Full Length Research Article

© 2026, Centre for Advanced Research in Agricultural Sciences
Research Journal of Agricultural Sciences
Volume 17; Issue 03 (May–June 2026); pp 276–281

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Seed Vigour Parameters as Predictors of Field Emergence in Paddy (*Oryza sativa* L.)

Kalyani Kumari*[1], Kalyanrao[2], Banoth Vinesh[3], Sripathy K. V.[4] and Uday Bhaskar K[5]

[1-5] ICAR-National Institute of Seed Science and Technology, Mau - 275 103, Uttar Pradesh, India

Received: 28 Mar 2026; Revised accepted: 03 May 2026

Abstract

Seed vigour is a critical component of seed quality that determines the potential of a seed lot to germinate rapidly, establish uniformly, and perform well under diverse field conditions. Farmers frequently encounter poor crop establishment despite acceptable laboratory germination, underscoring the need for reliable vigour assessment. The present study evaluated the effectiveness of different laboratory-based seed vigour parameters in predicting field emergence (FE) across fifteen seed lots of paddy (*Oryza sativa* L.). Radicle emergence, mean germination time (MGT), germination percentage, seedling length, seedling dry weight, vigour indices (VI-I and VI-II), germination factor (GF), seedling factor (SF), germination seedling factor (GSF), and field emergence were assessed following ISTA procedures. Significant variability was observed among seed lots for all parameters. Correlation analysis revealed that germination percentage, Vigour Index-I, and germination factor showed strong and significant positive association with field emergence, whereas VI-II, SF, and GSF showed weak or non-significant relationships. The study concludes that combining germination percentage with Vigour Index-I provides a robust and practical approach for predicting field performance of paddy seed lots.

Key words: *Oryza sativa* L., Field emergence, Mean germination time, Seed lots, Seed vigour

Seed quality is a fundamental prerequisite for successful crop establishment and productivity. While standard germination tests provide information on the maximum germination potential under optimal conditions, they often fail to predict seed performance under variable field environments. Seed vigour represents the sum total of seed properties that determine the level of activity and performance during germination and seedling establishment across a wide range of conditions [1]. In paddy cultivation, uneven emergence and poor crop stand are common problems even when seed lots meet the prescribed germination standards. Such discrepancies highlight the limitations of routine germination testing and emphasize the importance of seed vigour evaluation as a complementary tool [2]. Over the years, several direct and indirect vigour tests have been proposed, including speed of germination, radicle emergence, seedling growth parameters, vigour indices, and composite indices such as germination–seedling factor. Field emergence is often inconsistent despite high laboratory germination percentages, primarily due to environmental variability such as soil moisture fluctuations, temperature extremes, and pathogen pressure. In this context, seed vigour parameters including seedling length, seedling dry weight, vigour indices, electrical conductivity, and accelerated ageing serve as reliable indicators of physiological potential and storability of seeds [3]. These parameters help distinguish between seed lots of similar germination capacity but differing performance under suboptimal conditions, thus enabling more precise seed quality evaluation.

In paddy cultivation, rapid and uniform seedling emergence is essential for achieving optimal plant population and maximizing yield potential [4]. Poor field emergence leads to uneven crop stands, increased vulnerability to weed competition, and reduced resource-use efficiency. Therefore, identifying robust laboratory-based seed vigour tests that correlate strongly with field emergence is of paramount importance for seed technologists and farmers alike. Previous studies have demonstrated significant relationships between vigour indices and field performance in rice and other cereals, highlighting the practical utility of vigour testing in seed quality assessment [5]. Despite the recognized importance of seed vigour, there remains variability in the predictive accuracy of different vigour tests across crop species and environmental conditions. In rice, limited comprehensive studies have systematically evaluated the relationship between multiple seed vigour parameters and actual field emergence under local agro-climatic conditions. Consequently, there is a need to identify the most reliable and reproducible vigour tests that can serve as predictors of field performance.

