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Relationship between laboratory indices of soybean seed vigor with field emergence and yield

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Abstract

This study was conducted for evaluation the correlation of laboratory seed quality indices with field emergence in 2013. First the standard germination test and seed vigor tests were conducted for of two cultivars (Williams and L17) which were produced in last year and also recent year and germination percent and seedling vigor index were measured. Then vigor tests including cold and accelerated aging tests were conducted. The laboratory experiments were done as a factorial experiment with two factors based on completely randomized design in 4 replications and field experiment was as a factorial experiment with two factors based on randomized complete block design in 4 replications. According to results germination percent and seedling vigor index had a high correlation with final seedling emergence percent and cumulative emergence rate. The seedling vigor index in cold test specified the highest correlation with final seedling emergence percent (r= 0.941) and cumulative emergence rate (r=0.756). The correlation of laboratory traits and yield related traits defined that standard germination percent (r=0.756) and seedling vigor index (r=0.711) in cold test showed a high correlation with final yield and the related traits to accelerated aging test had a lesser correlation.

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Introduction

Germination and vigor tests can be used for awareness of differences of seed lots value and making decision about it (Copeland and McDonald, 2001). The aim of vigor tests is distinguishing of seed lots with low and high vigor. These tests, also suggest methods to estimate field's potential yield for seeds with different vigor levels at different laboratory conditions. Although seed germination and vigor tests are applied as an index to determine field emergence, but it's difficult to propose a direct relation between soybean's seed germination and its field emergence. For validating the seed vigor test, it should be attributed to specific trait such as seedling emergence potential at a wide range of environmental conditions. Seed vigor tests do not replace with the germination test, but they are its supplementary. Each factor that causes loss of germination formerly it reduces seed vigor, because vigor is more sensitive in comparison with germination.

Relations between seed vigor, laboratory germination, field emergence and yield have been the subjects of numerous studies. A lot of efforts have been done to relate the standard germination estimation with seedling emergence in field condition. Some researchers have reported a close correlation between standard germination and seedling field emergence, while other studies have shown that standard germination test always overestimates seedling field emergence (Tekrony and Egli, 1991). The differences in results are mostly due to variation of field conditions and the standard germination will provide precise prediction of field emergence when the field conditions are ideal.

Unfavorable conditions of seed media will reduce seedling field emergence and also the correlation of standard germination and field emergence (Tekrony and Egli, 1997). The estimation of seed vigor may provide a better correlation with field emergence compared to standard germination (AOSA, 2000). However, only vigor test does not precisely predict crop field yield at all conditions.

Saha and Sultana (2008) reported a high positive correlation (0.91) between seedling field emergence and seed germination percent. They also reported that seed electrical conductivity indicated a negative correlation with seedling field emergence percent.

Final seed germination percent of soybean correlates with seedlings field emergence only in favorable conditions (Tekrony and Egli, 1977). By taking to consideration that the seeds with high germination ability at laboratory (optimum conditions for germination) do not necessarily have efficient germination at field and number of seedlings established at field is lower due to occur of improper conditions for germination and seedling growth, therefore seed vigor test has a considerable importance in determining the seed quality and hence various tests have been developed for seed vigor assessment (Rammamoorthy, 2006).

The seed electrical conductivity measurement is used for seed vigor test of many crop species especially for different species of large seed legumes such as soybean, common bean, mung bean and faba bean.

The accelerated aging test initially was used for seed longevity in storage to predict viability duration of some different plant species (Delouche and Baskin, 1973). After wards this test was developed as a seed vigor index in numerous plant species and successfully demonstrated its correlation with seedling field emergence (Tekrony, 1983).

This study aims to evaluate the effect of sowing different aged soybean seeds on field performance and investigate the relationship between laboratory indices of soybean seed vigor with seedling field emergence and yield.

Materials and method

In order to assessment the seed vigor tests of commercial soybean cultivars produced in Ardebil province including Williams and L17, this study was conducted as a factorial experiment in 4 replications in 2013. The first factor consisted of Williams and L17 and the second factor included of current year produced seed and last year seed. The evaluated traits

in laboratory were standard germination, accelerated aging test, cold test and electrical conductivity. Also the field traits including initial seedling emergence (7 days after planting), final seedling emergence percent (14 days after planting) and speed of seedling emergence were measured.

