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Correlation of Germinative and Non-Germinative Parameters with Field Emergence in Pearl millet

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An investigation was carried out to study the correlation of germinative and non-germinative parameters with vigour and viability of seeds in pearl millet. Seeds of four hybrids of pearl millet *viz*., GHB 719, GHB 905, GHB 744 and GHB 732 along with their parental lines, totaling 10 entries, were stored and utilized for this study. The relative importance of the germinative and non-germinative criteria was judged by employing simple linear correlation and regression analysis, as well as stepwise multiple regression analyses; where field emergence (final count) was considered as the dependent parameter and rest of all as independent parameters. The prediction of the variation based on the environment, the genotypes and the interaction means based model is most suitable. In this case, qualitative tetrazolium test and vigour index I were the major predictors and the levels of prediction were almost 88 per cent and 90 per cent in Model No.1 and Model No.2, respectively. It is well justified that simply the standard germination test (SGT) (germination percentage at final count after 7 days) cannot predict the actual field performance, as there is always an over prediction. In view of above, the other important and vital parameters to be considered include tetrazolium test, vigour index and mobilization efficiency. These parameters as well as those found in the linear model, predicted the field performance not only precisely, but also well in advance in a shorter time.

Key words: Correlation, Germination, Pearl millet, Regression coefficient, Viability, Vigour

Pearl millet is an important *Kharif* crop, which is known by various vernacular names such as *Bajra* (Hindi, Punjabi and Urdu), *Bajri* (Rajasthan, Marathi and Gujarati), *Sajje* (Kannada), *Gantilu* (Telugu) and *Kambu* (Tamil). It is well adapted to drought prone areas, low soil fertility, and high temperature situation. It also performs well in soils with high salinity or low pH. It can be grown in all soils and climatic conditions, where other cereal crops, such as maize or rice, would not even survive. India is the largest producer of pearl millet in the world. In 2013-14, it occupied an area of 7.95 million ha with the production of 8.79 million tons per year and average productivity of 1106 kg/ha. Rajasthan, Maharashtra, Gujarat and Uttar Pradesh are the major pearl millet growing states of India. Gujarat has an area of 0.872 million hectares under pearl millet cultivation and production of 1.50 million tons with 1720 kg/ha productivity.

Present study was conducted to correlate the germinative and non-germinative parameters with germination, vigour and viability in pearl millet. The germinative criteria of physiological quality of seed are useful for evaluation of potential storage capacity of seed, seed viability and vigour, capacity to produce normal seedling and potential to develop a plant under favourable and adverse environmental conditions. Germinative evaluation, however, takes some time depending on the crop for assessment of physiological quality of seed. In pearl millet, standard germination test (SGT) takes seven days *i.e.* final count for germination percentage (GP) is taken on 7th day (ISTA, 1996). Non-germinative criteria of physiological quality require a higher level of expertise and greater degree of sophistication. It is estimated through checking solute leakage from imbibed seed by electrical conductivity, red and pink stained color of embryo determining viability of seed quickly by Tetrazolium test method (Moore, 1985 and Dadlani, 1997). Enzyme activities are also correlated with germination. As ageing progresses germination and enzyme-activities showed significant decrease during seed deterioration in both accelerated and in natural aged seed (Pukacka and Ratajczak, 2007; Shaban, 2013). If a feasible relationship is obtained between non-germinative criteria and physiological quality of seed, this may result in a quick assessment of later. The technique will be helpful to farmers and seed producers to know well in advance the quality of seed and there by, ensure good crop stand and good production.