However, the reliability of these tests varies with crop species, seed lot condition, and environmental factors. Field emergence percentage (FE) is considered the ultimate expression of seed quality, as it integrates the effects of seed vigour and field conditions. Nevertheless, field tests are time-consuming, labour-intensive, and influenced by environmental variability. Therefore, identifying laboratory-based vigour parameters that reliably predict field emergence is of practical

***Correspondence to:** Kalyani Kumari, E-mail: kalyani.kumari7@gmail.com; Tel: +91 7765835577

Citation: Kumari K, Kalyanrao, Vinesh B, Sripathy KV, Uday Bhaskar K. 2026. Seed vigour parameters as predictors of field emergence in paddy (*Oryza sativa* L.). *Res. Jr. Agril. Sci.* 17(3): 276-281.

significance for seed producers, certification agencies, and farmers. The germination test is a reliable indicator of potential seed performance. It is important to consider the seed's vigour when assessing its field performance [6]. The present study was undertaken to compare different seed vigour parameters and identify reliable predictors of field emergence in paddy.

MATERIALS AND METHODS

Experimental material

Fifteen seed lots of paddy (*Oryza sativa* L.) representing different varieties were collected from the Farm Section of ICAR–NISST, Mau. The seed lots included samples with germination levels both above and below the Indian Minimum Seed Certification Standards (IMSCS), ensuring a wide range of vigour levels.

Radicle emergence test

Radicle emergence was evaluated using the top-of-paper method as per ISTA guidelines [7]. Eight replications of 50 seeds each were placed in a germination chamber maintained at 25 ± 2 °C. Radicle protrusion of ≥2 mm was recorded at 2-hour intervals, and cumulative emergence percentages were calculated.

Germination test

Standard germination testing was conducted using the roll towel method with four replications of 100 seeds each. Seeds were incubated at 25 ± 2 °C and 95 ± 2% relative humidity. Normal seedlings were counted on the 14th day, and germination percentage was calculated.

Mean germination time (MGT)

Mean germination time was calculated to assess the speed and uniformity of germination using cumulative germination counts recorded at regular intervals. The Mean Germination Time (MGT) was calculated using following formula given by Ellis and Roberts [8]:

$$MGT = \Sigma(nt) / \Sigma n$$

Where;
n = Number of seeds newly germinated at time ‘t’ at 25 °C,
t = Hours

Seedling length and dry weight

Ten normal seedlings from each replication were randomly selected for measurement of total seedling length (cm). The same seedlings were oven-dried at 80 ± 2 °C for 24 hours to record seedling dry weight.

Vigour indices

Vigour indices were calculated as described by Abdul-Baki and Anderson [3]:

Vigour Index-I (VI-I): Germination (%) × Seedling length (cm)
Vigour Index-II (VI-II): Germination (%) × Seedling dry weight (g)

Field emergence test

Field emergence was assessed by sowing four replications of 100 seeds per lot in raised beds under field conditions. Normal seedlings were counted at 20 days after sowing (DAS), and field emergence percentage was calculated.

Germination and seedling factors

Germination factor (GF): Germination percentage divided by 100
Seedling factor (SF): Ratio of total seedling length of a lot to the maximum seedling length observed
Germination–seedling factor (GSF): Product of GF and SF

Statistical analysis

The experiment was conducted in a completely randomized design. Data were subjected to analysis of variance (ANOVA), and critical difference (CD) at p = 0.05 was calculated. Pearson correlation coefficients were computed to determine relationships among seed quality parameters and field emergence. The mean data obtained from the experimentation was statistically analysed and subjected to the Analysis of variance by adopting appropriate statistical methods as outlined by Panse and Sukhatme [9], Sundararaj *et al*. [10].

RESULTS AND DISCUSSION

Radicle emergence and mean germination time

Marked differences were observed among seed lots in the onset and rate of radicle emergence. High-vigour lots exhibited early radicle protrusion (42–46 h), while low-vigour lots showed delayed emergence extending up to 78–92 h. Mean germination time varied widely among seed lots, with lower MGT values recorded in high-vigour lots, indicating faster and more uniform germination. MTU 7029 (Lot 1) and Rajendra Swetha (Lot 3) recorded the lowest MGT (~43–44 h), indicating high vigour. Higher MGT values (≈85–89 h) were observed in Sona, Madhu, WGL-347 and WGL-32183, indicating low vigour and delayed germination. The results demonstrate that MGT effectively differentiates seed lots based on vigour.

