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Identification of suitable vigour test for onion (*Allium cepa* L.) seeds

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Abstract
A laboratory experiment was conducted during 2018-19 to identify the suitable vigour test for onion in the Department of Seed Science and Technology, University of Agricultural Sciences, Dharwad. The experiment consisted of 15 seed lots with varied levels of germination and it was laid out in CRD design with four replications. All seed lots were subjected to different vigour tests *viz.*, standard germination, electrical conductivity, radicle emergence, accelerated ageing and field emergence. The results indicated that electrical conductivity (EC) was negatively correlated with field emergence and germination r = -0.906 and -0.866, respectively. The mean germination time and field emergence was correlated with r = -0.900. The correlation between electrical conductivity and mean germination time was 0.872. The EC test therefore appears to be suitable for evaluating seed vigour in onion seeds and could be further developed as a rapid vigour test.

Keywords: Germination, vigour, electrical conductivity, correlation, onion

Introduction
Onion (*Allium cepa* L.) is one of the commercially important vegetables and major among the bulbous crops belongs to the family Amaryllidaceae. Currently, the demand for onion is increasing, mainly due to its nutritive and medicinal value such as antibacterial and antioxidant effects (Doijode, 2001) [4]. The non availability of quality seeds coupled with poor germination and low seedling vigour are the serious problems limiting the production of onion. The use of physiological low quality seeds is a common practice under tropical and sub-tropical conditions leading to inadequate plant population in the field. Further the carry over seeds generally exhibit poor germinability, less vigour and decline in their ability to germinate and emerge into vigorous seedlings leading to problems in successful crop production. Therefore, a reliable estimation of seed vigour is of prime importance to determine the planting value of the seed crop particularly for ones that have poor storage ability like an onion (Yousof *et al*., 2016) [15].

Different types of vigour tests assess either directly or indirectly the potential performance of the seed lot and provide more sensitive information of a seed lot or between seed lots than the standard germination test. The extensive use of vigour assessments in quality control programme of the seed industry is encouraging (McDonald, 1995) [9]. Seed vigour is an effort to examine the activity and conductance for seed lots of acceptable germination. There are abundant criteria to evaluate seed vigour. This has developed some confusion among growers, seed companies and end users to depict laboratory results. Considering the importance of this subject, it is necessary to establish the relationship amongst some existing and new seed vigour tests for onion and anticipating the storability through these vigour tests. Considering the above factors, the current investigation was carried out with the objective to identify the suitable vigour test for onion.

Material and methods
Fifteen fresh seed lots of onion variety Arka kalyan having varied levels of germination were collected from Seed Unit, UAS, Dharwad. The seeds were subjected to different vigour tests *viz*., standard germination, electrical conductivity, radicle emergence, accelerated ageing and field emergence at Seed Quality Research Laboratory, National Seed Project, University of Agricultural Sciences, Dharwad. The experiment was laid out in CRD (Completely Randomised Design) with four replications. 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 (1985) [11] and Sundararaj *et al.*, (1972) [14]. Correlation and regression analysis was carried out.

Germination test was conducted as per the procedure given by International Seed Testing Association (Anon., 2013) [2]. The seedling vigour index was calculated by using the formula suggested by Abdul Baki and Anderson (1973) [1] by multiplying the germination percentage with total seedling length (cm).

Electrical conductivity of seed leachate was determined as per method given by Presley (1958) [12] by using five grams of seeds, which were surface sterilized by using 0.1 per cent mercuric chloride solution and washed twice with distilled water, 25 ml distilled water was added to the seeds and incubated at 25 ± 1 ºC temperature for 24 h. The electrical conductivity of the seed leachate was measured by digital conductivity bridge with a cell constant of 1.0 and the mean values were expressed in dSm^{-1}.

Accelerated ageing test was conducted by keeping the seeds uniformly on a single layer of wire mesh tray fitted in plastic boxes having 40 ml of distilled water at the bottom. The boxes were placed in accelerated ageing chamber after closing their lids. The seeds were aged at 40 ± 1 ºC temperature and about 95 per cent relative humidity for 48 h and then tested for germination by following the procedure given by Delouche and Baskin, (1973) [3]. The number of normal seedlings were counted and expressed in per cent.

