

Seed Vigor and Field Performance of Soybean Seed Lots Case Study: Northern Areas of Iran

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Abstract: Laboratory and field tests were conducted to investigate the suitability of various laboratory vigor tests, to rank quality of commercial seed lots and the relationship between laboratory tests to field emergence and yield. The tests were done in 2010 at the research farm of Gorgan University of Agricultural Sciences and Natural Resources, Iran. Three seed cultivars were investigated in the study, as follows; Sahar (five lots: Gorgan, Gonbad, Sari, Babolsar and Kurdkuy), DPX (two lots: Gorgan and Gonbad) and Williams (two lots: Ardabil and Gonbad). The experiment was arranged as CRD and RCB based on a nested design with four replications. Results showed that among all the tests, the Electrical Conductivity (EC) test was more sensitive at ranking vigor of the different seed lots. The relationships of laboratory tests with field emergence tests were significant and the EC test had the highest R^2 (0.86**) relative to the other tests for: Standard germination, AA seedling dry weight and AA seedling normal percentage. Decreasing seed lot vigor led to a significant reduction in field emergence in nine of the seed lots mainly due to poor emergence rate. Low seed vigor caused delay in emergence and subsequent reduction in field emergence rate. Seed deterioration had no effect on soybean grain yield; however grain yield per unit area had no increase in seed vigor.

Key words: Seed quality Laboratory test • Field emergence • Yield

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 [1]. Measures of seed vigor on soybean [*Glycine max* L. Merr.] showed that this evaluation related better to emergence in the field under stress condition than did the results from the standard germination test. The results of vigor tests have also been shown to be excellent predictors of the storage capacity of soybean seeds [2]. Relations between seed vigor, laboratory germination, field emergence and yield have been the subjects of numerous studies.

Prete *et al.* [3] detected a highly significant negative correlation between the electrical conductivity evaluation and the field emergence of soybean seedlings. A detailed study on soybean by Vieira *et al.* [4] showed that significant correlations were detected between; standard germination, accelerated aging, electrical conductivity and seedling field emergence. However, in terms of the cultivar

or the year, the degree of association among these parameters can change based on the specific annual environmental conditions. Rapid emergence of seedlings from high vigor seed lots were reported for Kenaf [5], sorghum [6], safflower [7], common bean [8], winter barley and wheat [9], alfalfa, sudangrass, Siberai ryegrass and Purple vetch [10] and winter oil-seed rape [11].

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. However there is usually no such relationship in crops harvested at full reproductive maturity, 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 [11].

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.

The second way in which poor seed vigor might affect yield is because the individual plants that subsequently emerge perform less well than those from a better-quality seed lot. In spite of most of these deleterious effects of poor seed vigor, it is an evaluation that remains a good indicator of the rate of germination and early seedling growth [12,13]. Seed vigor has been reported to have had no relationship to yield in studies on soybean [1, 14,15], Onion [16], Oil seed rape and pea [17], spring and winter wheat [13, 9], winter barley [9] and Chick pea [18]. Plant establishment, growth and final yield are affected by many factors such as plant densities and environmental influences. Therefore, the effect of vigor on crop performance is complex [9] and it may be difficult to find a general relationship between results of a vigor test and actual crop performance [17].

This study aims to evaluate effects of sowing different quality seeds of soybean seed lots on field performance.

MATERIALS AND METHODS

Laboratory Trials: Nine seed lots of three soybean [*Glycine max* L. Merr.] cultivars ('DPX', 'Sahar' and 'Williams') were obtained from six areas of Iran (Gorgan, Gonbad, Sari, Kurdkuy, Babolsar and Ardabil). Seed quality was measured before planting. Four replicates of 25 seeds from each seed lot were tested for germination between double layered rolled filter papers at $25\pm1^{\circ}\text{C}$ for 7 days. In the accelerated aging (AA) test, 42 g of seeds were aged for 72 h at 41°C and evaluations for; germination, seedling dry weight and normal seedling after aging were measured with the SG, SGR [19]. 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 $\mu\text{S cm}^{-1}\text{ g}^{-1}$ [20]. The experiment was arranged as completely randomized, based on a nested design in four replicates. The treatments were three soybean cultivars and nine seed lots (cultivar) as various levels of vigor.