Germination percentage

Significant variation was recorded among seed lots for germination percentage. Germination ranged from 18.0% (Madhu) to 94.7% (Rajendra Swetha, Lot 1). Seed lots Rajendra Swetha (Lots 1–3), BPT 5204, and MTU7029 (Lot 2) recorded significantly higher germination, indicating better seed viability. In contrast, Madhu, Sona, WGL-347, and Swarna Sub-1 showed very low germination, falling well below IMSCS, reflecting poor seed quality.

Vigour index-I (VI-I)

Vigour Index-I showed a wide range from 329.47 to 3089.82, clearly differentiating seed lots based on vigour. The highest VI-I was recorded in Rajendra Swetha (Lot 2), followed by Rajendra Swetha (Lot 3), PB-1 (Lot 2), and BPT 5204. High VI-I values indicate superior seedling growth combined with good germination, whereas low-vigour lots such as Madhu, Sona, and WGL-347 exhibited very low VI-I values.

Vigour index-II (VI-II)

VI-II values varied significantly among seed lots, with PB-1 (Lot 2) recording the highest value (7.74), followed by Rajendra Swetha (Lots 2 and 3). Low-vigour seed lots such as Madhu, Sona, and WGL-347 recorded significantly lower VI-II values, reflecting poor seedling biomass accumulation.

Field emergence (FE)

Field emergence percentage differed significantly among seed lots, reflecting differences in vigour status. Seed lots with higher germination and vigour index values consistently produced better field emergence, whereas low-vigour lots exhibited poor establishment. Field emergence percentage ranged from 16.0% to 94.25%. Seed lots with high germination and vigour indices consistently showed higher field emergence, particularly Rajendra Swetha (Lots 1 and 2), BPT 5204, and MTU7029 (Lot 2). Poor-quality seed lots recorded low field emergence, confirming that acceptable laboratory germination alone does not guarantee good field performance. Marcos-Filho *et al*. [5] proposed that the speed and uniformity of seedling emergence were crucial components of seed performance as they can directly influence stand establishment in the field.

Total seedling length (TSL)

TSL varied significantly, with the maximum seedling length observed in WGL-32183 (36.57 cm), followed by Rajendra Swetha (Lot 2) and PB-1 (Lot 2). However, high TSL alone did not always correspond to high field emergence, suggesting that seedling length should be interpreted along with germination and vigour indices.

Germination factor (GF)

Germination factor **(**GF) values ranged from 0.18 to 0.94, closely reflecting germination percentage. High-vigour seed lots exhibited significantly higher GF values, whereas low-vigour seed lots recorded poor GF values, indicating slower and uneven germination.

Seedling factor (SF)

Seedling factor ranged from 0.29 to 0.98, with WGL-32183 showing the highest SF due to maximum seedling length. However, SF alone showed limited association with field emergence, suggesting that seedling size without viability may not ensure better establishment.

Table 1 Duration of incubation (h) for radicle emergence (2 mm length) in different lots of paddy

Variety	42hrs	44 hrs	46 hrs	66 hrs	68 hrs	70 hrs	72 hrs	74 hrs	76 hrs	78 hrs	84 hrs	86 hrs	88 hrs	90 hrs	92 hrs
L_1: MTU7029 (Lot 1)	34	57	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5
L_2: MTU7029 (Lot 2)	0	0	0	3.5	8	30	49.5	63	75	85	85	85	85	85	85
L_3: Rajendra Swetha (Lot 1)	0	0	0	25.5	27.5	27.5	27.5	30	50	70	85	85	85	85	85
L_4: Rajendra Swetha (Lot 2)	0	0	0	23	26.5	34	36	52	74	86	86	86	86	86	86
L_5: Rajendra Swetha (Lot 3)	36.5	62	88	88	88	88	88	88	88	88	88	88	88	88	88
L_6: PB- 1 (Lot 1)	0	0	0	0	0	15	21	40	56	70	85	85	85	85	85
L_7: PB- 1 (Lot 2)	0	0	0	0	0	14	24	37	52	62.5	68.5	74.5	79.5	87.5	87.5
L_8: Sarju- 52	0	0	0	0	16.5	19	28	50	59	70.5	82	82	82	82	82
L_9: BPT 5204	0	0	0	0	0	0	30	32	41	48.5	55	62.5	72.5	91.5	91.5
L_{10}: PB -1121	0	0	0	0	0	0	0	0	0	10.5	11	13	17	25.5	25.5
L_{11}: Swarna Sub -1	0	0	0	0	0	0	0	0	0	2.5	10	25	31	37.5	37.5
L_{12}: Madhu	0	0	0	0	0	0	0	0	0	0		3	5	7.5	16
L_{13}: Sona	0	0	0	0	0	0	0	0	0	0	3.5	5	8.5	11	17.5
L_{14}: WGL -347	0	0	0	0	0	0	0	0	0	0	4.5	4.5	8.5	13	17.5
L_{15}: WGL-32183	0	0	0	0	0	0	0	0	0	8	8	12.5	23	28	52.5