Radicle emergence test was conducted by keeping seeds for germination by using paper towel method and number of seeds germinated was counted at 24, 36, 48, 60 and 72 h based on the two mm radicle emerged from seeds. The observation on mean germination time (MGT) was calculated by using the following formula given by Ellis and Roberts (1980) [5].

$$MGT = \sum (n\, t) / \sum n$$

Where,

n = Number of seeds germinated (radicle emergence of 2 mm,) at time‘t’ at 25 ºC

t = Hours from the beginning of the germination

∑n = Final germination

Field emergence test was conducted by sowing seeds at three cm depth with spacing of 30 × 10 cm. The seedlings with shoot length of one cm above the ground were counted as emerged. The total seedlings emerged upto 15 days after sowing were considered and emergence percentage was calculated.

Results and discussion

The results of the study indicated that the seed lots with varied level of germination. The lots exhibited variations in vigour levels also and this variation was not associated with germination. Among the seed lots, Lot 13 recorded higher germination (92.00 %), seedling vigour index (1840), germination after accelerated ageing (66.75 %), lower mean germination time (37.38 h). However, in radicle emergence test, this lot was ranked second by taking higher mean germination time (37.38 h) compared to Lot 11 (37.27 h). Least value for electrical conductivity was observed for Lot 3 (0.635 dSm^{-1}) which recorded germination of 80.00 per cent followed by Lot 13 (0.654 dSm^{-1}) which showed higher germination of 92.00 per cent among the seed lots. Lot 1 which recorded higher germination (83.00 %) than lot 3 recorded higher electrical conductivity (0.712 dSm^{-1}) indicating lower vigour potential than Lot 3. Higher field emergence (82.00 %) was recorded with Lot 11 which showed germination of 89.00 per cent followed by Lot 13 which recorded 81.75 per cent of field emergence. Lot 14 recorded lower germination (40.00 %), seedling vigour index (604) and field emergence (33.00 %) and higher mean germination time (41.36 h), electrical conductivity (1.173 dSm^{-1}) and was least vigorous among the lots. However, field emergence of Lot 2 was lowest, whereas the Lot 14 was lowest (Table 1).

Among the vigour tests, the correlation of seedling vigour index (SVI) was higher with germination (r = 0.988), followed by field emergence (r = 0.949), electrical conductivity (r = -0.866), germination after accelerated ageing (r = 0.923) and mean germination time (r = -0.852). However, as the seedling vigour index largely dependent on germination, the seedling vigour index may not be appropriate to consider it as an effective measure for assessing seed vigour. Among the other tests, the correlation of electrical conductivity was found to be negative with germination after accelerated ageing (r = -0.933), field emergence (r = -0.906) and was positive with mean germination time (r = 0.872). The germination after accelerated ageing which was positively correlated with field emergence (r = 0.925) and negatively correlated with mean germination time (r = -0.857). The mean germination time also negatively correlated with field emergence (r = -0.900) (Table 2).

The regression analysis showed that germination contributed higher variation to seedling vigour index (R^2 = 0.980), followed by germination after accelerated ageing (R^2 = 0.922), field emergence (R^2 = 0.911), electrical conductivity (R^2 = 0.768) and mean germination time (R^2 = 0.726) (Fig. 1-5). The results of correlation exhibited higher negative relationship between electrical conductivity and field emergence and mean germination time. The electrical conductivity showed greater relationship with germination. The mean germination time and electrical conductivity were also highly correlated with each other. The results are in agreement with Ilbi and Eser (2006) [7], in onion seeds. According to them, the electrical conductivity can be used to evaluate the vigour of seeds as it gives higher negative correlation (r = - 0.913) with that of germination test, because the conductivity is related with the amount of ions leached into the solution, which in turn is directly associated with the integrity of the cellular membranes; and reduced vigour. The relationship between field emergence and laboratory indices tests were significant, and the electrical conductivity test had the maximum R^2 value (0.93**). Standard germination doesn't always show seed lot potential performance, especially if field conditions are not optimal (Hampton & Tekrony, 1995) [6]. Seed vigour has a positive relationship with seedling emergence in the field. So, vigour tests evaluation based on predicting seed planting value is important in providing better results for classification of the quality and for indicating planting value of seed lots than the standard germination test. Seed lots that do not differ in germination may differ in deterioration level and may differ substantially in field performance, thereby a vigour test is considered to be powerful to identify the true potential of seed lots (Kolasinska *et al.*, 2000) [8]. Electrical conductivity estimated the seed vigour better and can be used for predicting field emergence. Thus, electrical conductivity test can be used as one of the test to evaluate onion seed vigour and identify lots with higher or lower field emergence potential (Ilbi and Eser, 2006) [7]. Similar results were obtained by Mohammadi *et al.* (2011) in soybean and Smyali Rana (2016) [13] in groundnut.

