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Research Article

Correlation and R^2 analysis of radicle emergence test to predict seed vigour and field emergence in blackgram (*Vigna mungo* L.) seed lots

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Abstract
Blackgram (*Vigna mungo* L.) is one of the major pulse crops grown throughout India. Prediction of seed vigour and field emergence of seed before sowing is important for assured yield. A standard germination test is time-consuming and does not always show the seed lot potential performance, especially if field conditions are not optimal. There is need of advanced technology, which can give a precise result in a short period. The experiment was conducted to correlate the radicle emergence test with seed vigour parameters to predict seed vigour and planting value of 10 varying vigour lots (L_1, L_2, L_3, L_4 - high vigour lots; L_5, L_6, L_7 - medium vigour lots; L_8, L_9, L_{10} - low vigour lots) of blackgram var. VBN 6. The study showed that all the seed vigour parameters of the blackgram were more highly correlated with the percentage of radicle emergence with 2 mm length than with 1 mm length. The correlation analysis results showed that the radicle emergence test with 2 mm radicle length at 28 hours had a highly significant negative correlation with EC (electrical conductivity) of seed leachate (-0.974**), followed by MJGT (mean just germination time) (-0.967**) and MGT (mean germination time) (-0.933**). However, it was positively correlated with field emergence (0.972**), germination (0.952**) and dehydrogenase enzyme activity (0.928**). The maximum R^2 value of 0.923 was recorded in the 28-hour counting of radicle emergence with a length of 2 mm compared with the 26-hour counting of radicle emergence with a length of 1 mm (0.913). The study concluded that counting 2 mm radicle emergence at the 28th hour could be used to quickly evaluate seed vigour in field emergence in blackgram seed lots.

Keywords: Blackgram, Field emergence, Germination, Radicle emergence and Vigour

INTRODUCTION

Blackgram (*Vigna mungo* L.) is one of the major pulse crops grown throughout India. It belongs to the family Fabaceae. India is the largest producer, consumer and importer of blackgram. The standard germination test is considered the common test for seed quality to evaluate the particular seed lot performance only under an ideal set of environmental conditions, but this test is time consuming and does not always show field emergence potential performance (Mavi *et al*., 2016). Seed lots do not vary in viability and may also differ in field emergence potential; in that way, a seed vigour test is considered powerful when ranking the seed lots based on vigour level groups (Kolasinska *et al*., 2000; Matthews and Powell, 2011).

When purchasing seeds, farmers and seed producers require information to quickly assess the expected rapidity and uniformity of seedling emergence. The radicle emergence test is one of the options to assess seed vigour and field emergence potential in a wide range of environmental conditions (Chinnasamy *et al.,* 2019).

According to Indian Minimum Seed Certification Standards (IMSCS, 2013), black gram final count of seedling evaluation is 7th day for its germination percentage. The long days of the evaluation period are time-consuming. Advanced technology is needed, which

would give a precise result in a short period. In that case, the radicle emergence test is useful for the quick prediction of seed vigour and field emergence. With this backdrop, the present study carried out correlation and R^2 analysis of radicle emergence percent with seed vigour parameters to assess the seed vigour and planting value of blackgram var. VBN 6.

MATERIALS AND METHODS

Genetically pure 10 varying vigour lots (L_1, L_2, L_3, L_4 - high vigour lots; L_5, L_6, L_7 - medium vigour lots; L_8, L_9, L_{10} - low vigour lots) of blackgram var. VBN 6 were obtained from the National Pulses Research Centre (NPRC), and Vamban formed the base material for this study.

The top of paper method was used to conduct the radicle emergence test (ISTA, 2017). The observations were recorded, and the MJGT, MGT and radicle emergence percent (with 1 mm and 2 mm radicle lengths) were calculated (Ellis and Roberts, 1980).

Mean germination time (h) = Σ n t/Σ n …. Eq. 1

{n - Total number of seeds germinated (first appearance of the radicle); t - Time from starting of the radicle emergence test; Σ n - Final day of radicle emergence}

Mean germination time (h) = Σ n t/Σ n …. Eq. 2

{n - Total number of seeds germinated (with 2 mm length of radicle emergence); t - Time from starting of the radicle emergence test; Σ n - Final day of radicle emergence}

1 mm length of radicle emergence (%) = Radicle emergence with 1 mm length/Total number of seeds sown X 100 ...Eq.3

2 mm length of radicle emergence (%) = Radicle emergence with 2 mm length/ Total number of seeds sown X 100 ...Eq. 4

RESULTS AND DISCUSSION

A correlation study was carried out to evaluate the relationship of radicle emergence percent and other seed vigour parameters. In the present study, all the seed vigour parameters were more highly correlated with the percentage radicle emergence with 2 mm length than 1 mm length.

