Scientific Papers. Series A. Agronomy, Vol. LXII, No. 1, 2019
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

SEED VIGOUR INDEX ESTIMATION OF SOME ROMANIAN WINTER BARLEY BREEDING LINES

Liliana VASILESCU[1], Olga STAN[1], Eugen PETCU[1, 3], Alexandrina SÎRBU[2, 3], Alexandru BUDE[1], Victor PETCU[1]

[1]National Agricultural Research and Development Institute Fundulea, 1 N. Titulescu Street, Fundulea, Călăraşi County, Romania
[2]"Constantin Brâncoveanu" University, FMMAE Râmnicu Vâlcea, 39 Nicolae Bălcescu Blvd., Râmnicu Vâlcea, Vâlcea County, Romania
[3]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd., District 1, Bucharest, Romania

Corresponding author email: liliana@ricic.ro

Abstract

*A uniform emergence of barley plants in the field depends on their seed vigour potential and this index define the seed quality. The aim of this paper is to assess the germinative capacity and elements of seed vigour of some Romanian winter barley lines, estimated by two methods used at NARDI Fundulea. Thirty-five winter barley lines were tested under controlled conditions for different physiological traits to determine seed vigour index. The obtained results showed that at the second level of temperature (6°C), the length of shoot and seedling is significantly correlated with germination faculty (0.44**) and also the length of root and shoot with length of seedling (0.44** and 0.95***). The seed index vigour varied from 13.4 to 29.2 when was evaluated at 25°C and from 7.2 to 26.1 at 6°C. An increase tendency of root, shoot and seedling length at 6°C was noticed in average. The different level of temperature could be used for screening the winter barley lines developed in barley breeding program in order to promote genotypes which assure a fast and uniform emergence.*

***Key words**: germination, seed vigour index, winter barley lines.*

INTRODUCTION

The success of the winter barley emergence in the field depends first of all by seed vigour. This seed quality trait determines a fast and uniform emergence of plants but in the same time is influenced by environmental conditions as soil temperature and soil moisture (Perry, 1973).
Winter barley breeding efficiency can increase by early selection of new obtained biological material (barley lines in different generations). During field selection are noticed many barley genotypes and a reduction of biological material volume can be possible by seed vigour early selection criteria.
These genotypes can be studied by different methods in order to characterize seed vigour, in laboratory and under many conditions in the field.
In the latest, climate changes (particularly high oscillating of temperature) have an increased influence on behaviour of winter barley, especially when this crop is sown after optimal period.
In Romania, cultivated area with winter barley varieties, is usually sown in September when is warm (20-25°C), before the recommended period or at the beginning of November (when the temperature usually decreases). In order to predict field barley emergence could be use different types of test for malting and naked barley (Kim et al., 1989) as follow: seed aging treatment, warm germination test, cold germination test, tetrazolium vigour test, conductivity test, field test and also percent of germination, length of seedling and seed vigour index (Kim et al., 1994). For example, in the case of rice, germination and field emergence, were identified as the main contributors to seed yield per plant (Adebisi et al., 2010). Recently, a succesful fast estimation of seed vigour was made by using the absolute seed protein content for wheat and maize, tested under different conditions. The results of this research showed

that, both in wheat and maize, can be use to estimation of seed vigour (Wen et al., 2018).