Field Trials: The field experiment was carried out at the Research Farm of Gorgan University of Agricultural Sciences and Natural Resources (latitude $36^{\circ}51'\text{N}$; longitude $54^{\circ}16'\text{E}$; Altitude 13.3 m above sea level) in 2009. The experiment was arranged as a randomized complete block based on a nested design with four replicates. Treatments were three soybean cultivars and nine seed lots (of the cultivars) as various levels of vigor. Seeds were treated with 1.5 g/kg Benomyl and were then were

sown at two planting dates; 20th May and 1st July, 2009 at depths of 2.5 cm at a densities of 28 PIn/m². 5 rows were sown for each plot, each of which was 4 m long and they were spaced at 50 cm apart. Soil moisture 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) [21]. Subsequently, rates and percentages of seedling emergence were calculated [22]. At maturity, plants from 1 m² in the middle of each plot were harvested and grain yields per unit area were recorded. Analysis of variance of the data appropriate to the experimental design was conducted, using SAS software [16]. Means of each trait for the different treatments were compared according to LSD test at $P\leq 0.05$. Excel software was used to draw the figures.

RESULTS

Quality of Seed Lots Evaluated by Different Tests: Analysis of the results from all the emergence trials and electrical conductivity (EC) test showed that there were highly significant differences ($P < 0.01$) between the cultivars and seed lots within a cultivar (Table 1). The standard germination (SG) results showed that all seed lots except Gonbad seed lot from the Williams cultivar, had germination or viability $\geq 98\%$ which is a commercially acceptable level for seeds in Iran. Laboratory tests were able to rank the seed lots of cultivars into various quality groups, however the number of groups ranked for each seed lot differed between the tests. When seed lots of a cultivar were compared, SG had significant difference between seed lots of Williams and Sahar cultivars.

Accelerated aging (AA) and Seedling dry weight were both more variable statistics between the seed lots. For 'Sahar' AA Seedling dry weight ranged from 0.18 to 0.507 g. In 'DPX', AA Seedling dry weight was higher in Gorgan than Gonbad seed lots (Table. 2). The highest final result was observed in Gorgan and Ardabil seed lots (of 'DPX' and 'Williams' cultivars). In 'Sahar' AA Normal seedling of Babolsar and Kurdkuy seed lots were highest (81%) and lowest (43%) respectively, which were significantly higher than the others.

Electrical conductivity (EC) had an upper difference range (near $8\mu\text{S/cm.gr}$) among seed lots of 'Sahar' and Babolsar scored better in seed vigor. EC in Gorgan

Table 1: Results of variance analysis (mean squares) for Standard germination (%), Electrical conductivity ($\mu\text{S/cm.gr}$), AA Seedling dry weight (g) and AA Normal seedling (%).

Parameters	df	Laboratory Index			
		Standard germination (%)	Electrical conductivity ($\mu\text{S/cm.gr}$)	Seedling dry weight (g)(AA)	Normal seedling (%) (AA)
Cultivar	2	137.40**	91.063**	0.135**	3090.0**
Seed lot (Cultivar)	6	57.866**	36.099**	0.055**	844.66**
Error	27	2.555	0.623	0.0036	50.370

Table 2: Results of variance analysis (mean squares) for field trials (FE (%) and Field emergence rate (R90, 1/h)) and Yield (Kg/m²) at two planting dates (20th May, 1st -July).