The results of the present study clearly revealed that dry matter production (0.985**), field emergence (0.975**), germination (0.969**), vigour index (0.955**), speed of germination (0.947**), hundred seed weight (0.899**) and dehydrogenase activity (0.853**) were positively correlated with radicle emergence percent with 1 mm length at the 26th hour followed by 18, 22, 20, 16, and 24 hours. The EC of seed leachate (-0.967**), MJGT (-0.928**) and MGT (-0.906**) was more negatively correlated with the 1 mm length of radicle emergence percent at the 26th hour than at 18, 24, 16, 22 and 20 hours (Table 1 and Plate 1).

Similarly, the field emergence (0.972**), vigour index (0.956**), germination (0.952**), dry matter production (0.952**), hundred seed weight (0.938**), speed of germination (0.931**) and dehydrogenase activity (0.928**) were positively correlated with radicle emergence percent with 2 mm length at 28 hours followed by 20, 26, 22, 24 and 18 hours. However, the EC of seed leachate (-0.974**), MJGT (-0.967**) and MGT (-0.933**) was more negatively correlated with the 2 mm length of radicle emergence percent at the 28th hour than at 20, 26, 22, 24 and 18 hours (Table 2 and Plate 2).

Powell (1988) suggested that MGT was significantly correlated with germination, field emergence and yield in rapeseed and Italian rye grass. According to Naylor (2003), MGT was highly correlated with radicle emergence and field emergence in Italian rye grass seeds. Significant correlations of the mean germination time of 31 seed lots of maize and both the cold test and field emergence were also observed by Lovato (2005). In coriander, field emergence also showed a positive and significant correlation with the radicle emergence test, accelerating ageing test and dehydrogenase activity test, whereas it was negatively and significantly correlated with the electrical conductivity of seed leachate in coriander (Kumar, 2015). The significant correlation coefficient of mean germination time of 10 seed lots of okra and both the standard germination test and field emergence test were also observed by Chinnasamy *et al.* (2019).

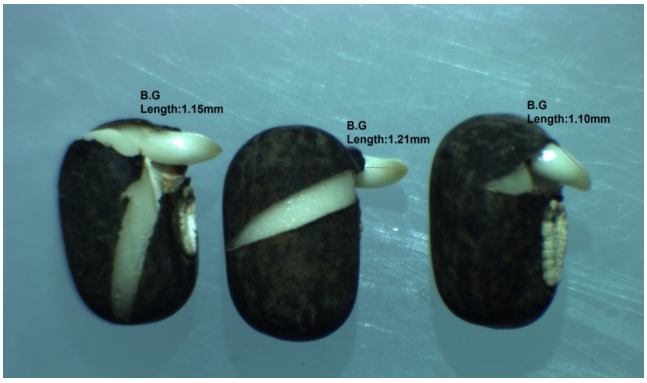

Plate 1. *Radicle emergence at 26 hours*

Plate 2. *Radicle emergence at 28 hours*

Table 1. *Correlation analysis between radicle emergence percent with 1 mm length and other seed vigour parameters in blackgram seeds*

	SOG	GER	DMP	VI	MJGT	MGT	EC	DA	HSW	FE	RE16 h	RE18 h	RE20 h	RE22 h	RE24 h	RE26 h
SOG	1															
GER	.922**	1														
DMP	.948**	.985**	1													
VI	.932**	.991**	.973**	1												
MJGT	-.851**	-.952**	-.945**	-.953**	1											
MGT	-.828**	-.897**	-.921**	-.891**	.973**	1										
EC	-.908**	-.923**	-.957**	-.920**	.915**	.900**	1									
DA	.913**	.874**	.886**	.912**	-.875**	-.853**	-.917**	1								
HSW	.930**	.870**	.899**	.884**	-.893**	-.904**	-.872**	.883**	1							
FE	.930**	.996**	.984**	.989**	-.953**	-.910**	-.923**	.895**	.887**	1						
RE16 h	.876**	.838**	.871**	.875**	-.871**	-.894**	-.870**	.957**	.863**	.865**	1					
RE18 h	.897**	.964**	.983**	.948**	-.923**	-.894**	-.960**	.852**	.820**	.956**	.840**	1				
RE20 h	.753*	.891**	.859**	.855**	-.776**	-.727*	-.713*	.641*	.655*	.890**	.645*	.888**	1			
RE22 h	.767**	.932**	.910**	.892**	-.874**	-.823**	-.798**	.670*	.690*	.916**	.687*	.909**	.942**	1		
RE24 h	.800**	.874**	.894**	.865**	-.828**	-.781**	-.878**	.729*	.706*	.845**	.722*	.868**	.776**	.862**	1	
RE26 h	.947**	.969**	.985**	.955**	-.928**	-.906**	-.967**	.853**	.899**	.975**	.857**	.957**	.851**	.921**	.946**	1