Final germination percent

In order to determine final germination percent, 4 replications of 100 seeds from each treatment were sown in containers between two layers of germination paper according to international seed testing association rules. Then the containers were placed in growth chamber at 25˚ c for 8 days. At the end of standard germination test period the number of normal seedlings was specified according to international seed testing association (Anonymous, 2006).

Seedling vigor

For evaluation of seed and seedling vigor, 10 normal seedlings were selected randomly from each replication after standard germination test and shoot and radicle length were measured by ruler in cm. Seedling vigor index was calculated by below relation (Abdul- baki and Anderson, 1973).

Seedling Vigor Index= (the mean primary radicle length + the mean of first shoot length)× final germination percent.

Cold test

4 replications of 100 seeds were counted from each treatment and were planted in plastic containers on germination papers and were kept in growth chamber at 10˚ c for 7 days. Then the containers transferred to growth chamber of 25˚ c for 4 days. The final germination percent and seedling vigor index were calculated similar to standard germination test.

Accelerated aging test

According to international seed testing association rules 4 replications of 100 seeds from each treatment were placed in specific containers of accelerated aging test. The containers were kept at 41± 0.3˚c for 72 hours and 100% relative humidity (anonymous, 2006). Then the standard germination test carried out for these seeds and germination and vigor related indices that previously mentioned were determined.

Cumulative seedling emergence rate (CER)

It's calculated by below relation (Orchard,1977):

$$CER=\frac{F1}{D}+\ldots+\frac{Fi}{D}$$

Which F is a number of counted seedlings and D is a number of days to final count.

Results and discussion

The analysis of variance's results (table 1, 2) revealed that the seed storage duration and cultivar had a significant effect on both laboratory and field measured traits except of the number of pod per plant. The mean comparison of seed storage duration× cultivar interaction for normal seedlings number and seedling vigor index specified that there was no significant difference between two cultivars for first level of storage (after 6 months) and approximately equal number of normal seedlings and also seedling's length vigor index were recorded for both cultivars.

A significant reduction of normal seedlings number and seedling's vigor index was observed in both cultivars by increasing the storage duration to 18 months (next planting season), but this reduction was significantly higher in L17 compared to Williams. The storage of seeds for next planting season (30 months seed storage) pointed out that normal seedlings number and seedling's vigor index significantly reduced between 18 and 30 months of seed storage (figure 1, 2).

The results of this experiment specified that the reduction speed of normal seedlings percent and seedling length vigor index was higher in third storage duration (after 30 months against 18 months) in comparison with the second storage duration (after 18 months against 6 months) especially for seedling length vigor index that indicates with enhancement of storage duration the seed deterioration rate will

increase and this loss of seed quality occurs more rapidly in seed vigor compared to germination ability.

Many researchers believe that oxidation of lipids and enhancement of free fatty acids in soybean seed during storage cause its rapid deterioration in comparison with other oilseed crops (Reuzeau and Cavalie,1995; Trawatha *et al.*, 1995; Balasevic- Tubic *et al.*,2005). Son *et al.*, (1996) demonstrated that seed germination and emergence of 6 soybean cultivars which have been stored for 8 months was higher in comparison with seeds of 20 months storage. Also a large variation was observed in seed germination and emergence after 20 months and more storage duration. Tekrony *et al.*, (2005) evaluated the corn seed storage effect on germination and vigor at uncontrolled storage conditions. The results indicated that germination of original seed lots dropped from 87-99% to 50-60% after 8 months seed storage.

Table 1. The variance analysis (mean squares) of measured traits in laboratory.