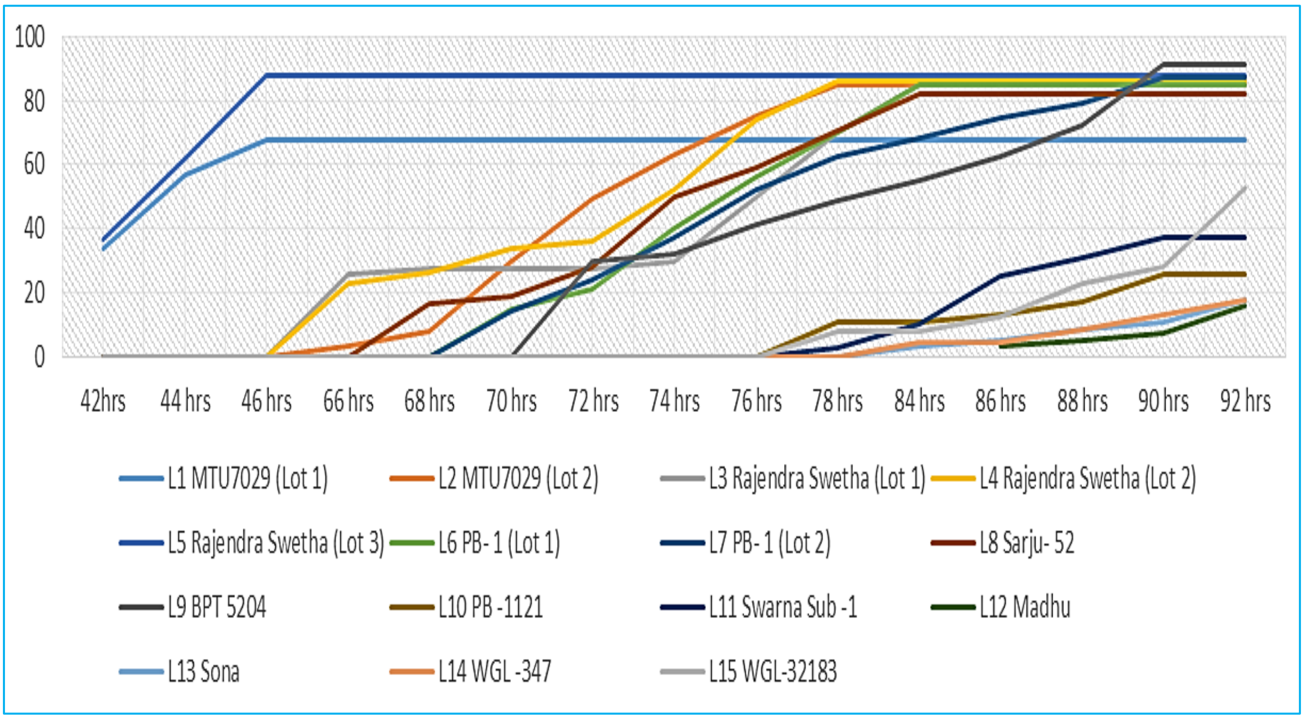

Fig 1 Radicle emergence (2 mm length) in different lots of paddy

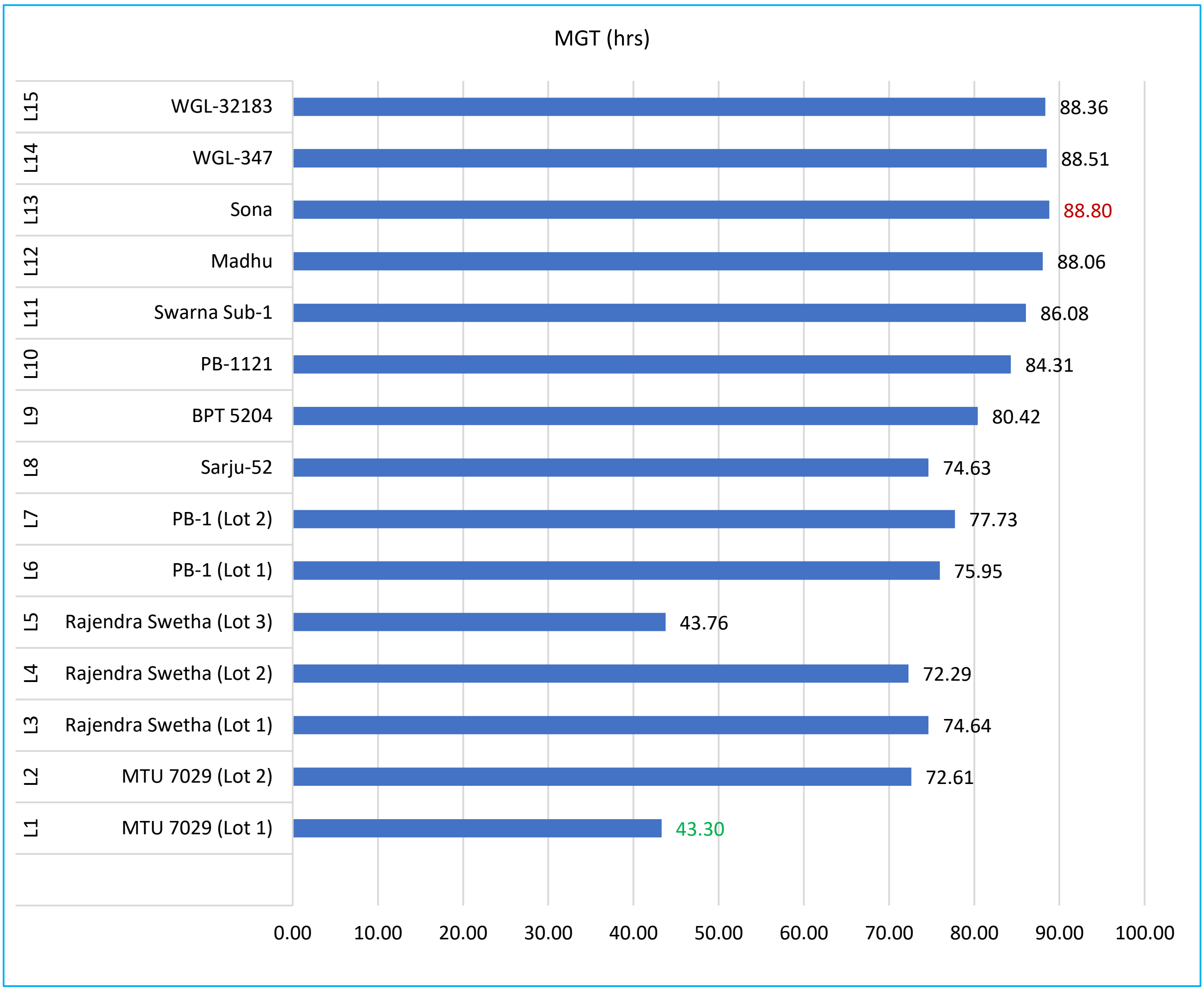

Fig 2 Mean germination time

Table 2 Evaluation of seed quality parameters in different lots of paddy

Variety	Germination (%)	VI-1	VI-2	FE (%)	TSL (cm)	GF	SF	GSF
L_1: MTU7029 (Lot 1)	64.0d	689.77e	3.50f	66.00d	10.70e	0.64d	0.29e	0.18e
L_2: MTU7029 (Lot 2)	89.7b	2242.80cd	5.68de	88.00b	25.00c	0.89b	0.67c	0.60cd
L_3: Rajendra Swetha (Lot 1)	94.7a	2382.35c	6.35cd	94.25a	25.15c	0.94a	0.67c	0.64c
L_4: Rajendra Swetha (Lot 2)	94.0ab	3089.82a	7.15ab	93.15a	32.87b	0.94ab	0.88b	0.83a
L_5: Rajendra Swetha (Lot 3)	94.0ab	2956.40ab	7.02bc	90.25b	31.47b	0.94ab	0.84b	0.79ab
L_6: PB- 1 (Lot 1)	81.0c	2173.45cd	5.20e	80.25c	26.82c	0.81c	0.72c	0.58cd
L_7: PB- 1 (Lot 2)	84.0c	2733.35b	7.74a	81.75c	32.57b	0.84c	0.87b	0.73b
L_8: Sarju- 52	82.5c	2055.22d	6.70bc	80.00c	24.82c	0.82c	0.67c	0.55d