Materials and Methods

The experiment was carried out to study the correlation of germinative and non-germinative parameters with vigour and viability of seed in pearl millet (*Pennisetum glaucum* (L.) R. Br.) during 2014, at the Department of Seed Science and Technology and Department of Biochemistry, College of Agriculture, Junagadh Agricultural University, Junagadh. The seeds of parents (95222A, J 2454,

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04999 A, 98444 A, J 2340 and 96222) of pearl millet hybrids GHB 719, GHB 905, GHB 744 and GHB 732 were procured from Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar and were multiplied. Also, hybrids were produced in the *kharif* season of 2013 at Sagadividi farm of Department of Seed Science and Technology, J.A.U., Junagadh. The harvesting was done in the month of November 2013 and ear heads were kept for air-drying. Threshing was done in the month of January 2014. Since pearl millet seeds have time bound dormancy, the seeds were stored up to February 2014 as suggested by Joshi *et al.,* (1996).

The seeds of each entry were stored in plastic containers at ambient conditions. The samples were drawn for evaluation of various non-germinative parameters at two months interval till the seed germination declined considerably below the Indian Minimum Seed Certification Standard. A number of germinative and non-germinative parameters were evaluated in the seed stored under ambient storage employing CRD with four replications. Simple correlation and regression analysis and multiple stepwise regression analysis were carried out considering the field emergence as the dependent variable and germinative and non-germinative parameters as independent variables for predicting the field performance of the seed lot.

Results and Discussion

Field emergence percentage at final count (7 days) represents the real field performance of a seed lot and in turn, the physiological quality of seed.

Table 1. Correlation between field emergence final count (7 days) and different germinative and non-germinative parameters

Parameters	Correlation values with significance		
	Entries mean	Storage interval mean	Interaction mean
Seed weight (g)	0.26	0.928*	0.327*
Seed moisture (%)	0.54	0.928*	0.714**
Imbibition 0-4 h (%)	0.01	0.877	0.292*
Imbibition 4-10 h (%)	-0.05	-0.890*	-0.268
Imbibition 10-16 h (%)	-0.15	0.974**	0.169
Imbibition rate index	-0.07	0.863	0.252
Germination (%) 24 h.	0.28	0.951*	0.546*
Germination (%) 36 h.	0.26	0.985**	0.646**
Germination (%)48 h.	0.32	0.930*	0.719**
Germination (%)72 h.	0.32	0.930*	0.719**
Germination (%)7 d	0.40	0.984**	0.862**
Germination index	0.30	0.953*	0.651**
Root length (cm)	0.27	0.783	0.321
Shoot length (cm)	0.42	0.854	0.625**
Seedling length (cm)	0.59	0.865	0.625**
Root fresh weight (mg)	0.80**	0.987**	0.397**
Shoot fresh weight (mg)	0.67*	0.780	0.219
Seedling fresh weight (mg)	0.75*	0.980**	0.265
Root dry weight (mg)	0.78**	0.912*	0.603**
Shoot dry weight (mg)	0.68*	0.985**	0.517**
Seedling dry wt (mg)	0.73*	0.980**	0.556**
Root/ Shoot length ratio	-0.19	-0.694	-0.344*
Root/ Shoot fresh weight ratio	0.74*	0.985**	0.418**
Root/ Shoot dry weight ratio	0.59	0.794	0.470**
Root moisture (%)	0.42	-0.753	-0.288*

Shoot moisture (%)	-0.01	-0.935*	-0..403**
Seedling moisture (%)	0.21	-0.930*	-0.352**
Mobilization efficiency (%)	0.74*	0.997**	0.715**
Vigour Index I 24 h germination	0.49	0.942*	0.710**
Vigour Index I 36 h germination	0.47	0.937*	0.728**
Vigour Index I 48 h germination	0.50	0.912*	0.753**
Vigour Index I 72 h germination	0.50	0.922**	0.754**
Vigour Index I 7 day germination	0.55	0.973**	0.817**
Vigour Index II 24 h germination	0.61	0.971**	0.576**
Vigour Index II 36 h germination	0.61	0.981**	0.613**
Vigour Index II 48 h germination	0.64*	0.958*	0.654**
Vigour Index II 72 h germination	0.64*	0.971**	0.659**
Vigour Index II 7 day germination	0.69*	0.983**	0.733**
Field Eme. first count	0.82**	0.946*	0.920**
Field emergence final count	-0.99**	0.995**	0.993**
Electrical conductivity	-0.38	-0.959*	-0.444**
Ph of seed leachate	-0.06	0.674	0.488**
Qualitative TZ	0.31	0.987**	0.937**
Quantitative TZ	0.81**	0.767	0.418**
Membrane performance	0.12	-0.977**	-0614**
Catalase	-0.21	-0.736	-0.496
Peroxidase	-0.35	0.940*	0.840**
Glutathione reducatase	0.19	-0.769	-0.394**
Lipoxygenase	-0.46	0.248	0.223
Amylase Activity	-0.18	-0.678	-0.366**
Protease	0.31	0.937*	0.508**
	(n-2)=10-2=8	(n-2)=5-2=3	(n-2)=50-2=48