Table 1: Seed vigour parameters as influenced by levels of germination in onion seed

Seed lots	Germination (%)	Field emergence (%)	Seedling vigour index-I (SVI-I)	Electrical conductivity (dSm^{-1})	Germination after accelerated ageing (%)	Mean germination time (h)
L_1	83.00 (65.65)	70.75 (57.27)	1516	0.712	59.50 (50.37)	39.59
L_2	45.00 (42.11)	32.50 (34.61)	711	1.029	13.75 (21.68)	41.12
L_3	80.00 (63.48)	81.50 (64.54)	1567	0.635	56.75 (48.81)	37.57
L_4	62.00 (51.94)	61.00 (51.41)	1229	0.718	44.75 (41.92)	38.71
L_5	50.00 (44.98)	44.75 (41.90)	829	0.957	11.75 (19.95)	39.91
L_6	71.00 (57.40)	65.00 (53.77)	1287	0.849	48.75 (44.22)	39.32
L_7	68.00 (55.53)	61.75 (51.85)	1227	0.818	37.00 (37.43)	38.16
L_8	65.00 (53.73)	60.75 (51.21)	1233	0.736	44.00 (41.92)	39.28
L_9	77.00 (61.32)	60.00 (50.84)	1399	0.814	50.50 (45.17)	38.90
L_{10}	74.00 (59.36)	64.75 (53.55)	1342	0.783	48.50 (44.03)	39.24
L_{11}	89.00 (70.81)	82.00 (65.03)	1688	0.758	57.50 (49.20)	37.27
L_{12}	86.00 (68.03)	75.50 (60.41)	1674	0.668	58.75 (49.98)	37.91
L_{13}	92.00 (73.75)	81.75 (64.71)	1840	0.654	66.75 (54.72)	37.38
L_{14}	40.00 (39.21)	33.00 (35.00)	604	1.173	1.50 (6.53)	41.36
L_{15}	58.00 (49.59)	44.50 (41.71)	974	0.819	26.75 (31.07)	39.52
Mean	69.50 (57.12)	61.22 (51.86)	1274.85	0.803	39.11	39.1
SEm±	1.21	2.29	38.73	0.025	0.84	1.00
CD at (0.01)	4.38	6.64	150.63	0.097	3.27	3.88

* Figures in paranthesis indicates arcsine transformed values

Table 2: Correlation among the vigour tests at the initiation of storage period

	Germination (%)	Field emergence (%)	Electrical conductivity (dSm^{-1})	Seedling vigour index-I (SVI-I)	Germination after accelerated ageing (%)	Mean germination time (h)
Germination (%)	1					
Field emergence (%)	0.949**	1				
Electrical conductivity (dSm^{-1})	-0.866**	-0.906**	1			
Seedling vigour index-I (SVI-I)	0.988**	0.972**	-0.908**	1		
Germination after accelerated ageing (%)	0.923**	0.925**	-0.933**	0.955**	1	
Mean germination time (h)	-0.852**	-0.900**	0.872**	-0.896**	-0.857**	1

