International Journal of Agriculture, Environment and Biotechnology
Citation: *IJAEB*: **16**(01): 13-20, March 2023
DOI: 10.30954/0974-1712.01.2023.3

ASSOCIATION FOR AGRICULTURE ENVIRONMENT AND BIOTECHNOLOGY

RESEARCH PAPER

Evaluation of Seed Vigour Tests to Predict Field Emergence Potential of Finger Millet [*Eleusine coracana* (L.) Gaertn.] and Barnyard Millet [*Echinochloa frumentacea* (Roxb.) Link.] Varieties

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Paper No. 1068 **Received:** 19-11-2022 **Revised:** 28-02-2023 **Accepted:** 05-03-2023

ABSTRACT

The present study was conducted to evaluate seed vigour tests to predict the field emergence potential of finger millet and barnyard millet varieties. The three varieties each of finger millet and barnyard millet were evaluated in laboratory by different physical, physiological and biochemical vigour tests. The laboratory experiments were laid out in complete randomized design and the field emergence evaluation was carried out in randomized block design with four replications. The variety PRM-2 of finger millet and PRB-903 of barnyard millet were assessed as more vigorous than other varieties. PRM-2 of finger millet and PRB-903 of barnyard millet recorded significantly higher field emergence than other varieties. The correlation coefficient of test weight, final count, standard germination, seedling vigour index I and relative growth index were found significantly correlated with field emergence in both finger millet and barnyard millet. The correlation coefficient of test weight (r = 0.859** in finger millet and r = 0.807** in barnyard millet) and seedling vigour index I (r = 0.990** in finger millet and r = 0.999** in barnyard millet) were recorded highly significant with field emergence. Therefore, test weight and seedling vigour index I were able to predict field emergence potential of finger millet and barnyard millet.

HIGHLIGHTS

- Finger millet and barnyard millet is one of the most popular traditional crop in Garhwal Himalayan region of Uttarakhand.
- To predict field potential under laboratory condition test weight and seedling vigour index I might be a good approach.

Keywords: Barnyard millet, field emergence, finger millet, vigour test, SVI I, Test weight

The good quality seeds are the prime requirement for the better crop production and productivity. The quality seed possesses various characteristics i.e. improved variety, genetic purity, physical purity, seed germination and vigour, planting value, free

How to cite this article: Rawat, A., Kumar, A., Paliwal, A., Kumar, P. and Rawat, D. (2023). Evaluation of Seed Vigour Tests to Predict Field Emergence Potential of Finger Millet [*Eleusine coracana* (L.) Gaertn.] and Barnyard Millet [*Echinochloa frumentacea* (Roxb.) Link.] Varieties. *Int. J. Ag. Env. Biotech.*, **16**(01): 13-20.

