).

Materials and Methods

Plant materials

Laboratory trials

Experiments were performed on three soybean [*Glycine max* (L) Merr.] cultivars (‘DPX’, ‘Sahar’ and ‘Williams’). These cultivars were chosen because they were located in the extreme northern regions of Iran, and because they are the most important compared with other soybean cultivars. Seeds were obtained from Gonbad (latitude: 37° 15' 18N, longitude: 55° 10' 17E; altitude: 52m asl). Seed quality was measured before planting. Four replicates of 25 seeds from each seed lot were tested using the standard germination test for germination between double layered rolled filter papers at 25±1°C for 7 days. For the accelerated aging (AA) test, 42 g of seed were aged for 72 h at 41^{o}C and germination, seedling dry weight, and normal seedling after aging were evaluated with the SG, SGR (ISTA, 2009). Electrical conductivity (EC) was evaluated using 250 mL deionized water in 20 °C for 24 h. Conductivity of the leachate was then measured, and the results were expressed as µS cm^{-1} g^{-1} (Hampton and Tekrony, 1995).

Field trials

The field experiment was carried out at the Research Farms of Gonbad Oil Seeds Center (latitude: 37°25´N; longitude: 545°16´E; altitude: 52 m asl) in 2009. Seeds were treated with 1.5 g/kg Benomyl and were then sown on the two planting dates of 20th May and 1st July, 2009 at depths of 2.5 cm and at a density of 28 Pln/m^2. Five rows, each measuring 4 m long and spaced 50 cm apart, were sown for each plot. The soil was kept sufficiently wet for germination, and subsequent irrigation was carried out as required. Weeds were controlled by hand during crop growth and development stages. Seedling emergence in each plot was counted at daily intervals until no more emergences were observed (growth stage VE) (Fehr and Cavieness, 1977). Subsequently, rates and percentages of seedling emergence were calculated (Soltani and Maddah-Yazdi, 2010). At maturity, plants from 1 m^2 in the middle of each plot were harvested, and grain yields per unit area were recorded.

Statistical analysis

The experiments were performed on three treatments of soybean (DPX’, ‘Sahar’ and ‘Williams’ cultivars) arranged in a completely randomized design (for laboratory experiments) and in randomized complete blocks (for field experiments) and were replicated four times.. Variance analysis and correlation tests were conducted using SAS software (Soltani,

Table 4. The results of mean comparison of field measured traits for soybean cultivars.

Cultivars	Sowing date			
	20- May		1-July	
	FE (%)	FER (1/h)	FE (%)	FER (1/h)
DPX	60.93 b	0.252 a	52.5 b	0.255 b
Sahar	73.43 a	0.27 a	66.56 a	0.262 a
Williams	35.31 c	0.215 b	23.75 c	0.205 c
LSD(0.05)	7.86	0.021	14.43	0.005

Table 5. Results of correlation analysis among Standard germination(Gmax, %), Electrical conductivity(EC, $\mu s/cm.g$), Germination rate(GR, 1/h), AA-Seedling dry weight(SDW, g), AA-Normal seedling(NS, %), AA-Standard germination(Gmax, %),AA-Germination rate (GR,1/h), Field emergence (FE, %) and Field emergence rate (FER, 1/h) (Sum of two Sowing date).

	EC	Gmax	GR	SDW(AA)	NS(AA)	Gmax (AA)	GR (AA)	FE	FER
EC	1								
Gmax	-0.88**	1							
GR	-0.1^{ns}	-012 ^{ns}	1						
SDW(AA)	-0.79**	0.76**	0.12 ^{ns}	1					
NS(AA)	-0.86**	0.83**	-0.07 ^{ns}	0.83**	1				
Gmax (AA)	-0.89**	0.93**	-0.19 ^{ns}	0.78**	0.81**	1			
GR (AA)	-0.56**	0.68**	0.09 ^{ns}	0.55**	0.54**	0.59**	1		
FE	-0.91**	0.83**	0.15 ^{ns}	0.77**	0.82**	0.89**	0.56**	1	
FER	-0.93**	0.84**	0.08 ^{ns}	0.76**	0.80**	0.84**	0.57**	0.87**	1

** and * Significantly probability in 0.01 and 0.05 respectability.

2007). Means of each trait for the different treatments were compared using the LSD test at P≤0.05.

Conclusion

Overall, the results showed that (i) differences in seed vigor between soybean cultivars was related to genotype; (ii) the EC test could predict seed emergence in the field better than the SG and AA tests; (iii) during the vegetative growth stage, field emergence and field emergence rates of soybean cultivars had positive relationships with seed vigor.

References

Damavandi A, Latifi N, Dashtban A R (2007) Analysis of seed vigor tests and it's performance in Sorghum. J Agric Sci Natur Resour. 14(5), 16-23.