Parameters	df	Field Emergence				Harvesting	
		20- May		1-July		20- May	1-July
		FE (%)	R90 (1/h)	Emax (%)	R90 (1/h)	Yield (Kg/m ²)	Yield (Kg/m ²)
R	3	139.30**	0.0004*	75.46	0.0022**	2072.52	271.88
Cultivar	3	2949.11**	0.0041**	3332.12**	0.0052	33377.41**	38991.63**
Seed lot (Cultivar)	6	1189.14**	0.0008**	1402.71**	0.0009**	3341.28*	2492.4
Error	27	13.49	0.0001	42.82	0.00002	1314.7	1737.84

Table 3: The results of comparisons mean Laboratory Indexes in laboratory and field trials (FE (%) and Field emergence rate (R90, 1/h)) and Yield (Kg/m²) in two planting date (20- May1-July).

Cultivar		Vigor classification	Laboratory Index				Field emergence		Harvesting			
			Standard germination (%)	Electrical conductivity ($\mu\text{S/cm.gr}$)	Seedling dry weight (g)(AA)	Normal seedling (%) (AA)	20- May		1-July		Yield (Kg/m ²)	Yield (Kg/m ²)
							FE (%)	R90 (1/h)	FE (%)	R90 (1/h)		
DPX	Gorgan	V1	100a	19.38b	0.449a	78a	90.93a	0.2800a	82.18a	0.2775a	369.21a	325.51a
	Gonbad	V2	99a	23.87a	0.251b	53b	60.93b	0.2525a	52.5b	0.2550b	330.50a	313.55a
Williams	Ardabil	V1	99.5a	26.68b	0.140a	35a	41.25a	0.2325a	32.5a	0.2225a	353.33a	257.91a
	Gonbad	V2	86.5b	28.57a	0.098a	26b	35.31b	0.215a	23.75a	0.2050b	358.43a	296.11a
Sahar	Babolsar	V1	100a	18.56c	0.507a	81a	94.68a	0.2825a	87.18a	0.2850a	261.92ab	218.10a
	Sari	V2	100a	20.44d	0.348b	66b	79.68b	0.2725ab	75ab	0.2650b	283.45ab	225.06a
	Gorgan	V3	100a	25.10b	0.232dc	48c	73.43c	0.27ab	66.56b	0.2625b	297.4a	217a
	Gonbad	V4	100a	22.26c	0.302bc	62b	55.31d	0.255bc	46.25c	0.2475c	307.67a	236.31a
	Kurdkuy	V5	98.5b	26.46a	0.180d	43c	50.31d	0.2475c	38.43c	0.2375d	310.64a	189.99a

Table 4: Results of regression analysis of relationship between Standard germination (%), Electrical conductivity ($\mu\text{S/cm.gr}$), AA Seedling dry weight (g) and AA Normal seedling (%) to Field trials (FE (%) and Field emergence rate (R90, 1/h)) and Yield (Kg/m²) (Sum of two planting date)

Standard germination (%)	Field trials		Harvesting	
	df	FE (%)	R90(1/h)	Yield (Kg/m ²)
Regression	1	10361**	0.0185**	18031
Error	78	354.009	0.0037	3151.36
Electrical conductivity ($\mu\text{S/cm.gr}$)				
Regression	1	32798**	0.0374**	6980.77
Error	78	66.35	0.00013	3293.02
Seedling dry weight(g)(AA)				
Regression	1	28674**	0.0326**	5513.86
Error	78	119.56	0.00019	3311.83
Normal seedling (%) (AA)				
Regression	1	29806**	0.0347**	9091.43
Error	78	204.71	0.00017	3265.96

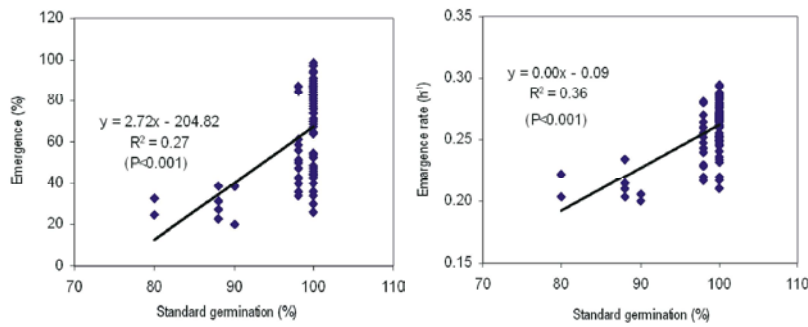


Fig. 1: Relations between Standard germination, emergence percent and emergence rate (Sum of two sowing date, 4 replication and nine seed lots).