** Correlation is significant at the 0.01 level of probability

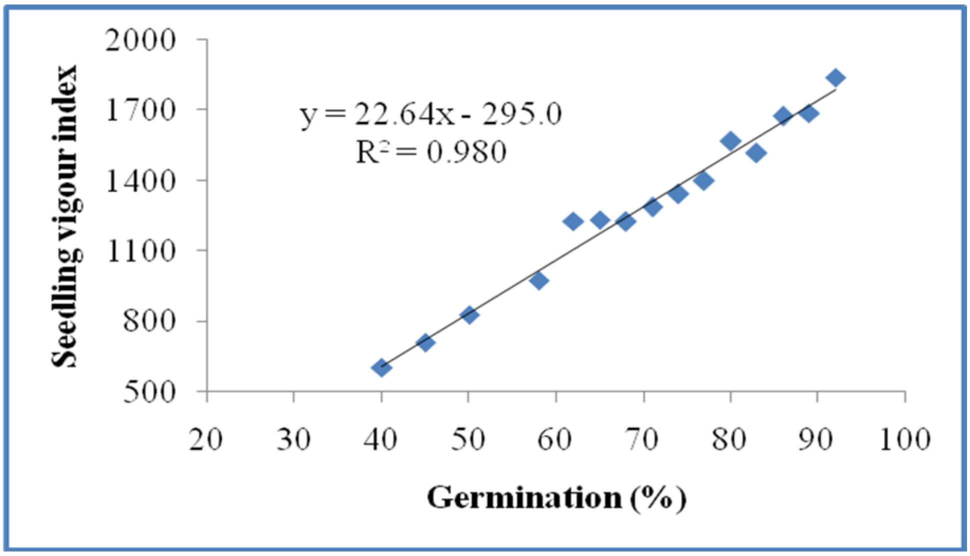

Fig 1: Relationship between germination and seedling vigour index (SVI)