L_9: BPT 5204	91.0ab	2804.20b	5.02e	90.25b	30.85b	0.91ab	0.83b	0.75b
L_{10}: PB -1121	35.0f	902.50e	2.37g	34.25g	25.77c	0.35f	0.69c	0.24e
L_{11}: Swarna Sub -1	32.2f	800.77e	1.92g	24.00h	24.90c	0.32f	0.67	0.21e
L_{12}: Madhu	18.0g	329.47f	0.67h	16.00i	18.37d	0.18g	0.49d	0.09f
L_{13}: Sona	19.0g	337.30f	0.62h	38.00f	17.80d	0.19g	0.48d	0.09f
L_{14}: WGL -347	19.0g	336.35f	0.68h	16.25i	17.20d	0.19g	0.46d	0.09f
L_{15}: WGL-32183	58.0e	2121.12d	3.09f	56.00e	36.57a	0.58e	0.98a	0.57d
CD (p=0.05)	4.78	240.94	0.69	2.34	2.82	0.04	0.07	0.06
CV (%)	5.26	9.77	11.47	2.75	7.8	5.26	7.77	9.82

Germination–seedling factor (GSF)

Germination–seedling factor (GSF) values ranged from 0.09 to 0.83. Higher GSF values were observed in Rajendra Swetha (Lots 2 and 3), PB-1 (Lot 2), and BPT 5204, indicating combined effects of germination and seedling growth. Very low GSF values in Madhu, Sona, and WGL-347 further confirmed their poor vigour status. The components of the seedling vigour test, which includes the contribution of germination values with seedling length measured at final count, are responsible for a similar trend of response with respect to seedling vigour as that of germination potential of the tested seed lots. The study's findings are consistent with those of [11-12].

Table 3 Correlation between seed quality parameters and field emergence (%) in paddy

	Field emergence	Germination energy rate	Vigour indices -1	Vigour indices -2	Germination factor	Seedling factor	Germination seedling factor
Field emergence	1						
Germination energy rate	1.000**	1					
Vigour indices -1	0.859**	0.863**	1				
Vigour indices -2	0.299NS	0.311NS	0.376NS	1			
Germination factor	0.750**	0.758**	0.699**	0.852**	1		
Seedling factor	0.270NS	0.283NS	0.357NS	0.999**	0.836**	1	
Germination seedling factor	0.075NS	0.089NS	0.205NS	0.973**	0.711**	0.980**	1