** 0.01 level of significance, * 0.05 level of significance, SOG (Speed of germination), GER (Germination),DMP (Dry matter production), VI (Vigour index),MJGT (Mean just germination time), MGT (Mean germination time), EC (Electrical conductivity of seed leachate), DA (Dehydrogenase enzyme activity), HSW (Hundred seed weight), FE (Field emergence), RE (Radicle emergence)

Table 2. *Correlation analysis between radicle emergence percent with 2 mm length and other seed vigour parameters in blackgram seeds*

	SOG	GER	DMP	VI	MJGT	MGT	EC	DA	HSW	FE	RE18 h	RE20 h	RE22 h	RE24 h	RE26 h	RE28 h
SOG	1															
GER	.922**	1														
DMP	.948**	.985**	1													
VI	.932**	.991**	.973**	1												
MJGT	-.851**	-.952**	-.945**	-.953**	1											
MGT	-.828**	-.897**	-.921**	-.891**	.973**	1										
EC	-.908**	-.923**	-.957**	-.920**	.915**	.900**	1									
DA	.913**	.874**	.886**	.912**	-.875**	-.853**	-.917**	1								
HSW	.930**	.870**	.899**	.884**	-.893**	-.904**	-.872**	.883**	1							
FE	.930**	.996**	.984**	.989**	-.953**	-.910**	-.923**	.895**	.887**	1						
RE18 h	.850**	.798**	.810**	.809**	-.809**	-.828**	-.717*	.803**	.873**	.832**	1					
RE20 h	.876**	.964**	.967**	.963**	-.962**	-.925**	-.970**	.910**	.839**	.961**	.728*	1				
RE22 h	.723*	.905**	.867**	.898**	-.896**	-.853**	-.797**	.772**	.714*	.908**	.633*	.848**	1			
RE24 h	.615	.852**	.796**	.841**	-.881**	-.826**	-.737*	.706*	.629	.850**	.578	.789**	.973**	1		
RE26 h	.833**	.958**	.933**	.962**	-.950**	-.892**	-.885**	.861**	.783**	.950**	.716*	.894**	.942**	.927**	1	
RE28 h	.931**	.952**	.952**	.956**	-.967**	-.933**	-.974**	.928**	.938**	.972**	.917**	.924**	.906**	.868**	.964**	1

** 0.01 level of significance, * 0.05 level of significance, SOG (Speed of germination), GER (Germination),DMP (Dry matter production), VI (Vigour index),MJGT (Mean just germination time), MGT (Mean germination time), EC (Electrical conductivity of seed leachate), DA (Dehydrogenase enzyme activity), HSW (Hundred seed weight), FE (Field emergence), RE (Radicle emergence)

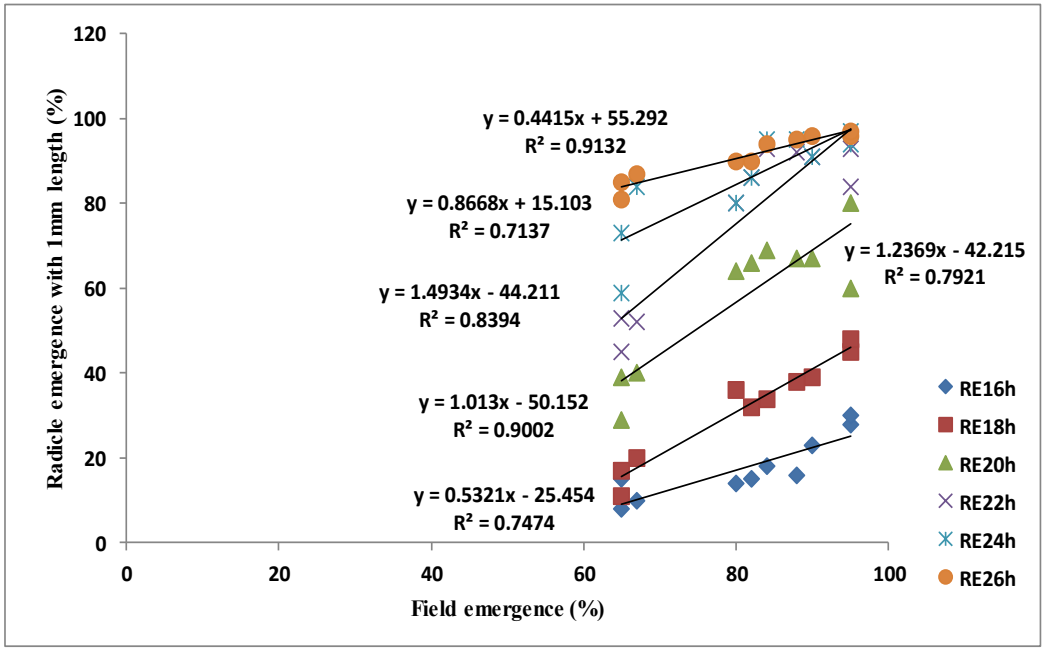

Fig. 1. *R^2 analysis of 1 mm length of radicle emergence and field emergence in blackgram seeds*