S.O.V	df	Mean squares					
		Standard Germination Test		Cold Test		Accelerated Aging Test	
		Seedling vigor index	Germination percent	Seedling vigor index	Germination percent	Seedling vigor index	Germination percent
Cultivar	1	163086.1**	192.666**	147188**	253.50**	124329**	459.37**
Storage duration	1	828991.7**	645.542**	325449**	421.16**	1345803**	2277.37**
Cultivar*Storage duration	1	28958.4*	26.042**	6974 ns	18.50ns	98590**	153.37**
Error	12	5807.5	3.66	9663	8.16	13812	7.59
C.V		4.94	2.60	7.69	4.30	16.14	6.50

ns: non significant ; ** significant at 1% level; * significant at 5% level.

The mean comparison results (Table 3) indicated that the Williams cultivar recorded significantly higher final seedling emergence, cumulative seedling emergence and yield compared to L17 cultivar, these results comply with laboratory tests results; therefore with attention to more normal seedlings at laboratorial tests, especially after storage durations we could observe higher seedling field emergence in Williams.

Table 2. The variance analysis (mean squares) of measured traits in field.

S.O.V	df	Mean squares			
		final seedling emergence percent	CER	yield	The number of pod per plant
block	3	28.02ns	31.73 ns	8194 ns	14.15 ns
Cultivar	1	646.88**	372.80**	510416**	7.04 ns
Storage duration	2	1399.34**	2989.42**	1367917**	5.79 ns
Cultivar*Storage duration	2	10.68 ns	62.63 ns	107916 ns	0.54 ns
Error	15	14.39	22.35	52861	11.78
C.V		7.93	9.20	6.42	8.52

ns: non significant ; ** significant at 1% level; * significant at 5% level.

On the other hand regarded to vigor indices and seed vigor tests in laboratory that demonstrated the seed vigor is properly preserved during storage in Williams cultivar compared to L17, so this cultivar had more rapid emergence at field condition than L17. These factors lead to more appropriate condition of Williams cultivar in terms of seedling emergence indices and speed of emergence and finally it had higher yield.

Table 3. The mean comparison of measured traits for cultivars and storage duration time.

	Mean				
	Germination percent (cold test)	SVI (cold test)	final seedling emergence percent	CER	yield
Cultivar					
Williams	69.67a	1355.07a	53.02a	55.28a	3725a
L17	63.17b	1198.44b	42.63 b	47.40b	3433b
LSD (0.05)	2.45	84.31	3.30	4.11	200.06
		Storage duration			
6 month	73.50a	1474.53a	60.97a	68.62a	3975a
18 month	66.75b	1284.39b	47.97b	54.93b	3612b
30 month	59.00c	1071.35c	34.52c	30.46c	3150c
LSD (0.05)	3.00	103.26	4.04	5.03	245.03

Means with the same letter are not significantly different.

The findings of Saha and Sultana (2008) suggested that by increasing the storage duration up to 20 months, the seedling field emergence percent declined. The reduction of field emergence of deteriorated seeds may be the result of reducing activity of alpha amylase and sugars (Mitra *et al.*, 1974) or denaturation of proteins (Nautyal *et al.*, 1985).

The mean comparison results (table 3) specified that the increase of storage duration significantly reduced the final seedling emergence percent, cumulative seedling emergence rate and seed yield. The reduction value of these traits for 18 months storage compared to 6 months and also for 30 months compared to 18 months of seed storage was 21% and 28% for final seedling emergence percent; 19.9 %and 44.5% for cumulative emergence rate and 9.1% and 12.8% for yield. Considering to reduction value of these traits at two storage phases it can be concluded that like germination test results the seed quality after 30 months storage compared to 18 months storage showed more reduction in comparison with the difference of 18 months and 6 months storages. This signifies that by increasing the storage duration moreover the increase of seed deterioration, also the seed deterioration speed raises.

The number of pods per plant didn't affect by cultivar and storage duration. With delay of seed germination the pods number will decrease due to shortening of proper growing season, but more space for per plant achieved by less seedling number per unit area permits better growth of each plant.

Table 4. The correlation of laboratory traits and seedling field emergence and yield.