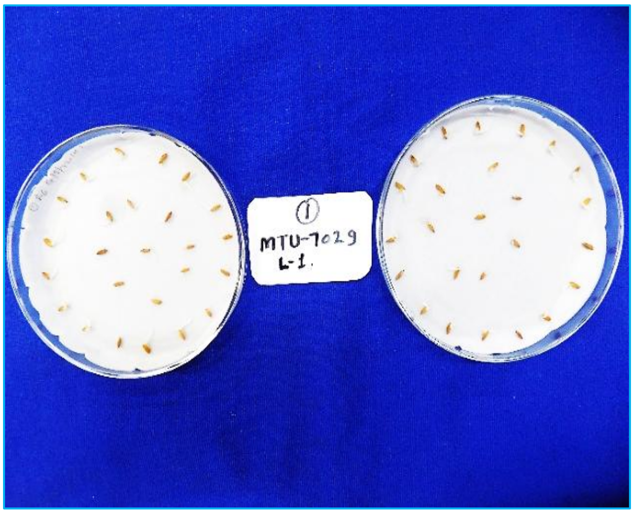

Plate 1 Radicle emergence in paddy seeds

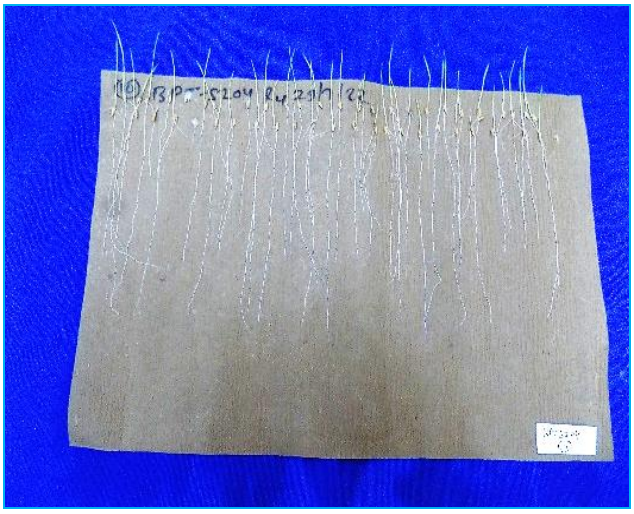
Plate 2 Germination in paddy seeds

Correlation analysis

Correlation analysis revealed a strong and significant positive association of field emergence with germination percentage and Vigour Index-I. Germination factor also showed a significant positive correlation with field emergence. In contrast, Vigour Index-II, seedling factor, and germination–seedling factor exhibited weak or non-significant correlations with field emergence. Strong inter-correlations were observed among germination factor (GF), seedling factor (SF) and germination seedling factor (GSF), indicating internal consistency among these indices. [13-16] showed that there are close relationships between seed testing results and emergence in the field under ideal environmental conditions.

The wide variation observed among paddy seed lots for radicle emergence, mean germination time (MGT), and vigour parameters highlights differences in physiological quality. Early radicle emergence and lower mean germination time (MGT) in high-vigour lots reflect better metabolic efficiency and membrane integrity, which are essential for rapid seedling establishment. The study clearly demonstrates that seed lots with higher germination percentage, Vigour Index-I, and germination factor consistently exhibited better field emergence. While parameters such as seedling length, seedling factor and germination seedling factor contributed to vigour assessment, they were less reliable as independent predictors of field performance. The strong association of germination percentage and Vigour Index-I with field emergence confirms their usefulness as reliable predictors of field performance. Vigour Index-I integrates both germination capacity and seedling growth, providing a more comprehensive assessment of seed lot performance than germination alone. Although composite indices such as germination seedling factor (GSF) showed strong inter-relationships with other vigour parameters, their weak association with field emergence limits their practical applicability. The findings emphasize that not all vigour parameters are equally effective in predicting field emergence and that crop-specific validation is essential before recommending vigour tests for routine use. These findings are consistent with earlier reports emphasizing that laboratory vigour tests, when integrated with germination, enhance the predictability of field emergence under variable conditions [16-19].

CONCLUSION

The study demonstrated significant variability in seed vigour among paddy seed lots and confirmed the importance of vigour testing for predicting field performance. Germination percentage, Vigour Index-I, and germination factor emerged as reliable laboratory indicators of field emergence. Combining germination percentage with Vigour Index-I provides a robust and practical approach for seed quality assessment and can assist seed technologists and farmers in ensuring uniform crop establishment. Furthermore, the strong association of germination energy rate (GER) with field emergence underscores its potential as an additional rapid and reliable parameter for assessing seed vigour and predicting early crop establishment under field conditions.