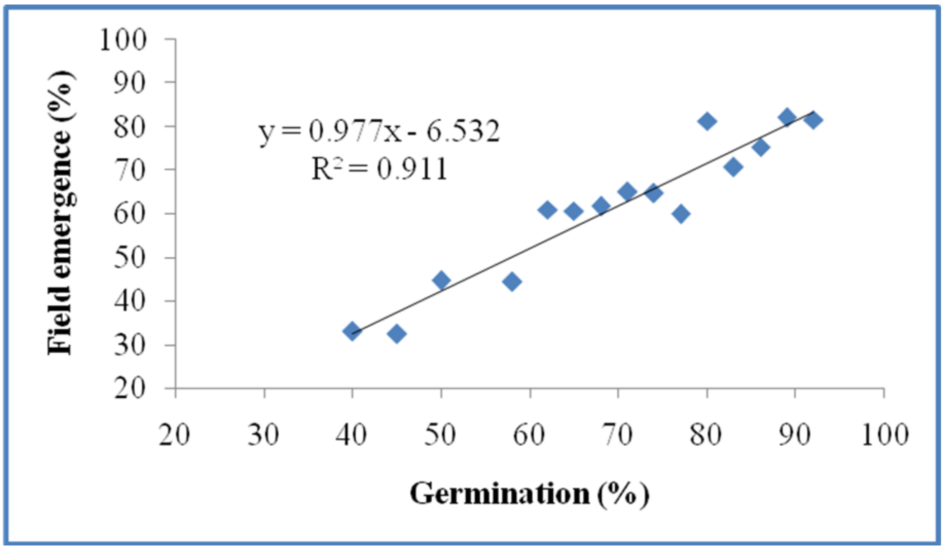

Fig 2: Relationship between germination and field emergence

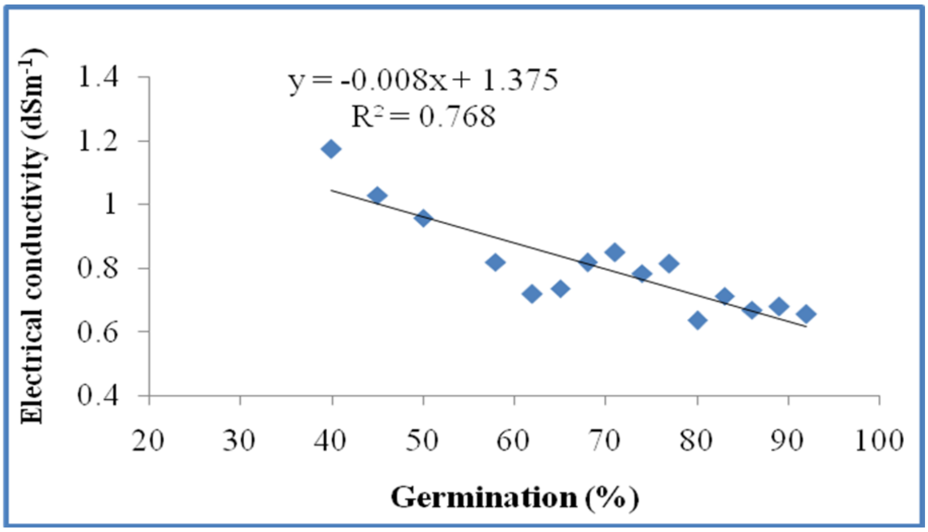

Fig 3: Relationship between germination and electrical conductivity

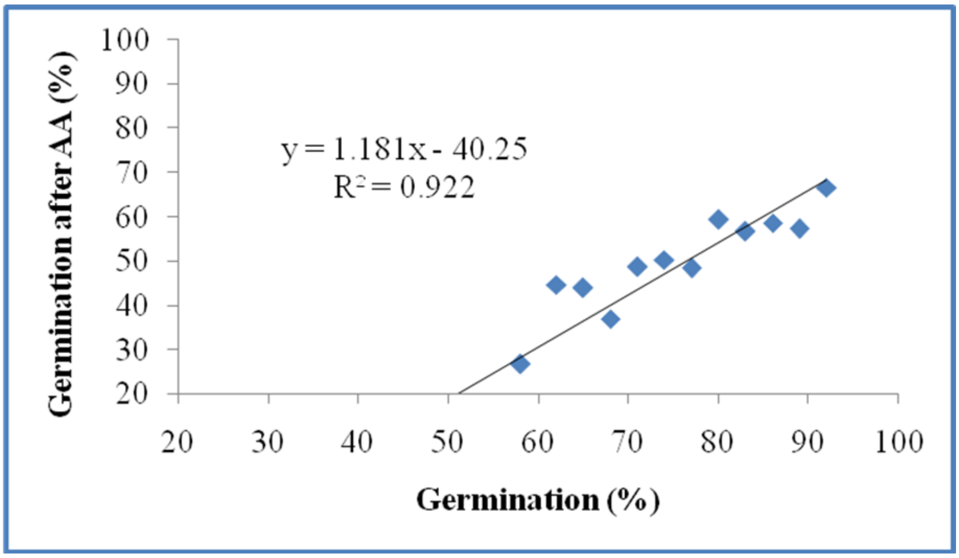

Fig 4: Relationship between germination and germination after accelerated ageing

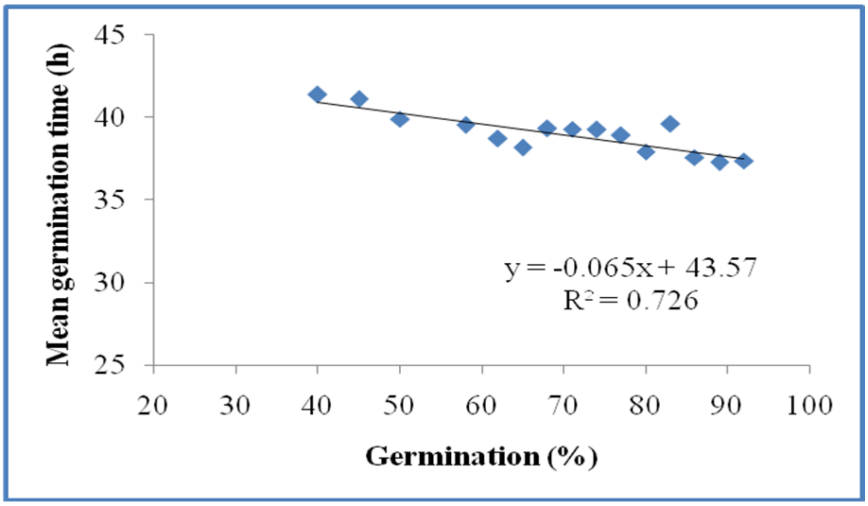

Fig 5: Relationship between germination and mean germination time

Conclusion

From the results it is concluded that EC test could be used as a sensitive index to predict potentiality of seed lots of onion as germination test was not able to predict the narrow variations present in the seed lots. Electrical conductivity test was able to provide the variation among the lots with similar germination percentage. Similarly, other vigour tests including the radicle emergence test which is recently recommended for estimation of vigour in some crops was also useful in assessing the vigour levels. This test being easy to carry out and is less time consuming could also be used in onion. The repeatability and reproducibility of these vigour tests need to be assessed in different laboratories.

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