MATERIALS AND METHODS

Thirty-five winter barley lines developed at NARDI Fundulea (21 lines in F_8, 8 lines in F_7 and 6 lines in F_6 generation) and one specific winter barley variety were used as check (Simbol variety), to evaluate the behaviour under different temperature regarding the germination and the component of seed vigour.
We adopt a standard treatment suggested by the Association of Official Seed Analysts for maize, namely Cold test method at 6°C and beside that, was used a warm germination test conducted at 25°C (Stan et al., 2008), under laboratory condition in order to simulate field conditions during optimal sowing (October) and later (in the first decade of November).
The principle of the warm method is to determine the germination faculty in optimal conditions of temperature and humidity in a well-established time.
The seeds are placed on rolls of industrial filter paper moistened with 60% water of its retaining capacity in four repetitions of one hundred seeds. Rolls are placed in the germination chamber at a temperature of 25°C for seven days. Determination of germination is performed at 4 and 7 days, respectively, according to internal rules and the evaluation of the germs is done after the ISTA evaluation manual (2006). Normal seedlings were counted and the obtained results are expressed in percent.
The principle of the Cold test method is to create in the laboratory, similar conditions to those in the soil, conditions that allow the microflora of the soil and seeds to participate in a competition from which those seeds, germs, or those individuals lacking sufficient resistance either due to heredity or to some physical, physiological or biochemical damage.
The cold test method (6°C) applied to study winter barley genotype is genuine, being improved at NARDI Fundulea, namely Fundulea Test Seed (FTS) by the Biology, pathology and seed quality control laboratory (Stan et al., 2016).
According to this method, the seed is placed in a 1/1 soil/sand mix, wetted with 60% water of its retaining capacity, in four repetitions of 100 seeds. The germination temperature is 6°C for seven days and after that, the seed is transferred to the growth chamber at a temperature of 25°C for four days.
The evaluation of the germs is carried out after the 11 days, based on international standards for ISTA-2006 seed testing. Length of root and shoot were determined separately by a ruler and after that in order to calculate the seed vigour index, these were summed and expressed as seedling length (Mishra et al., 2017).
Seedling vigour index was calculated as the product between percent of germination (G) and the seedling length (SL) in centimetres, with Abdul-Baki and Anderson formula (1973): SVI = G (%) x SL (cm) /100.
As check was used the winter barley variety Simbol due its high germination under low temperature (G=100% tested at 6°C). The obtained results were the subject of ANOVA, correlation analysis and expressed as minimum, mean and maxim values. The objectives of this study were to investigate the behaviour of seed vigour elements using 2 methods in order to detect the influence of temperature level and identify the barley genotypes with a superior resistance to one of the abiotic stress (low temperature during germination) and if the variation of this could help to perform early selection on winter barley lines.

RESULTS AND DISCUSSIONS

Analysis of variance showed a significant influence of temperature level, genotype and their interaction on germination, root and shoot length (Table 1). Also, as source of variation, the temperature level had a significant influence on length of seedling, Seed Index Vigour and on the interaction between these.

Table 1. ANOVA for germination, root length, shoot length, length of seedling and Seed Index Vigour

Source of variation	Germination		Root length		Shoot length		Length of seedling		Seed Index Vigour	
	F	P-value	F	P-value	F	P-value	F	P-value	F	P-value
Temperature	223.59**	8.2E-31	31.06**	1.2E-07	6.23*	0.014	42.11**	1.30E-09	104.05**	1.00E-18
Genotype	6.84**	1.0E-16	5.56**	1.6E-13	10.77**	4.9E-25	8.49**	5.37E-21	10.74**	1.22E-25
T x G	5.99**	1.3E-14	3.15**	1.1E-06	39.82**	2.1E-56	16.04**	1.67E-34	21.68**	7.81E-42

*significant at a probability level of p<0.05; **significant at a probability level of p<0.01.

The registered minimum value of germination (Figure 1) was 85.0% under 25°C while under 6°C, decreased at 33.0%, the percent of decreasing was very high (67%). This means that the temperature influenced negatively this parameter on many winter barley genotypes.

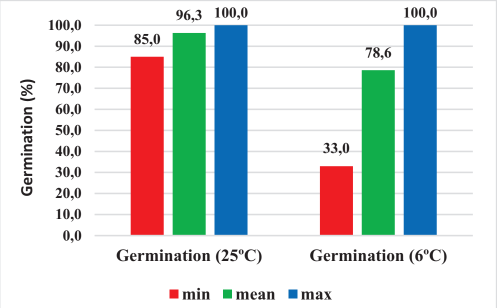

Figure 1. The minimum, mean and maximum value of germination registered under 25°C and 6°C

In Romania, the minimum accepted value for winter barley seed used for sowing, has to be 85.0%. Any variety with germination under this standard is not recommended for sowing and also the price per kg decreased at half (the seeds are used for animal feed).

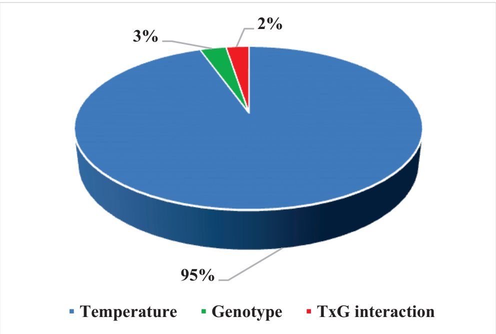

Figure 2. The influence of temperature, genotype and their interaction on germination

The temperature has the biggest influence on the level of germination (95%) while the influence of genotype and the interaction between temperature and genotype is 3% and 2% respectively (Figure 2).