With this in view, various germinative and non-germinative parameters were correlated with field emergence percentage at final count (Table 1). Based on correlation, the parameters were selected to develop linear regression model for the prediction of field performance. To assess and derive the best criteria for prediction of field performance, multiple step wise regression analyses were done. As far as

Table 2. Stepwise multiple regression analyses using entries means depicting regression coefficients, correlation coefficients and allied statistic along with the models developed

Model 1

Parameters	Regression coefficient	r	t	F	R^2
Quantitative TZ	29.23	0.808	3.89**	15.05**	0.653
Constant	58.65				

Model 2

Parameters	Regression coefficient	r	t	F	R^2
Quantitative TZ	26.44	0.731	4.462**	15.799**	0.819
Vigour Index I 7 days	0.011	0.414	2.529*		
Constant	47.00				

Model 1 $Y = 29.23\,x + 58.65$

Model 2 $Y = 26.44\,x1 + 0.011x2 + 47.00$

Table 3. Stepwise multiple regression analyses using storage intervals means depicting regression coefficients, correlation coefficients and allied statistic along with the models developed

Model 1

Parameters	Regression coefficient	r	t	F	R^2
Mobilization Efficiency	10.52	0.997	23.19**	538**	0.994
Constant	-38.55				

Model 1 Y= 10.52 x – 38.55

Table 4. Stepwise multiple regression analyses using interaction means depicting regression coefficients, correlation coefficients and allied statistic along with the models developed

Model 1

Parameters	Regression coefficient	r	t	F	R^2
Qualitative TZ	1.055	0.9	18.56**	344**	0.878
Constant	-4.805	37			

Model 2

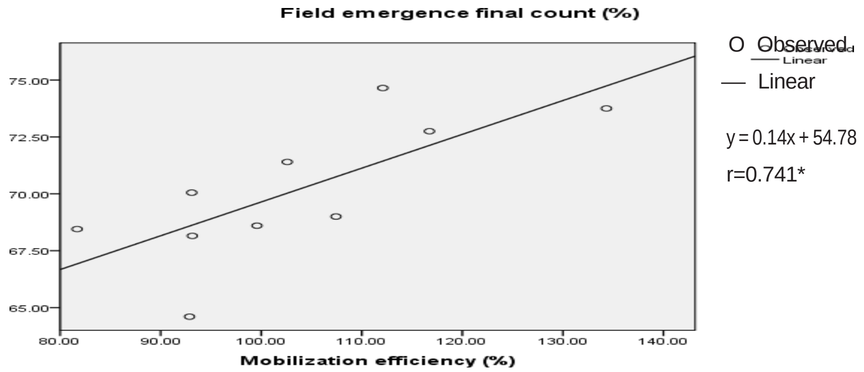
Parameters	Regression coefficient	r	t	F	R^2
Qualitative TZ	0.853	0.757	10.45**	211**	0.900
Vigour Index I	0.014	0.233	3.11**		
Constant	-6.776				

