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# Correlation and Regression Analysis of Various Viability and Vigour Parameters in Pearl millet [*Pennisetum glaucum* (L.) R. Br.]

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**ABSTRACT:** Pearl millet is a small seeded crop which is chiefly grown in the *Kharif* season that is characterised by severe weather conditions. Therefore, uniform and good field emergence is very crucial for the success of the crop. A study was conducted to determine the correlation among various seed viability/ vigour parameters and their ability to predict the field emergence of forty-two genotypes of pearl millet, comprising of hybrids, their parents and other inbred lines. Nine seed vigour parameters *viz.* standard germination, test weight, seedling length, seedling dry weight, vigour index I, vigour index II, accelerated ageing test, electrical conductivity and field emergence were observed and the correlation between these parameters were calculated. Results revealed that all the seed vigour parameters significantly and positively correlated with each other except electrical conductivity, which showed negative correlation. Regression analysis was also performed for prediction of field emergence, with the help of other seed vigour parameters. Estimated mean of field emergence obtained by various viability and vigour parameters were at par with the actual value obtained. The maximum value of coefficient of regression (0.937) was obtained for standard germination, indicating the reliability of this test, followed by electrical conductivity (0.821), vigour index-I (0.743), vigour index-II (0.641) and accelerated ageing (0.559), as these tests were found to be highly correlated with field emergence.

**Key words:** Pearl millet, Hybrids, Inbreds, Seed vigour, Regression

## INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.], can be successfully grown in arid and semi-arid regions of the world that are characterized by low precipitation and less fertile sandy soils. India is the largest producer of pearl millet, both in terms of land (7.38 million ha) and yield (9.18 million tonnes), with a productivity of 1255 kg $ha^{-1}$ [1]. It is a small seeded crop and commonly grows in the harsh environmental conditions. Therefore, uniform germination in the field is very critical for a good plant stand and flourishing crop. In most crops, if seedling emergence is inadequate, total crop yield will be reduced [2] and no amount of effort or inputs during later crop development will compensate for this effect. Irregularity in seedling establishment is a major constraint in pearl millet production and high seed vigour therefore, contributes directly to the economic success of this crop.

Determination of seed quality and its vigour potential, indicates which seed lot can be sown in the field, and for that reason it is very important to assess the quality and vigour of the seed. Good seedling establishment is essential for crop production, to be both sustainable and profitable and is therefore, widely accepted as a critically important trait for farmers. So, great importance is given to the predictability of field emergence of seeds, which is influenced directly by seed vigour.

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Two types of methods are commonly used for detection of seed vigour: one is by measuring the seed germination related parameters like standard germination percentage, seedling length, seedling weight, vigour indices etc. and another is through detecting the stress bearing ability and biochemical vigour indicators of seed. Testing of seed performance using different seed vigour tests is very significant, since vigour tests give results, which are often better correlated with the results of field germination under unfavourable environmental conditions [3].

## MATERIALS AND METHODS

The seed material comprised of forty-two genotypes and was obtained from, Department of Genetics and Plant Breeding, C.C.S. Haryana Agricultural University, Hisar, in October, 2014. The vigour potential of these seeds was assessed by recording nine parameters *viz.* test weight, standard germination, seedling length, seedling dry weight, vigour index I, vigour index II, accelerated ageing test, electrical conductivity and field emergence. All these parameters were calculated in three replications.

For test weight, samples of 1000 seeds were taken out for each inbred and weighed. Standard germination test was conducted using between paper (BP) method. One hundred seeds of each variety, in three replications, were placed in between moistened rolled towel papers and kept at 25°C in seed germinator. The final count was taken on 7th day and normal seedlings were considered for calculating per cent germination [4].