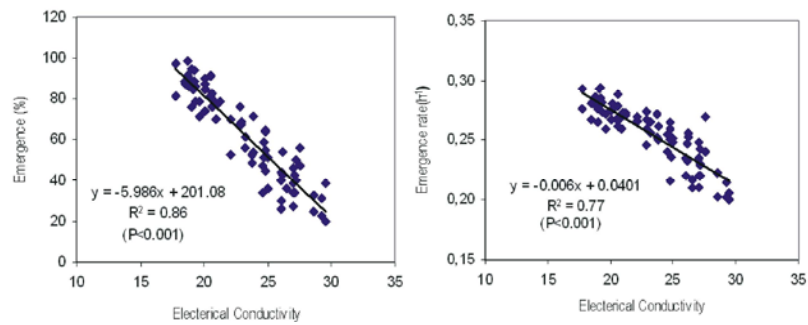


Fig. 2: Relations between emergence percent, emergence rate and Electrical conductivity (Sum of two sowing date, 4 replication and nine seed lots).

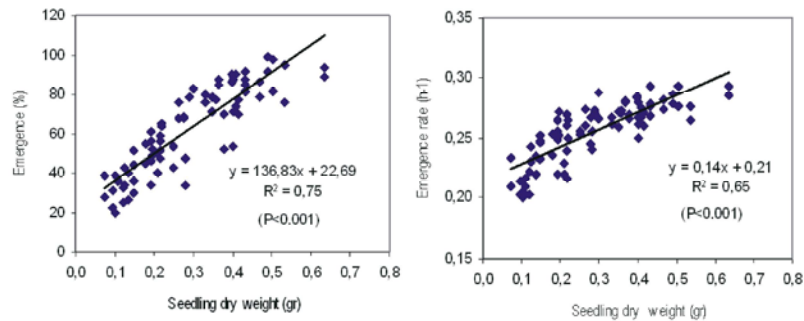


Fig. 3: Relations between emergence percent, emergence rate and AA Seeding dry weight (Sum of two sowing date, 4 replication and nine seed lots).

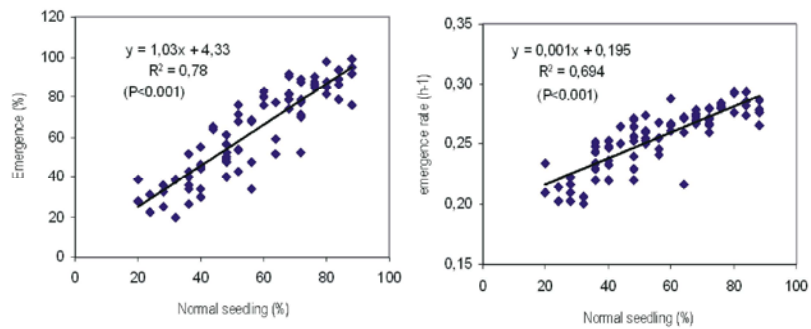


Fig. 4: Relations between emergence percent, emergence rate and AA Normal seedling percent (Sum of two sowing date, 4 replication and nine seed lots).

(DPX, cultivar) and Ardabil (Williams, cultivar) seed lots were the lower and Gonbad seed lot (DPX and Williams cultivars) scored higher in seed vigor (Table 2).