Source of Support: None; **Conflict of Interest:** None

from weed seed and other crop seed, moisture content and seed health (Agarwal, 1980; Lopes *et al.* 2017). The increasing demand for food in the whole earth and the impact of climate change on food production will causes the greater demands on seed quality to ensure successful crop establishment. Increased stress in the soil environment as a result of drought, high temperature or erratic rainfall can impact on seed performance. In such circumstances, use of high vigour seeds will improve the ability to respond to, and overcome, stress in the soil environment, leading to successful establishment (Reed *et al.* 2022). But, nowadays the most important constraint is non availability of quality seeds. As to assess seed quality, standard germination test under laboratory condition is right method (ISTA, 2017) .The finger millet and the barnyard millet are dominant crop among *Kharif* season crops of hilly region of Garhwal and Kumaon region of Uttarakhand. The low seed production and low seed replacement ratio of these crops are the major problem in Uttarakhand (Anonymous, 2007a, Anonymous, 2007b). Seed deterioration is inevitable during storage period, which leads to reduction in loss in seed vigour (McDonald, 1999). The reduction in the seed vigour during storage affects the production, productivity and performance of a crop (Rodo and Marcos-Filho, 2003; Rao *et al.* 2006; Feda *et al.* 2018). Therefore, seed vigour is one of the common methods to determine the quality seed because seed vigour is an important aspect of seed quality (Foolad *et al.* 2007; Shinohara *et al*. 2021), which is defined as the sum total of those properties of the seed which determine the level of activity and the performance of a seed or seed lot during germination and seedling emergence (Sun et al. 2007; Anonymous, 2022). To be effective and reliable in predicting vigour, any test must be repeatable and reproducible, a requirement that is satisfied by the vigour tests described for species in the ISTA Rules (2022) and measurement of physiological potential (Marhino *et al.* 2019). The potential performance of seed lot in the field conditions can be determined with the help of physical vigour tests viz. test weight and seed density, physiological vigour tests viz. standard germination, seedling fresh weight, seedling dry weight, seedling vigour index I, seedling vigour index II, cool test, cold test (Marcos Filho, 2015) and biochemical vigour tests viz. accelerated ageing and electrical conductivity test. The principle objective of vigour test is to assess vigorousness of seed to achieve high seedling emergence and optimum plant establishment under a favorable environment (Ghassemi-Golezani, 2008; Khajeh-Hosseini *et al.* 2009; Khajeh-Hosseini *et al.* 2010; Mavi *et al.* 2014).The principle objective of seed vigour test is also to differentiate the quality seed in ranges such as high, medium and low. The seed lot which is highly vigorous improves the yield of a crop because seedling emergence is rapid and uniform (Finch-savage and Bassel, 2016; Parihar *et al.* 2022). The seed quality tests which are correlated with field emergence can be used to predict field emergence (Kolasinskan *et al.* 2000; Ermis *et al.* 2015; Lv *et al.* 2016). The ability of vigour tests to predict the field emergence is variable and strongly depends on the vigour (TeKrony and Egli, 1991). The vigour test should be crop specific and/or a combination of methods may be preferred in specific cases (Agarwal, 1993). The very limited information is available about vigour tests which are suitable to predict the field emergence potential of finger millet and barnyard millet. Therefore, the present study was attempted to evaluate the vigour test to predict field emergence potential of finger millet and barnyard millet varieties with three objectives to study the vigorousness of different varieties of finger millet and barnyard millet; to find the suitable vigour test for finger millet and barnyard millet and; to establish the relationship between seed vigour tests and field emergence level in finger millet and barnyard millet.

MATERIALS AND METHODS

The studies pertaining to seed vigour tests and field emergence were conducted at College of Forestry, V.C.S.G Uttarakhand University of Horticulture and Forestry, Ranichauri, Tehri Garhwal, Uttarakhand, India during 2019-20.The experiment contained three varieties of finger millet *viz.* PRM-1, PRM-2 and VL-352 and three of barnyard millet *viz.* PRB-903, VL-207 and PRJ-1 were taken for evaluation of vigour tests for both the crops. The seed samples were hand sorted, cleaned thoroughly and tested for moisture content and physical purity. These seeds were stored in steel containers. The four replications of laboratory and field experiments were laid out in complete randomized design and randomized block design respectively. The following laboratory vigour tests were conducted into three categories *i.e.* physical test (test weight and seed density), physiological tests (first count, final count, standard germination, seedling shoot length, seedling root length, seedling total length, seedling fresh weight, seedling dry weight, seedling vigour index I, seedling vigour index II, speed of germination, relative growth index, paper piercing test, cool test, mean daily germination and radical emergence) and biochemical test (accelerated ageing test and electrical conductivity test). The physical tests like test weight and seed density were performed according to the procedure described by ISTA (2007).

The physiological test like first count, final count and standard germination percentage were conducted according to ISTA (2007) procedure; seeds were incubated in seed germinator at 24˚C temperature and first count was taken on 4th day for both finger millet and barnyard millet while the final count and standard germination were recorded on 8th day for finger millet and 10th day for barnyard millet. The mean of 10 normal seedlings were taken for seedling shoot length, seedling root length, total seedling length, seedling fresh weight and seedling dry weight at the time of final count day. For seedling dry weight, the seedlings were dried at 80±1˚C for 5 hours in oven. Seedling vigour index I and II were calculated by using formula given by Abdul-Baki and Anderson (1973). The experiment to determine speed of germination was conducted by protocols and method given by Maguire (1962) and relative growth index was determined by method given by Brown and Mayer (1986). For conducting paper piercing test,steel trays were taken containing 1.5cm moist soil in the bottom of tray, then the seeds were placed and then piercing paper and then at the top of tray again 3cm moist soil placed. The trays were kept in incubator at 26˚C±1˚C temperature till 8 days for finger millet and till 10 days for barnyard millet to record germination. The procedure for cool test was followed according to ISTA (1995) and germination percentage was calculated on 8th day for finger millet and 10th day for barnyard millet. Mean daily germination was recorded by final germination (%) dividing by final count day. Radical emergence was estimated by following the method given in ISTA (2012).