The root length varied between 5.8 and 11.2 cm for first condition and from 7.5 to 10.8 cm in the second condition. We noticed that the minimum value of this parameter had a slightly increasing (1.7 cm), comparing with the registered value under 25°C (Figure 3).

In the case of shoot length, the trend was similar (Figure 3), the minimum value had increased from 4.4 cm (at 25°C) to 9.3 cm (6°C) and the difference between minimum and maximum value was much higher under first condition (14.5 cm) than those between the second condition (8.5 cm).

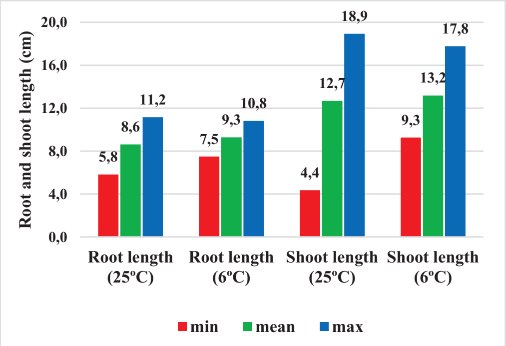

Figure 3. The minimum, mean and maximum value of root and shoot registered under 25°C and 6°C

The temperature, genotype and their interaction were different regarding the root and shoot length (Figures 4 and 5). In the case of root length, the genotype had a higher influence (14%) than the previous parameter (germination) and the influence of temperature still remain important (78%).

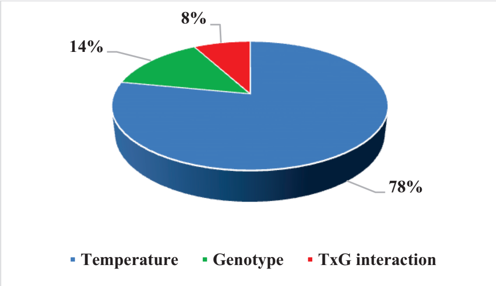

Figure 4. The influence of temperature, genotype and their interaction on root length

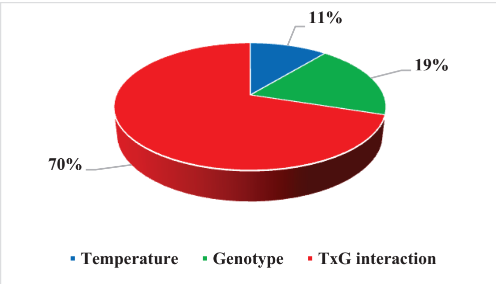

Figure 5. The influence of temperature, genotype and their interaction on shoot length

The shoot length was influenced by the interaction between temperature and genotype (70%) and the contribution of genotype increase at 19%.

The length of seedling oscillated between 13.6 cm and 30.1 cm at first level of tested temperature and from 18.1 cm to 27.8 cm at second level. Also, was noticed a length seedling increasing when the level of tested temperature decreased (Figure 6).

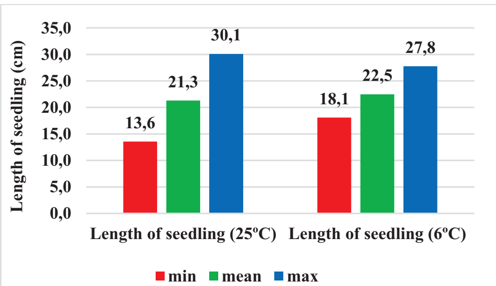

Figure 6. The minimum, mean and maximum value of length of seedling registered under 25°C and 6°C

In Figure 7, it is observed that the level of temperature contribution and studied factors interaction is 63% and 13% respectively.

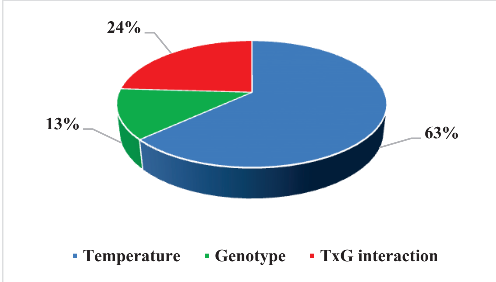

Figure 7. The influence of temperature, genotype and their interaction on length of seedling

The Seed Vigour Index ranged from minimum 13.4 to 29.2 in the first conditions and from 7.2 to 26.1 in the second condition (Figure 8). The analyse of Seed Vigour Index minimum value showed that when the temperature decreased at 6°C, this affected the percent of germination much more for some genotypes than others, resulting a high influence on seed vigour, especially on shoot length (the length is bigger than under the 25°C). According to the level of percent of germination, it is clear that influence of temperature on Seed Index Vigour is high (76%) but the interaction between factors as source of variation, had 16% contribution (Figure 9), higher than the genotype (8%).