Relationship Between Laboratory Tests and Field Emergence: Two sowing dates (20th May and 1st July) were used to increase the chance of encountering stress conditions during the stage of emergence to maturity. This strategy was only partially successful. Field emergence (FE) produced significant difference among the seed lots at the two sowing dates (Table 2). 'Babolsar' seed lot of Sahar cultivar had significantly higher field emergence (FE) and field emergence rate (R90) than the other lots at both sowing dates. Also, Gorgan (of 'DPX' cultivar) and Ardabil (of 'Williams' cultivar) seed lots appeared to have the highest Emax and R90 at both sowing dates. The first sowing date was expected to produce the upper Emax and higher R90 than the second sowing date (Table 3).

The yield did not differ ($P > 0.05$) significantly between any seed lots but differences among the cultivars were significant (Table 2). At both sowing dates, in spite of expectations, yields of Babolsar and Ardabil seed lots which had higher vigor (V1) were lower than seed lots with low vigor: Gonbad within 'Sahar' and Williams cultivars, respectively (Table 3). Although, yield of Gorgan seed lot in DPX cultivar at both sowing dates was higher than Gonbad seed lot but no significant difference was found. Also, yield of soybean stands was better at the sowing date: of 20th May than the sowing date of 1st July (Table 3).

Laboratory indexes were evidently significantly related to field emergence (Table 4). 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 (Fig.1). FE (5.98 %) and R90 (0.006 1/h) decreased significantly by increasing in EC (Fig.2). Values of AA seedling dry weight and AA Normal seedling percentage both had a significantly positive relation ($P < 0.01$) with FE but yield had no relationship with any of the laboratory indexes (Table 4). In field, FE augmentation 13.68 % by 0.1 g enhanced in AA Seedling dry weight (Fig.3). Although, Emax (1.03 %) and R90 (0.001 1/h) increased when AA Normal seedling was increasable (Fig. 4).

DISCUSSION

For all the nine seed lots, EC provided the most sensitive index in ranking quality of the seed lots within a cultivar. For Sahar cultivar, EC divided the seed lots into

five groups, whereas SG, AA Normal seedling percentage and AA Seedling dry weight divided lots of 'Sahar' in to groups of: two, three and four (Table 3). Data from previous research similarly demonstrated that compared with SG, AA Normal seedling percentage and AA Seedling dry weight, the EC test was more sensitive in ranking seed lots and provided more precise evaluations of potential seed lot performances; for soybean [20,23,4], aubergine [24], safflower [7], four forage species (purple vetch, alfalfa, sudangrass and moench subsp.) [10] and Kenaf [5].

Seeds can retain high quality for some time and therefore begin to deteriorate on the mother plant or during storage, losing viability and vigor [25,26]. It seems that differences in seed lots within a cultivar related to genotype type and environmental conditions during maturity and storage. All of the laboratory indexes had a significant relationship with FE but accuracy of EC test ($R^2=0.86^{**}$) was evidently the most accurate in predicting FE (%). Deterioration of seed lots within cultivars caused reductions in viability percentage and seedling establishment. Also, because of poor vigor rate, field emergence declined ($R^2=0.77^{**}$).

Studies with soybean seed harvested at different times and stored in specific environments revealed that SG, AA and EC tests allowed for the differentiation of levels of physiological quality of seeds and an estimation of the potential of FE of a seedling with emphasis on EC, which provided more precise information, although the degree of association among these parameters can change based on environmental conditions [27,20,23]

Our data clearly indicate that variation in the vigor of the seed lots had no significant effect on yield for any of the seed lots within the various cultivars and differences in yields of seed lots were not related to differences in seed vigor levels. Tekrony and Egli [11] reported that the effect of seed vigor on yield depended on when the crops were harvested. Crops harvested during the vegetative growth stage or during early reproductive growth showed a consistently positive relationship between seed vigor and yield. These results are in agreement with the findings of tests on soybean [14,2,28,15,29], corn [30], onion [16], spring wheat [13], rape and pea [17], Kenaf [5].

Finally, the results obtained showed that (i) seed vigor is affected by growing conditions under which the seed is matured and during storage (ii) the EC test could predict seed emergence in the field better than SG and AA tests. (iii) Field emergence percentage and field emergence rate were influenced by soybean seed vigor but yield was not affected.

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