The accelerated ageing test method was performed by following procedure stated by Abdul-Baki and Anderson (1973).The electrical conductivity test was conducted according to Agarwal (1993) and the mean values were expressed in micro Siemens per centimeter (μS/cm).

The field emergence of each variety of both the crop were recorded on 15th day and expressed in percentage. The 20 seeds of one variety were sown in each row and one treatment consists 5 rows. The field emergence was calculated by dividing number of seedlings emerged by total number of seeds sown and multiplied by hundred.

The data recorded from different experiments were subjected to statistical analysis by using STPR3 designed by Department of Mathematics and Statistics of GBPUA&T, Pantnagar. The correlation analyses were done through OPSTAT program of Hissar Agriculture University (Sheron *et al.*, 1998).

RESULTS AND DISCUSSION

The vigorousness of six varieties were evaluated under laboratory condition through different vigour tests (Table 1). Among the physical tests, test weight and seed density were performed and found higher in PRM-2 of finger millet and PRB-903 of barnyard millet. The mean of test weight and seed density of barnyard millet varieties were recorded higher than the finger millet varieties. The finger millet variety PRM-2 and barnyard millet variety PRB-903 were recorded significantly higher in test weight and seed density than VL-352 and VL-207 respectively. The smaller seed size leads to less food reserve available at the time of germination in comparison to larger seed size (Cao *et al.* 2011). The more test weight and seed density produced larger embryos and exhibited faster germination and greater field emergence than small seeded.

Among the physiological vigour tests, the first count, final count and standard germination of barnyard millet were recorded higher than finger millet because the mean test weight of barnyard millet varieties were higher than mean test weight of finger millet varieties. The PRM-2 of finger millet and PRB-903 of barnyard millet were recorded significantly higher first count, final count and standard germination than VL-352 of finger millet and VL-207 of barnyard millet due to higher speed

Table 1: Performance of finger millet and barnyard millet varieties in relation to vigour tests and field emergence

Tests	Finger Millet			Barnyard Millet			CD	P value
	PRM-1	PRM-2	VL-352	PRB-903	VL-207	PRJ-1		
Test weight (g)	2.85	2.95	2.52	3.90	3.60	3.85	0.25	**
Seed density (g/cc)	0.53	0.54	0.50	0.63	0.59	0.61	0.68	**
First count (%)	91.00	95.25	79.00	97	82.50	94.50	6.08	**
Final count (%)	92.00	96.75	83.25	97.75	84.00	95.25	6.83	**
Standard germination (%)	91.75	96.25	80.50	97.75	81.25	94.25	6.79	**
Seedling shoot length (cm)	4.76	4.80	4.71	9.55	9.32	9.48	0.74	**
Seedling root length (cm)	7.40	7.95	7.06	6.49	6.13	6.32	0.96	**
Total seedling length (cm)	12.07	12.74	11.77	16.05	15.45	15.80	1.44	**
Seedling fresh weight (mg)	2.87	2.90	2.85	3.06	3.02	3.04		NS
Seedling dry weight (mg)	0.29	0.35	0.26	0.37	0.28	0.34	0.72	*
Seedling vigour index I	1025.42	1226.72	946.32	1569.97	1256.52	1490.03	159.79	*
Seedling vigour index II	27.32	33.76	21.44	36.40	22.83	32.26	9.84	*
Speed of germination	33.82	37.42	30.80	37.67	31.40	36.72	4.67	**
Relative growth index (%)	98.89	98.96	97.96	98.96	95.21	98.87	2.57	*
Paper piercing test (%)	56.75	70.50	54.50	72.00	57.75	60.25	13.19	**
Cool test (%)	86.85	90.25	79.50	90.75	84.25	87.00	5.99	**
Mean daily germination	11.46	11.90	10.49	9.82	8.90	9.57	0.64	**
Radical emergence (%)	86.50	89.75	70.50	90.75	74.25	88.50	6.70	**
Accelerated ageing test (%)	97.25	93.75	85.50	97.00	95.25	96.75	6.10	**
Electrical conductivity test (μS/cm)	43.62	39.82	45.07	33.32	35.81	34.95	3.97	**
Field emergence (%)	81.87	83.75	68.12	88.12	66.12	77.62	11.31	**