	SVI (ST)	GP (ST)	SVI (CT)	GP (CT)	SVI (AA)	GP (AA)	Final Seedling Emergence	CER	No. pod	yield
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	1									
(2)	0.964**	1								
(3)	0.865**	0.891**	1							
(4)	0.888**	0.910**	0.954**	1						
(5)	0.851**	0.907**	0.817**	0.847**	1					
(6)	0.879**	0.923**	0.867**	0.900**	0.977**	1				
(7)	0.872**	0.913**	0.941**	0.872**	0.874**	0.888**	1			
(8)	0.907**	0.906**	0.975**	0.879**	0.886**	0.895**	0.932**	1		
(9)	-0.174ns	-0.126ns	-0.065 ns	-0.020 ns	-0.172 ns	-0.133 ns	-0.031 ns	-0.124 ns	1	
(10)	0.701**	0.691**	0.711**	0.756**	0.584**	0.628**	0.689**	0.716**	0.010 ns	1

ns: non significant ; ** significant at 1% level; * significant at 5% level.
ST: Standard Test; GP: Germination Percent; CT: Cold Test; AA: Accelerated Aging Test.

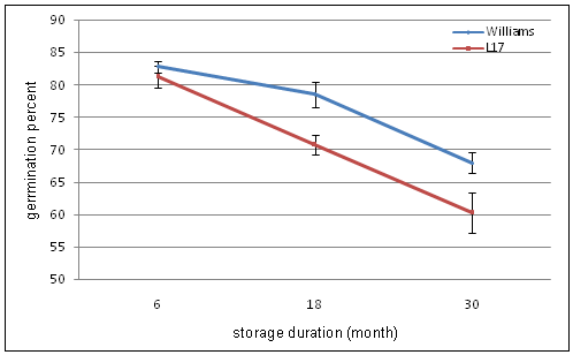

Fig. 1. The mean comparison of storage duration × cultivar on normal seedlings percent at standard germination test LSD (0.05)=2.844.

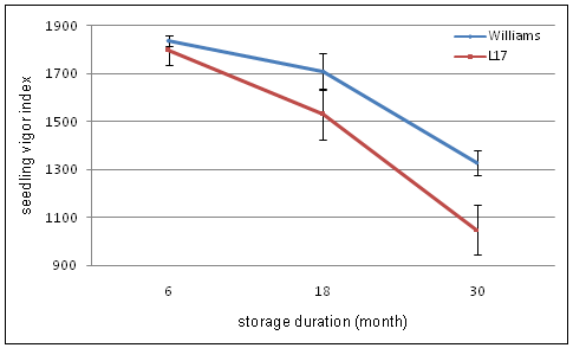

Fig. 2. The mean comparison of storage duration × cultivar on vigor index at standard germination test LSD (0.05)=113.211.

The correlation of laboratory traits and seedling field emergence and yield

The table of correlation between laboratory traits and seedling emergence and yield at field (Table 4) indicated that germination percent and seedling vigor index had a high correlation with final seedling emergence percent and cumulative emergence rate. The seedling vigor index in cold test specified the highest correlation with final seedling emergence percent (r= 0.941) and cumulative emergence rate (r=0.756). The correlation of laboratory traits and yield related traits defined that standard germination percent (r=0.756) and seedling vigor index (r=0.711) in cold test showed a high correlation with final yield and the related traits to accelerated aging test had a lesser correlation. It seems that a high germination percent resulted in high plant density per unit area that causes increased final yield. Generally the better physiological quality of a seed lot will induce the higher germination percent and lesser number of abnormal seedlings. The number of pod per plant signified no significant correlation with laboratory measured traits so it can be concluded that the seed quality has no impact on pods number per plant.

The seed aging and deterioration effect on soybean yield and yield components was assessed by increasing the storage duration and it was observed that a plant density per unit area will decline by increase of seed aging, ultimately seed yield will reduce per unit area (Saha and Sultana,2008). Soltani *et al.*,(2001) reported that high seed vigor causes proper establishment of plant population and minimizing the competence between plants that will result in higher potential seed yield and maximizing crops productivity. The application of low vigor seeds specifically in stress conditions of field could drastically decrease seedling emergence percent. Thus by application of high vigor seeds can reach proper crop establishment at a wide range of environmental conditions that may also have influence on final yield.

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