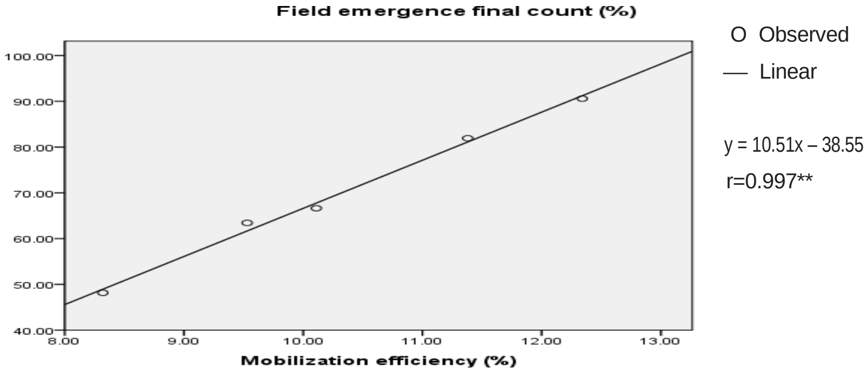
Model 1 Y= 1.055 x – 4.805

Model 2 Y= 0.853x1 + 0.014x2 – 6.776

possible, the derived parameters showing co-linearity were avoided in the multiple regression analysis. Three types of correlation and regression analysis were done which were based on (1) entries means, (2) storage interval means and (3) the interaction means, since the interaction between storage intervals and entries were significant for almost all the parameters studied.

So far as, simple linear regression based on entries means, disregarding the storage time, the highest value of correlation coefficient was obtained between field emergence first count, quantitative tetrazolium test and field emergence final count followed by root fresh weight and dry weight, respectively (Table 1). With regards to linear regression based on storage time disregarding the genotypic differences, the highest coefficient of correlation value were found between mobilization efficiency, field emergence at final count followed by qualitative tetrazolium test, root fresh weight, shoot dry weight, and germination percentage at 36 hours,





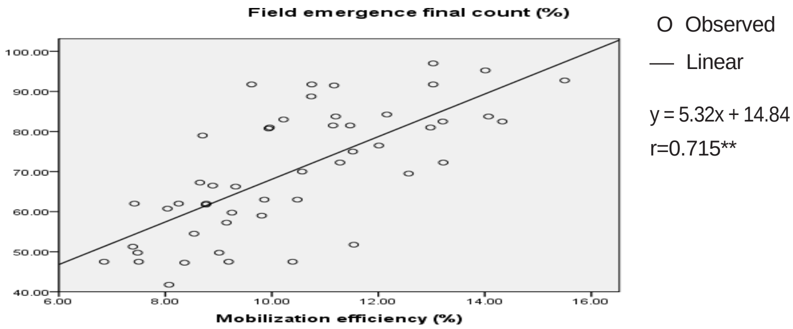


Fig.1. Simple regression analysis between field emergence final count (7 days) and mobilization efficiency (%) (A) varietal (B) storage time interval (C) interaction effect.

respectively. Peroxidase and protease enzymes also exhibited significant association with field performance. As discussed earlier, the interaction was significant in almost all the parameters, the actual representation of the prediction would be based on the linear models developed from the interaction table between individual germinative and non-germinative parameters as independent variables and the field performance *i.e.* field emergence at final count as the dependent variable. Interestingly linear model developed from interaction means represented both significant linear models based on storage time as well as entries. To identify finally, the role of a few independent variables in the prediction of field performance (dependent variable), multiple stepwise regression analyses based on storage time mean, entries mean and the interaction mean were recorded (Table 2, 3 and 4). The parameters identified in the entries mean based models were quantitative tetrazolium test and vigour index-I of which quantitative tetrazolium test played the major role. The two models predicted almost 65 per cent and 82 per cent variation in the field performance. The model developed on storage time identified mobilization efficiency as the major predictor of field performance almost explaining 99 per cent of the variation. As justified earlier for the prediction of the variation based on both the environment and the genotypes, the interaction mean based model is most suitable.