LITERATURE CITED

1. Finch-Savage WE, Bassel GW. 2016. Seed vigour and crop establishment: extending performance beyond adaptation. *Journal of Experimental Botany* 67(3): 567-591. https://doi.org/10.1093/jxb/erv490
2. Farooq M, Basra SMA, Kareem HA, Afzal I. 2004. Optimization of Seed hardening techniques for rice seed invigoration. *Emirates Jr. of Agric. Sciences* 16: 48-57.
3. Abdul-Baki AA, Anderson JD. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Science* 13: 630-633.
4. Jahn CE, Mckay JK, Mauleon R, Stephens J, McNally KL, Bush DR, Leung H, Leach JE. 2011. Genetic variation in biomass traits among 20 diverse rice varieties. *Plant Physiology* 155: 157-168.
5. Filho JM. 2015. Seed vigor testing: An overview of the past, present and future perspective. *Scientia Agricola* 72: 363-374.
6. Abdelmageed MS, Walaa SE. 2023. The relationship between seed vigor tests and field emergence of wheat lots. *Egyptian Journal of Agricultural Research* 101(4): 1054-1061. DOI: 10.21608/ejar.2023.227019.1424
7. International Seed Testing Association (ISTA). 1999. *International Rules for Seed Testing*. ISTA, Zurich.
8. Ellis RH, Roberts EH. 1980. Towards a rational basis for testing seed quality. *In*: (Eds) Seed Production. P. D. Hebblethwaite. pp 605-635.
9. Panse VG, Sukhatme PV. 1978. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi.
10. Sundararaj N, Nagaraju S, Venkataramu MN, Jagannath MK. 1972. *Design and Analysis of Experiment*. University of Agricultural Sciences, Bangalore.
11. Patil KG, Karjule A, Patel DA, Sasidharan N. 2019. Effect of accelerated ageing on viability and longevity of wheat (*Triticum aestivum*) seed. *Indian Journal of Agricultural Sciences* 89(6): 920-928. https://doi.org/10.56093/ijas.v89i6.90760.
12. Kumari N, Chaurasia AK, Mishra SN. 2021. Effect of accelerated ageing on quality, growth and yield in seeds (Artificial ageing techniques): Review. *The Pharma Innovation Journal* 10(7): 1750-1752. http://www.thepharmajournal.com.
13. Adebisi MA, Ajala MO, Rasaki NO. 2003. Comparison of seed vigour of sesame in laboratory and field tests. *Journal of Tropical Forest Resource* 19(3): 21-23.
14. Ghaderi-far MEMEF. 2011. The appropriate laboratory tests for predicting field emergence and performance of chickpea. *Seed Science and Biotechnology* 5(1): 21-24.
15. Jeong GS, Na YW, Shim SI, Kim SH. 2014. Application of seed vigour test for predicting field emergence in Azuki bean (*Vigna angularis* Wight). *Korean Journal of Crop Science* 59(3): 341-349. https://doi.org/10.7740/kjcs.2014.59.3.341
16. Biradarpatil NK, Rana S, Patil SS. 2023. Prediction of field performance of seed lots of groundnut (*Arachis hypogaea* L.) through vigour tests. *Legume Research* 46(11): 1467-1474. doi: 10.18805/LR-4458.
17. Khan AZ, Shah P, Mohd F, Khan H, Amanullah, Perveen S, Nigar S, Khalil SK, Zubair M. 2010. Vigour tests used to rank seed lot quality and predict field emergence in wheat. *Pakistan Journal of Botany* 42(5): 3147-3155.
18. Mersal I. 2011. The accuracy of accelerated aging test for evaluating the physiological quality of seeds. *Journal of Plant Production* 2(9): 1249-1258. https://doi.org/10.21608/jpp.2011.85655
19. Sharma S, Punia RC, Singh V, Mor VS, der H. 2017. Prediction of seedling establishment in field by using various seed vigour parameters in wheat (*Triticum* spp.). *International Journal of Current Microbiology and Applied Sciences* 6(11): 410-414.