Seedling length (root + shoot) was measured on ten randomly selected normal seedlings taken from three replications of standard germination and recorded in centimetres. Average of the ten seedlings was taken for final calculation. These ten seedlings whose length was measured, were dried in hot air oven for 24 hours at 80 ±1ÚC. The dried seedlings of each replication were weighed and average seedling dry weight of each genotype was calculated and expressed in milligrams. The seedling vigour indices were calculated [5] as follows:

Vigour Index-I = Standard germination (%) × Average seedling length (cm)

Vigour Index-II = Standard germination (%) × Average seedling dry weight (mg)

For accelerated ageing test, seeds were placed in a single layer on the wire mesh trays fitted in plastic boxes. Each box contained about 40 ml of distilled water. The boxes were placed in ageing chamber after closing their lids. The seeds were aged at 40 ± 1ºC and 100% relative humidity for 48 hours and tested for germination in three replications of 100 seeds for each genotype. The number of normal seedlings were counted on 7th day and expressed in percentage.

Electrical conductivity of the seed leachates was measured to know the status of membrane permeability. Fifty normal and undamaged seeds of each genotype were taken randomly (replicated thrice) and soaked in 100 ml beakers, each containing 75 ml of distilled water. The seeds were immersed completely in water and beakers were covered with aluminium foil. Thereafter, these samples were kept at 25°C for 24 hours. The electrical conductivity of seed leachates was measured by conductivity meter [4] and expressed in mS/cm/seed.

Field emergence was recorded by sowing 100 seeds of all genotypes in three replications in a Randomized Block Design (RBD) in the experimental field of Department of Seed Science & Technology in July, 2015. The seeds were sown in sandy loam soil containing 13% moisture content at a depth of 5 cm. The field emergence was determined by counting the total number of seedlings when the emergence was completed or when there was no further addition in total emergence.

The factorial experiment in Completely Randomized Design (CRD) as well as in Randomized Block Design (RBD) has been conducted for laboratory and field parameters, respectively. The data obtained from experiments conducted in CRD and RBD were analyzed as per standard methods [6].

The correlation and regression analysis was done by using OPSTAT online statistical software. The regression analysis was done by taking field emergence (%) as dependent parameter and all the remaining parameters as independent ones. The regression equations between different parameters were estimated as per the formula given below:

$$Y = a + bX$$

Where,

Y = dependent variable

X = independent variable

a = constant

b = regression coefficient

## RESULTS AND DISCUSSION

The data representing the correlation coefficient among different seed vigour parameters has been furnished in the Table 2. It is evident from the data that test weight, seedling length, seedling

**Table 1. List of genotypes used for the study**

| S.No. | Name of genotype | Origin | S.No. | Name of genotype | Origin |
|---|---|---|---|---|---|
| 1. | HPT-10-144 | CCSHAU | 22. | PT-1-10-1021 | CCSHAU |
| 2. | PT-1-10-1047 | CCSHAU | 23. | TPT-A2-1-11-101 | CCSHAU |
| 3. | RAJ 3 | CCSHAU | 24. | WHC 901-445 | CCSHAU |
| 4. | TCP-10-110 | CCSHAU | 25. | A5R-10-205 | CCSHAU |
| 5. | TCP-10-124 | CCSHAU | 26. | HPT-1-12-189 | CCSHAU |
| 6. | HPT-10-129 | CCSHAU | 27. | HPT-2-12-59 | CCSHAU |
| 7. | (96111B×4025-3-2-B)-1-6-1 | ICRISAT | 28. | SGP-10-108 | CCSHAU |
| 8. | HPT-2-12-10 | CCSHAU | 29. | TPT-A1-1-11-137 | CCSHAU |
| 9. | HTP 94/54 | CCSHAU | 30. | HPT-1-12-44 | CCSHAU |
| 10. | MP 293-4 | CCSHAU | 31. | HPT-2-12-48 | CCSHAU |
| 11. | HFIT-3-11-125 | CCSHAU | 32. | HPT-1-12-90 | CCSHAU |
| 12. | HPT-2-12-32 | CCSHAU | 33. | TPT-A2-1-11-155 | CCSHAU |
| 13. | PT-1-10-1002 | CCSHAU | 34. | A5R-10-119 | CCSHAU |
| 14. | PT-1-10-1131 | CCSHAU | 35. | HHB 234 | CCSHAU |
| 15. | PT-2-10-173 | CCSHAU | 36. | HHB 226 | CCSHAU |
| 16. | TPT-A2-1-11-121 | CCSHAU | 37. | HHB 223 | CCSHAU |
| 17. | HPT-1-12-84 | CCSHAU | 38. | HMS-7A | CCSHAU |
| 18. | (D2BLN95-107×EEBC-1-1)-6-B | ICRISAT | 39. | ICMA 843-22 | CCSHAU |
| 19. | EMRT-11-104 | CCSHAU | 40. | ICMA 94555 | CCSHAU |
| 20. | HFPT-2-11-119 | CCSHAU | 41. | H77/833-2-202 | CCSHAU |
| 21. | HTP 92/80 | CCSHAU | 42. | HBL 11 | CCSHAU |