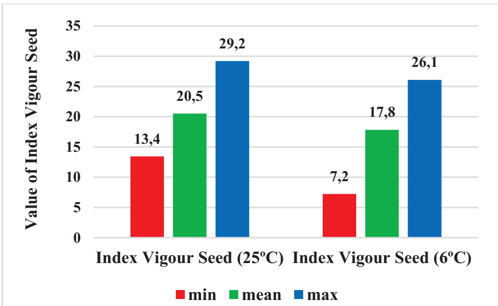

Figure 8. The minimum, mean and maximum value of Index Vigour Seed registered under 25°C and 6°C

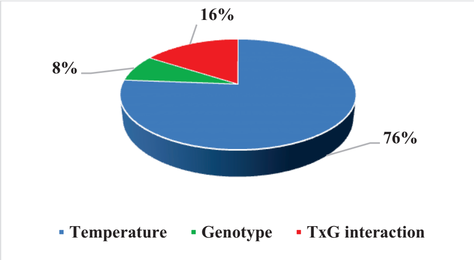

Figure 9. The influence of temperature, genotype and their interaction on Seed Index Vigour

The value of germination (Table 2) under warm condition, ranged from 85 to 100% (Simbol variety had 93%, the mean value was 96.28%) and the line L 383-1 (purple bolded colour), was near germination value limit (85%). Under cold condition ranged from 33 to 97% (Simbol variety had 100% and the mean value was 78.61%) and seventeen genotypes had a germination very low (between 33 and 83%).

Table 2. Experimental data for germination, root and shoot length, length of seedling and Seed Index Vigour

No.	Name of genotype	G (%) 25ºC	G (%) 6ºC	RL (cm) 25ºC	RL (cm) 6ºC	SL (cm) 25ºC	SL (cm) 6ºC	LS (cm) 25ºC	LS (cm) 6ºC	SIV 25ºC	SIV 6ºC
1	**Simbol**	93	100	9.88	9.30	**5.55**	**13.73**	15.43	23.03	**14.5**	**23.0**
2	**L19-10**	97	93	11.14	9.73	11.54	15.19	22.68	24.92	**22.0**	**23.2**
3	**L20-10**	93	96	10.44	9.01	13.37	15.47	23.81	24.48	**22.1**	**23.5**
4	**L9-12**	99	92	9.85	9.73	10.79	15.42	20.64	25.15	**20.4**	**23.1**
5	**L2-12**	95	96	9.32	9.26	12.85	14.97	22.17	24.23	**21.1**	**23.3**
6	**L3-01**	99	97	6.89	9.00	12.63	13.28	19.52	22.28	**19.3**	**21.6**
7	**L1-12**	100	88	7.98	8.73	10.88	13.39	18.86	22.12	**18.9**	**19.5**
8	**L3-12**	91	96	5.82	9.36	11.50	13.70	17.32	23.06	**15.8**	**22.1**
9	**L4-12**	99	97	6.35	10.23	11.70	14.24	18.05	24.47	**17.9**	**23.7**
10	**L5-12**	97	88	6.98	8.36	11.43	12.50	18.41	20.86	**17.9**	**18.4**
11	**L6-12**	97	84	8.52	8.40	11.11	13.81	19.63	22.21	**19.0**	**18.7**
12	**L7-12**	99	93	9.21	8.31	**4.36**	**13.31**	13.57	21.62	**13.4**	**20.1**
13	**L8-12**	100	95	8.36	9.68	11.50	12.75	19.86	22.43	**19.9**	**21.3**
14	**L10-12**	97	89	6.48	9.41	11.62	16.24	18.10	25.65	**17.6**	**22.8**
15	**L11-12**	97	91	8.72	9.34	12.52	14.78	21.24	24.12	**20.6**	**21.9**
16	**L2-13**	97	33	7.04	9.30	12.28	14.11	19.32	23.41	**18.7**	**7.7**
17	**L5-13**	99	41	7.45	8.94	12.06	15.26	19.51	24.20	**19.3**	**9.9**
18	**L6-94**	95	63	9.29	9.32	11.62	15.54	20.91	24.86	**19.9**	**15.7**
19	**L15-15**	99	96	8.85	10.65	12.78	16.52	21.63	27.17	**21.4**	**26.1**
20	**L101-12**	95	96	9.03	9.14	11.24	15.73	20.27	24.87	**19.3**	**23.9**
21	**L333-36**	96	93	6.37	9.99	**8.58**	**17.78**	14.95	27.77	**14.4**	**25.8**
22	**L383-1**	85	64	7.48	9.34	10.43	12.98	17.91	22.32	**15.2**	**14.3**
23	**L201-1**	93	59	7.71	9.15	14.15	9.26	21.86	18.41	**20.3**	**10.9**
24	**L201-2**	93	80	9.29	9.94	17.40	11.51	26.69	21.45	**24.8**	**17.2**
25	**L201-3**	95	36	8.89	9.27	14.69	10.81	23.58	20.08	**22.4**	**7.2**
26	**L201-4**	93	63	10.09	10.13	14.47	10.32	24.56	20.45	**22.8**	**12.9**
27	**L201-5**	97	63	9.96	9.48	14.93	10.81	24.89	20.29	**24.1**	**12.8**
28	**L202-6**	99	72	8.59	9.97	12.18	11.04	20.77	21.01	**20.6**	**15.1**
29	**L600-1**	97	65	8.23	9.27	15.25	12.14	23.48	21.41	**22.8**	**13.9**
30	**L600-4**	99	83	10.46	10.07	16.22	10.26	26.68	20.33	**26.4**	**16.9**
31	**L600-6**	99	80	11.04	9.36	16.28	11.53	27.32	20.89	**27.0**	**16.7**
32	**L600-7**	93	67	9.95	7.87	13.48	11.98	23.43	19.85	**21.8**	**13.3**
33	**L600-9**	100	77	8.25	9.02	16.80	11.34	25.05	20.36	**25.1**	**15.7**
34	**L600-10**	97	64	11.17	10.82	18.93	10.71	30.10	21.53	**29.2**	**13.8**
35	**L600-13**	97	57	8.57	7.49	14.08	10.59	22.65	18.08	**22.0**	**10.3**
36	**L600-14**	95	83	6.89	7.85	15.30	11.47	22.19	19.32	**21.1**	**16.0**
Mean		**96.28**	**78.61**	**8.63**	**9.28**	**12.68**	**13.18**	**21.31**	**22.46**	**20.52**	**17.84**
LSD (5%)		**8.67**		**1.05**		**0.80**		**1.42**		**1.86**	