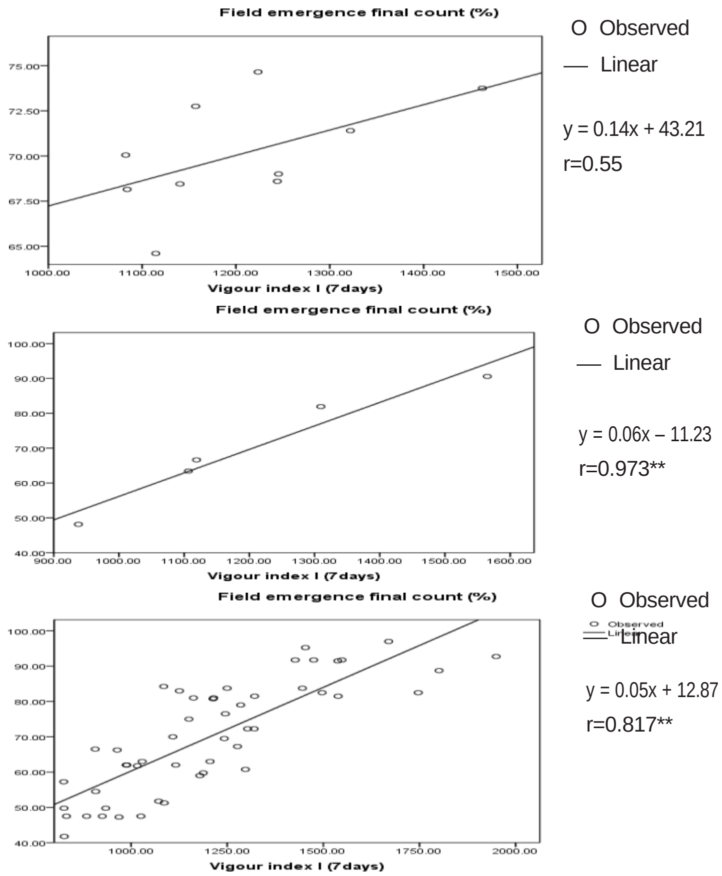


Fig.2. Simple regression analysis between field emergence final count (7 days) and vigour index I (7 days) (A) varietal (B) storage time interval (C) interaction effect

In this case, qualitative tetrazolium test and vigour index-I were the major predictors and the levels of prediction were almost 88 per cent and 90 per cent in model No.1 and Model No.2, respectively. Finally, the case is well justified that simply the standard germination test (SGT) (germination percentage final count after 7 days) cannot predict the actual field performance, as there is always an over prediction. In view of above, the other important and vital parameters, which include the vigour of the seeds is to be considered.