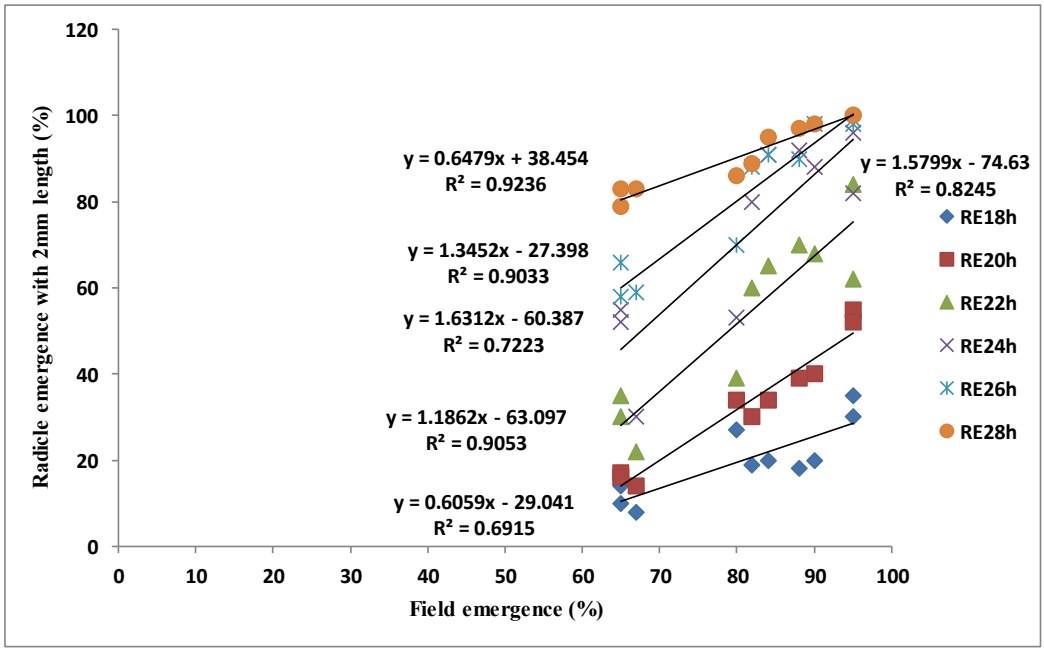

Fig. 2. *R^2 analysis of 2 mm length of radicle emergence and field emergence in blackgram seeds*

The radicle emergence and field emergence R^2 analyses were evaluated. The highest R^2 value (0.913) was recorded at 26 hours, followed by 18, 22, 20, 16, and 24 hours of counting radicle emergence with a length of 1 mm, and the highest R^2 value (0.923) was recorded 28 hours, followed by 20, 26, 22, 24 and 18 hours of counting radicle emergence with a length of 2 mm (Fig. 1 and 2). Similar results were obtained by Luo *et al.* (2015), who found that the R^2 analysis between field emergence and radicle emergence count was used for quick prediction of seed vigour in terms of field emergence performance in sweet corn seeds.

Conclusion

The present study concluded that all the seed vigour parameters of the blackgram were closely correlated with the percentage of radicle emergence with 2 mm length than with 1 mm length. The correlation analysis results showed that the radicle emergence test with 2 mm radicle length at 28 hours had a highly significant negative correlation with EC of seed leachate (-0.974**), followed by MJGT (-0.967**) and MGT (-0.933**). However, it was positively correlated with field emergence (0.972**), germination (0.952**) and dehy-

drogenase enzyme activity (0.928**) and also the maximum R^2 value of 0.923 was recorded in the 28-hour counting of radicle emergence with a length of 2 mm compared with the 26-hour counting of radicle emergence with a length of 1 mm (0.913). Finally, the study concluded that the mean germination time with 2 mm radicle emergence at the 28th-hour count could be used as a quick indicator of seed vigour in terms of field emergence in blackgram var. VBN 6 seed lots.

Conflict of interest

The authors declare that they have no conflict of interest.

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