**Table 2: Correlation coefficients (r) for viability and vigour parameters of pearl millet genotypes.**

| | SG | TW | SL | SDW | VI-I | VI-II | AA | EC | FE |
|---|---|---|---|---|---|---|---|---|---|
| **SG** | 1.000 | | | | | | | | |
| **TW** | 0.365* | 1.000 | | | | | | | |
| **SL** | 0.403** | 0.507** | 1.000 | | | | | | |
| **SDW** | 0.384* | 0.736** | 0.825** | 1.000 | | | | | |
| **VI-I** | 0.854** | 0.528** | 0.813** | 0.710** | 1.000 | | | | |
| **VI-II** | 0.768** | 0.708** | 0.770** | 0.879** | 0.926** | 1.000 | | | |
| **AA** | 0.771** | 0.342* | 0.444** | 0.383* | 0.746** | 0.659** | 1.000 | | |
| **EC** | -0.884** | -0.456** | -0.505** | -0.520** | -0.841** | -0.801** | -0.727** | 1.000 | |
| **FE** | 0.968** | 0.421** | 0.459** | 0.460** | 0.862** | 0.799** | 0.748** | -0.906** | 1.000 |

*(Significant at 5%); **(Significant at 1%); (SG-Standard germination, TW-Test weight, SL- Seedling length, SDW-Seedling dry weight, VI-I- Vigour index-I, VI-II- Vigour index-II, AA- Accelerated ageing (48 hrs), EC-Electrical conductivity test, FE- Field emergence)

dry weight, vigour index I, vigour index II, accelerated ageing at 48 hrs and electrical conductivity were significantly correlated with standard germination and seedling establishment.

The present study revealed that standard germination showed positive and significant association with seedling establishment, seedling length, seedling dry weight, vigour index and accelerated ageing. The standard germination test has been always used as a reliable test for prediction of the seed lot performance and results obtained in this study also supported this fact. Similar findings were also reported in pearl millet [7] [8], oats [9], maize [10], soybean [11] and cotton [12].

Test weight was found to be significantly associated with standard germination (0.365*), seedling establishment (0.421**), vigour index-II (0.708**), accelerated ageing at 48 hrs (0.342*), seedling length (0.507**), seedling dry weight (0.736**) and vigour index-I (0.528**). Large seeds are desirable in that they tend to germinate more vigorously and give large seedlings [13]. In some previous studies for pearl millet [14], wheat [15] and pigeon pea [16], it was reported that test weight significantly affects the seedling length, seedling dry weight and seedling vigour index. More seedling weight and seedling length of the heavy seeds might be attributed to large food reserves of these seeds.

Vigour indices were found to be positively and significantly correlated with field emergence and other vigour parameters. Similar conclusion was also drawn in pearl millet [8], chickpea [17], cotton [12] and soybean [18].

The accelerated ageing at 48 hrs was positively and significantly correlated with all the seed vigour parameters which backed the usefulness of this stress test for evaluation of vigour potential of the seed. Comparable results were reported in pearl millet [8] [19], maize [20] [21] and corn [22]. So, accelerated ageing test positively related with seed performance, which indicated that the seeds which bear stress of high temperature and relative humidity will be more vigorous. So, it is obvious that the field emergence and vigour of the seed can be predicted by accelerated ageing test.

Seedling establishment was shown to be significantly associated with standard germination (0.968**), vigour index-I (0.862**), vigour index-II (0.799**), accelerated ageing at 48 hrs (0.748**), seedling dry weight (0.460**), seedling length

(0.459**) and test weight (0.421*). Highest correlation of seedling establishment was found with standard germination followed by electrical conductivity, vigour index-I and so on. Some studies had reported strong correlation between the standard germination test and field emergence in sesame [23] and wheat [24].