**Significant at 5% (p=0.05) and **Significant at 1% (p= 0.01).*

of germination in case of barnyard millet. The higher speed of germination might be due to enhanced metabolites activity at the time of germination (Delouche, 1974). The vigourous seed has high speed of germination (Carmago and Vaughan, 1973). The seedling shoot length and total seedling length of barnyard millet was exhibited higher than seedling shoot length of finger millet because of higher test weight/ seed size of barnyard millet. But the root length of finger millet was recorded higher than barnyard millet varieties it might be due to ethylene inhibit the auxin transportation in both shoot and root. Therefore, ethylene inhibited the growth of root through accumulation of auxin in barnyard millet (Marchant *et al.* 1999). PRM-2 of finger millet recorded maximum seedling root length and minimum in VL-352. Among barnyard millet varieties, PRB-903 recorded maximum seedling root length and minimum in VL-207.The seedling fresh weight and dry weight of barnyard millet was recorded higher than finger millet. The seedling fresh weight and dry weight of finger millet in PRM-2 exhibited higher than VL-352 while, in case of barnyard millet PRB-903 recorded higher than VL-207. It might be due to seed quality attributes like seedling shoot length; seedling root length, seedling length, seedling fresh weight and seedling dry weight were found highest in high vigour seeds and high mobilization of food reserve during seedling growth (Nautiyal *et al.* 1990). The seedling vigour index I and seedling vigour index II were recorded significantly higher in PRM-1 of finger millet and PRB-903 of barnyard millet in comparison to VL-352 of finger millet and VL-207 of barnyard millet. The lower seedling vigour index in VL-352 and VL-207 was mainly due to lower germination percentage; seedling length and seedling dry weight. The result was close conformity with Alison *et al.* (2000) in cabbage. The relative growth index of barnyard millet was recorded higher than finger millet. Among finger millet varieties PRM-2 recorded significantly higher relative growth index than VL-352 and in case of, barnyard millet PRB-903 recorded significantly higher relative growth index than VL-207. It might be due to early germination of PRB-903 and PRM-2 that lead to increased relative growth index. Relative growth index also depends on genetic make-up of the variety and mass of seed (Swanborough and Westoby, 1996). The germination percentage under paper piercing test was recorded significantly higher in PRM-2 of finger millet and PRB-903 of barnyard millet than VL-352 of finger millet and VL-207 of barnyard millet. Therefore, PRM-2 and PRB-903 might be considered as more vigorous because seedlingsof these varieties were able to penetrate the paper. The result was close conformity with the Fritz 1965). The PRM-2 of finger millet recorded significantly higher cool germination percentage than VL-352. PRB-903 of barnyard millet also recorded significantly higher cool germination percentage than VL-207. The mean daily germination of finger millet varieties was recorded higher than barnyard millet because in finger millet the final count day was on 8th day while in barnyard millet final count day was on 10th day according to ISTA (2007). The higher radical emergence of PRB-903 and PRM-2 was might be due to less time for metabolic repair, DNA repair and enzymatic synthesis before the radical emergence (Matthews and Powell, 2012).

The accelerated ageing germination test of barnyard millet recorded higher than finger millet. The germination percentage of barnyard millet variety PRB-903 and finger millet PRM-2 under accelerated ageing test were registered almost similar germination percentage in comparison to standard germination. It might be due to more number of mature seeds and very less deterioration of food reserve over the period of time in these varieties. The electric conductivity in PRM-2 of finger millet and PRB-903 of barnyard millet was lower than the VL-352 of finger millet and VL-207 of barnyard millet. The lower electric conductivity might be due to the less membrane permeability in case of PRM-2 and PRB-903. The loss of selective permeability of cell wall by auto-oxidation of polyunsaturated fatty acid, free radical per oxidation via auto-oxidation, lipo-oxygenase and hydrolytic damage leads to more deterioration of food reserve which result more electrolyte in seed leachate (Coolbear *et al.* 1984).

The field emergence percentage of finger millet variety PRM-2 was found significantly higher than VL-352 and statistically on par with PRM-1. In case of barnyard millet, PRB-903 was recorded significantly higher field emergence than VL-207 and statistically at par with PRJ-1.