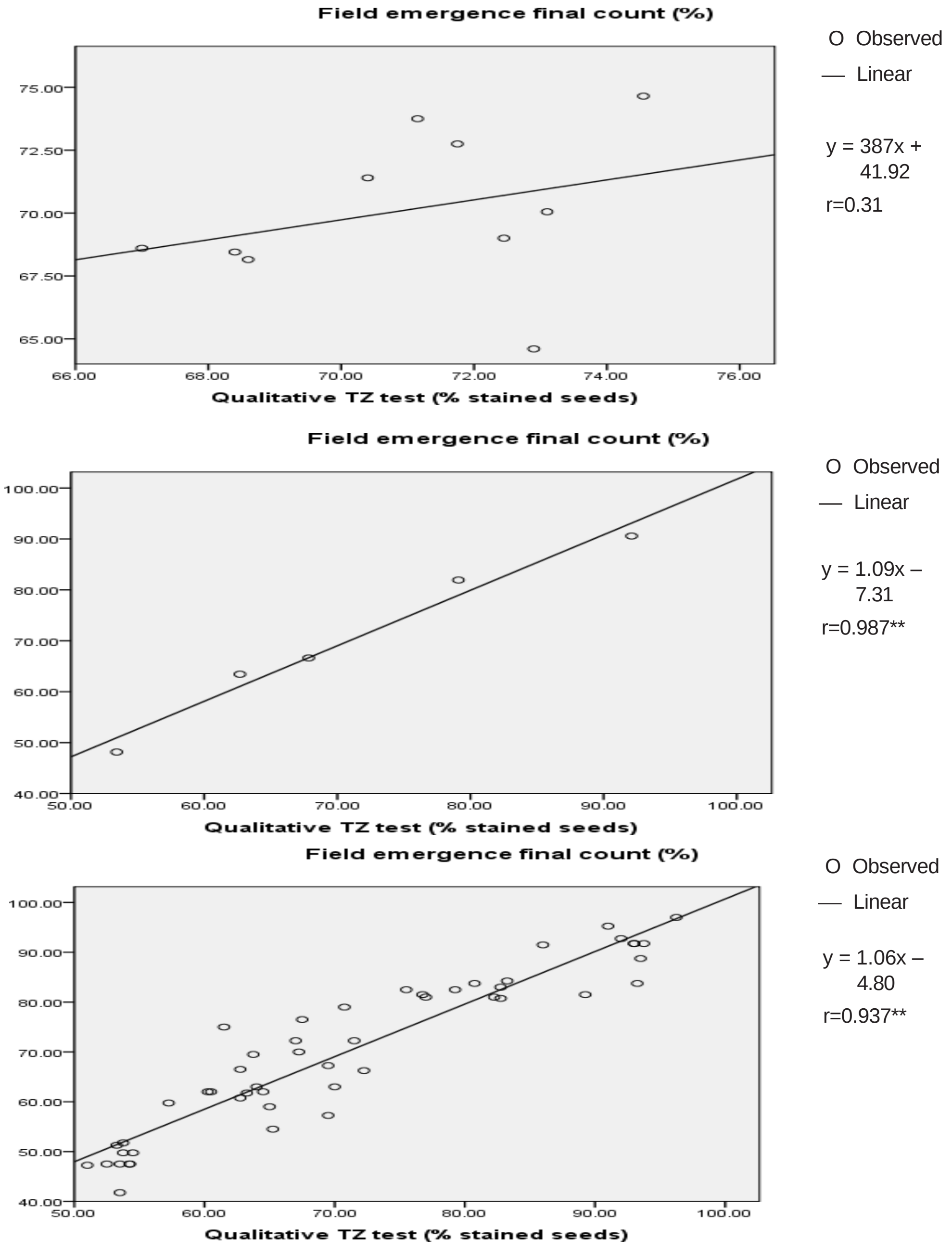


Fig.3. Simple regression analysis between field emergence final count (7 days) and qualitative TZ test (% stained seeds) (A) varietal (B) storage time interval (C) interaction effect

In the present investigation, other important parameters identified for predicting are tetrazolium test, vigour index and mobilization efficiency. There are a number of reports corroborating our findings with respect to vigour index (Krishnaveni, 1984 and German *et al*., 1993), tetrazolium test (maize - Dias and Barros, 1995), (garden bean - Bhering *et al*. 1996), (peanut- Vieira and Von Pinho, 1999), (pumpkin - Dias *et al*., 2001) and (tomato -Santosh *et al*., 2007) and mobilization efficiency (pearl millet- Joshi, 1997). These parameters along with those found in the linear model (Figure 1, 2 and 3) predict the field performance not only precisely, but also well in advance in shorter time.

Conclusion

Based on correlation and regression study, it is well justified that simply the standard germination test (SGT) (germination percentage at final count after 7 days) cannot predict the actual field performance as there is always an over prediction. In view of the above, the other important and vital parameters, which include the vigour of the seeds, tetrazolium test, vigour index and mobilization efficiency are very much important. These parameters along with those found in the linear model, predicted the field performance not only precisely but also well in advance in shorter time.

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