Demir I, Ermis S, Okcu G, Matthews S (2005) Vigor tests for predicting seedling emergence of aubergine (*Solanum melongena* L.) seed lots. Seed Sci Techno. 33, 481-484.

Egli d B, Rucker M (2012) Seed vigor and the uniformity of emergence of corn seedling, Crop Sci. 52(6):2774-2782.

Egli, DB, Tekrony DM (1979) Relationship between soybean seed vigor and yield. Agron J. 71,755-759.

Ellis RH (1992) Seed and seedling vigor in relation to crop growth and yield. Plant Growth Reg. 11, 249-255.

Ellis RH, Pieta-Filho C (1992) Seed development and cereal seed longevity. Seed Sci Res. 3, 247-257.

Fehr WR, Cavieness CE (1977) Stage of soybean development. Special Report 80. Coop. Ext. Service Agric. And home Economic Expt. Sta., Iowa State Univ. Ames, Iowa.

Ghassemi-Golezani K, Bakhshy Y, Raey J, Hossenizadeh-Mahotchi A (2010) Seed vigor and field performance of winter oilseed rape (*Brassica napus* L.) cultivars. Not Botany Hort Agro-botanica Cluj. 38, 146-150.

Ghassemi-Golezani K, Hossenizadeh-Mahotchi A (2009) Change in seed vigor of faba bean (*Vicia faba*L.) cultivars during development and maturity. Seed Sci Techno. 37, 713-720.

Hampton JG, TeKrony DM (1995) Handbook of vigor test methods.3rd Zurich, Switzerland, ISTA.

ISTA (2009) Handbook of Vigor Test Methods. 3rd Edn., International Seed Testing Association, Zurich, Switzerland.

Kanouni H, Khalily M, Malhotra RS (2009) Assessment of cold tolerance of chick pea at rain fed highlands of Iran, Am. Eur J Agric Environ Sci. 5, 250-254.

Khah EM, Roberts EH, Ellis RH (1989) Effects of seed aging on growth and yield of spring wheat at different plant-population densities. Filed Crop Res. 20, 175-190.

Khaliliaqdam N, Soltani A, Latifi N, Ghaderi-Far F (2012a) Seed vigor and filed performance of soybean seed lots case study: Northern of Iran. Am Eur J Agric Environ Sci. 12, 262-268.

Khaliliaqdam N, Soltani A, Latifi N, Ghaderi-Far F (2012b) Effect of Environmental conditions on soybean vigor in different area of Iran, Electronic J Crop Produc. 5(4):1-21

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

Kolasinska K, Szyrmer J, Dul S (2000) Relation between seed quality tests and field emergence of common bean seed. Field Crop Res. 40, 470-475.

Larsen SU, Pulsen FV, Eriksen EN, Pedersen HC (1998) The influence of seed vigor on field performance and the evaluation of the applicability of the controlled deterioration vigor test in oil seed rape (*Brassica napus* L.) and pea (*Pisum sativum* L.). Seed Sci Techno. 26, 627-641.

Mentis PD, Smith CA (2003) Kenaf seed storage duration on germination, emergence and yield. Ind Crops Product. 17, 9-14.

Mondo VHV, Cicero SM, Dourado-Neto D, Pupim TL, Dias MAN (2012) Effect of seed vigor on intraspecific comepetition and grain yield in Maize, Agron J. 105(1):222-228.

Pedersen JF, Toy JJ (2001) Germination, Emergence and yield of 20 plant-color, seed-color, near-isogenic lines of grain sorghum. Crop Sci. 41,107-110.

Prete CEC, Cicero SM, Folegatti MV (1994) Soybean seedling field emergence and relation of imbibition and Electerical conductivity of the seeds. Semina 15, 32-37.

Rodo AB, Marcos-Filho L (2003) Onion seed vigor in relation to plant growth and yield. Hort Bras Bras. 21(2), 220-226.

Soltani A, Maddah-Yazdi V (2010) Simple Applied Programs in Agricultural and Natural Resources. Daneshgahi Press, Mashhad, Iran.

Soltani A (2007) Application and Using of SAS Program in Statistical Analysis. Jihad-Daneshgahi Press, Mashhad, Iran.

Tekrony DM Egli DB (1991) Relationship of seed vigor to crop yield: a review. Crop Sci. 31,816-822.

Tekrony DM, Bustaman T, Egli DB, Pfeiffer TW (1987) Effect of soybean seed size, vigor and maturity on crop performance in row and hill plots. Crop Sci. 27, 1040-1045.

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

Waes JV (1995) The use of a cold-test to predict field emergence of maize in official variety trials in Belgium, Seed Sci Techno. 23, 211-224.

Zaman Kan A, Shah P, Mohd F, Khan H, Amanullah A, Pervin S, Nigar S, Khalili S k, Zubair M (2010) Vigor tests used to rank seed lot quality and predict field emergence in wheat. Pak J Bot. 42(5):3147-3155.