The correlation studies among laboratory vigour tests and field emergence were performed to predict the potential field emergence (Table 2). The test weight showed positive and significant correlation (r = 0.859** for finger millet and r = 0.807** for barnyard

Table 2: Comparison of vigour tests against field emergence in finger millet and barnyard millet varieties

Vigour tests	Correlation coefficient		P value	
	Finger millet	Barnyard millet	Finger millet	Barnyard millet
Test weight (g)	0.859	0.807	**	**
Seed density (g/cc)	0.417	0.348	**	**
First count (%)	0.310	0.257	**	**
Final count (%)	0.566	0.523	**	**
Standard germination (%)	0.525	0.542	**	**
Seedling shoot length (cm)	0.161	0.109	**	NS
Seedling root length (cm)	0.234	0.159	**	**
Total seedling length (cm)	0.575	0.526	**	**
Seedling fresh weight (mg)	0.088	0.060	NS	NS
Seedling dry weight (mg)	0.068	0.046	NS	NS
Seedling vigour index I	0.990	0.999	**	**
Seedling vigour index II	0.457	0.406	**	**
Speed of germination	0.274	0.254	**	**
Relative growth index (%)	0.538	0.502	**	**
Paper piercing test (%)	0.492	0.530	**	**
Cool test (%)	0.160	0.110	**	NS
Mean daily germination	0.226	0.167	**	**
Radical emergence (%)	0.580	0.489	**	**
Accelerated ageing test (%)	0.107	0.074	NS	NS
Electrical conductivity test (μS/cm)	0.088	0.053	NS	NS

***Significant level p= 0.01 and NS = non-significant.*

millet) with field emergence. The result was close conformity with Roy *et al.* 1996 in rice, Cookson *et al.* 2001 in wheat, Peksen *et al.* 2004 in pea and Ndor *et al.* 2012 in pumpkin. The seed density and first count showed non-significant relationship with field emergence. Similar finding was also reported by Shakuntala *et al.* (2007) in chili seeds. The final count (r = 0.566** in finger millet and r = 0.523** in barnyard millet) and standard germination (r = 0.525** in finger millet and r = 0.542** in barnyard millet) were correlated with field emergence. The same findings were reported by Aliloo and Shokati (2011) in two maize hybrids (SC704 and SC500) and Yousof *et al.* (2016) in onion. The seedling shoot length, seedling root length, seedling fresh weight and seedling dry weight were not found highly significant correlation with field emergence while total seedling length was recorded correlation with field emergence. The seedling vigour index I was recorded highly significant correlation (r = 0.990** in finger millet and r = 0.999** in barnyard millet) with field emergence. The same findings were reported by Adebisi *et al*. 2010 in rice and Olasan *et al.* 2018 in groundnut. While, the seedling vigour index II was recorded lower correlation coefficient (r = 0.457** for finger millet and r = 0.406** for barnyard millet) with field emergence. The significant positive correlation of finger millet (r = 0.538**) and barnyard millet (r = 0.502**) were registered in relative growth index with field emergence. The paper piercing test of both finger millet and barnyard millet were correlated with field emergence. The correlation between paper piercing test and field emergence was also reported by Pandita *et al*. (2014) in okra seeds. The cool test and mean daily germination of finger millet and barnyard millet were showed non-significant correlation with field emergence. The radical emergence of finger millet (r = 0.580**) and barnyard millet (r = 0.489**) was correlated with field emergence. The similar findings were also reported by Siviritepe *et al.* (2016) in maize seed and Ermis *et al.* (2015) in leek seeds.

Among the biochemical test, accelerated ageing test and electrical conductivity test were registered non-significant correlation with field emergence. Peksen (2007) revealed that electrical conductivity test results were not related to speed of germination, germination power and field emergence percentage. The correlation study revealed that seedling vigour index I and test weight were found significantly and positively correlated with field emergence in finger millet and barnyard millet.

CONCLUSION

Our data indicates that finger millet variety PRM-2 and barnyard millet variety PRB-903 were found more vigorous than other varieties. Among the vigour tests, seedling vigour index I and test weight were found most reliable predicator of field emergence for finger millet and barnyard millet. Since, these findings are based on one year data, investigation need to be further validated before future use.

ACKNOWLEDGEMENTS

This research work is supported by College of Forestry, V.C.S.G Uttarakhand University of Horticulture and Forestry, Ranichauri, Tehri Garhwal, Uttarakhand. The authors are thankful to college for providing essential equipments and helpful nature shown by each person during research.

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