G (%) – germination; RL (cm) – root length; SL (cm) – shoot length; LS (cm) – length of seedling; SVI – Seed Index Vigour

Table 3. Correlations between germination, root and shoot length, length of seedling and Seed Index Vigour

Parameters	G 25ºC	G 6ºC	RL 25ºC	RL 6ºC	SL 25ºC	SL 6ºC	LS 25ºC	L S6ºC	SIV 25ºC	SIV 6ºC
G 25ºC	1									
G 6ºC	0.18	1								
RL 25ºC	0.08	-0.05	1							
RL 6ºC	0.08	0.11	0.21	1						
SL 25ºC	-0.02	-0.33^{o}	0.36*	0.21	1					
SL 6ºC	0.07	0.44**	-0.24	0.14	-0.59^{ooo}	1				
LS 25ºC	0.02	-0.27	0.70***	0.25	0.92***	-0.55^{ooo}	1			
LS 6ºC	0.09	0.44**	-0.15	0.44**	-0.47^{ooo}	0.95***	-0.42^{oo}	1		
SIV 25ºC	0.20	-0.23	0.69***	0.27	0.90***	-0.53^{ooo}	0.98***	-0.40^{o}	1	
SIV 6ºC	0.17	0.95***	-0.08	0.25	-0.42^{oo}	0.68***	-0.36^{o}	0.70***	-0.32	1

G (%) – germination; RL (cm) – root length; SL (cm) – shoot length; LS (cm) –length of seedling; SIV – Seed Index Vigour

The mean value of the root, shoot and seedling length was higher at 6°C comparing 25°C. We noticed an increase tendency of root, shoot and seedling length with 1.65, 0.50 and 1.35 units respectively. The value of Seed Index Vigour was in average higher under warm condition, difference between the obtained values being 2.68.

It has to be mentioned that some genotypes had a similar behaviour (black bolded colour) under both testing conditions, some of them registered a higher seed index vigour at 6°C than under 25°C (green bolded colour) and several had a lower SIV under the second condition due to a very low germination (red bolded colour).