Electrical conductivity showed negative and highly significant association with seedling establishment (-0.906**), standard germination (-0.884**), vigour index-I (-0.841**) and vigour index-II (-0.801**). The electrical conductivity test measured the amount of electrolytes which leach out from the seeds as they deteriorate. Poor membrane structure and leaky cells were associated with deteriorating and low vigour genotypes. In the present study, this test negatively correlated with all other parameters. High negative correlation was found between the EC test and field emergence. The high EC value is normally associated with low seed quality. In a previous study, it was found that the electrical conductivity test gave best correlation with the field emergence than the other laboratory seed quality tests [25]. Later on, significant correlation coefficient was reported between EC and field emergence for alfalfa seed [26]. Similar findings were supported in pearl millet [8] and wheat [27].

Regression equations were also established for the prediction of field emergence on the basis of different vigour parameters. The data referring to the regression analysis has been provided in Table 3. The estimated mean of field emergence obtained by different viability and vigour parameters *viz.* vigour index-I (66.59), standard germination (66.02), vigour index-II (65.86), accelerated ageing (65.97), seedling length (65.89), seedling dry weight (65.85), test weight (65.85) and electrical conductivity (65.82) were at par with the value obtained by observed seedling establishment (65.87) as shown in Table 2. The maximum value of $R^2$ (0.937) was obtained for standard germination, indicating the reliability of this test, followed by electrical conductivity ($R^2$ = 0.821), vigour index-I ($R^2$ = 0.743), vigour index-II ($R^2$ = 0.641) and accelerated ageing ($R^2$ = 0.559), as these tests are found highly correlated with field emergence.

The results of regression analysis between

**Table 3: Prediction of seedling establishment (%) by various viability and vigour tests in pearl millet**

| Parameter studied | Mean | | Regression | R-Square |
|---|---|---|---|---|
| | Actual mean of independent | Estimated mean of dependent | a+(b)x | |
| parameter (x) | | | | |
| parameter | | | | |
| Standard Germination (%) | 77.87 | 66.02 | -7.18+(0.94)x | 0.937 |
| Electrical conductivity (mS/cm/seed) | 0.156 | 65.82 | 100.77+(-224.04)x | 0.821 |
| V-I [SG(%)×SL(cm)] | 1615.35 | 66.59 | 26.21+(0.025)x | 0.743 |
| V-II [SG(%)×SDW(mg)] | 3252.39 | 66.02 | 36.75+(0.009)x | 0.641 |
| Accelerated ageing (48 hrs) | 43.67 | 65.97 | 32.78+(0.76)x | 0.559 |
| Seedling dry weight (mg) | 41.22 | 65.85 | 41.45+(0.592)x | 0.219 |
| Seedling length (cm) | 20.56 | 65.89 | 29.09+(1.79)x | 0.211 |
| Test weight (g) | 9.05 | 65.85 | 43.23+(2.50)x | 0.177 |

Field emergence(%) is dependent parameter. Actual mean = 65.87

seedling establishment in field and various viability and vigour parameters revealed that standard germination and electrical conductivity were the reliable predictors of field emergence in pearl millet. EC and standard germination both showed good correlation with field emergence. Interestingly, the highest value of $R^2$ for standard germination test indicated that individual regression ratios gave more accurate information. Thus, it is evident that SG test may be used as a reliable predictor for field emergence. The estimated mean of field emergence by vigour index I, vigour index II, accelerated ageing at 48 hrs, electrical conductivity and standard germination revealed the better predictability of field emergence. In a similar study, the regression equations were established for predicting field emergence performance in sweet corn [28]. The results of the present study are in line with a study in which the simple regression analysis showed that standard germination test is the best predictor of field emergence in chickpea [17]. Standard germination test and acceleration ageing test were found to be the best seed tests for prediction of field emergence based on simple and multiple regression and correlation coefficient in various crops [29].

From the study it can be concluded that standard germination, vigour indices, accelerated ageing test and electrical conductivity test are reliable tests which can be successfully employed for prediction of seed emergence of pearl millet seeds in sandy loam soils containing desirable moisture content.

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