From the total of tested genotypes, 11 winter barley lines (green bolded colour) had presented a higher seed index vigour under cold condition (similar to check) due to a better shoot developed. Two winter barley lines were remarked due a lowest shoot length value (4.36 and 8.58 cm, blue bolded values) under warm condition, one of them having a higher value (17.78 cm) than check (13.73 cm), when the temperature was low.

The obtained results of correlation coefficient are presented in Table 3, where the germination at 25°C is not correlated with any of seed studied vigour elements, while the germination at 6°C showed distinct significant positive correlation with shoot length, length of seedling and very significant with Seed Index Vigour (0.95***) value at 6°C. A low temperature influenced negatively the shoot length (-0.33°). A higher temperature (25°C) can positively influence the root length in relationship with shoot length, length of seedling and Seed Index Vigour, while at low temperature (6°C), only the root length is positively influenced. The shoot length is differently influenced by the level of temperature, being a strong correlation between this vigour seed element, length of seedling and respectively Seed Index Vigour (0.92*** and 0.90***) at 25°C. Almost the same correlations was at 6°C between these elements (0.98*** and 0.68***), which showed a higher contribution at length of seedling and also to Seed Index Vigour. The length of seedling had a significant role in the Seed Index Vigour final value, considering the strong positively correlation with this.

CONCLUSIONS

Evaluation and analysis of winter barley breeding lines showed that germination (G) and root length (RL) are mainly temperature dependent and shoot length (SL) is highly dependent by the TxG interaction.

Increase seed index vigour (SIV) means an improved seedling response to different temperatures and therefore fast emergence and increased yield. The genotype has a higher influence in developing of root (14%) and shoot (19%), but seed index vigour is influenced by the temperature during the germination (76%).

Based on the described behaviour in the mentioned conditions, it can know that a winter barley variety have a fast emergence under warm or cold conditions.

These results showed that implementation and using these methods in early generation study for seed vigour (especially cold test method) may be very usefully for barley breeder work selection and therefore to breed improved winter barley varieties which performed better under future Romania climate changes.

REFERENCES

Abdul-Baki, A.A., and Anderson, J.D. (1973). Vigour determination in soybean seed by multiple criteria. *Crop Science, 13*, 630–633.

Adebisi, M.A., Okelola, F.S., Alake, C.O., Ayo-Vaughan, M.A., Ajala, M.O. (2010). Interrelationship between seed vigour traits and field performance in new rice for Africa (Nerica) genotypes (*Oryza sativa* L.). *Journal of Agricultural Science and Environment*, *10*(2), 15–24.

International Seed Testing Association. (2006). *ISTA Handbook on Seedling Evaluation*, second ed. International Seed Testing Association, Zurich, Switzerland.

Kim, S.H., Bin, Y.H., Choe, Z.R. (1989). The use of multiple seed vigour indices to predict field emergence and grain yield of naked and malting barley. *Korean Journal Crop Science*, *34*(2), 134–141.

Kim, S.H., Choe, Z.R., Kang, J.H., Copeland, L.O., Elias, S.G. (1994). Multiple seed vigour indices to predict field emergence and performance of barley. *Seed Science and Technology*, *22*, 29–68.

Mishra, A., Kumar, V., Sharma, A.D., Srinivasan, K. (2017). Evaluation of Seed Quality of Barley Varieties through Controlled Deterioration Test. *International Journal of Current Microbiology and Applied Sciences, 6*(6), 3123–3131. ISSN: 2319-7706 .

Perry, D.A. (1973). Interacting effects of seed vigour and environment on seedling establishment. *In: W. Heydecker, Ed., Seed Ecology, Penn. State Univ. Press*, 311–324. University Park,

Stan, O., Petcu, E., Antohe, I., Stan, C. (2008). Caracterizarea vigorii unor hibrizi de porumb prin metoda Cold test 6°C. *Analele I.N.C.D.A. Fundulea*, *LXXVI*, 43–52.

Stan, O., Martura, T., Partal, E., Iordan, H. (2016). Estimarea însușirilor de calitate și vigoare la sământa noilor genotipuri de porumb, prin metoda coldtest și deteriorare controlată. *Analele I.N.C.D.A. Fundulea*, *LXXXIV*. 141–156.

Wen, D., Hou, H., Meng, A., Meng, J., Xie, L., Zhang, C. (2018). Rapid evaluation of seed vigour by the absolute content of protein in seed within the same crop. *Scientific Reports*, *8*, 55–69.

MISCELLANEOUS