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Controlled deterioration and paper-piercing tests predict seedling emergence potential in okra seed lots

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ABSTRACT

The present study was conducted to evaluate some of the available seed vigour tests to predict field emergence in okra (*Abelmoschus esculentus* L. Moench) seed lots. Twenty-one commercial seed lots of okra were evaluated by the following laboratory vigour tests: germination, speed of germination, vigour index, brick gravel test, paper-piercing test, accelerated ageing, controlled deterioration, dehydrogenase activity and electrical conductivity. The vigour tests were able to assess vigour differences among the seed lots. The seedling emergence percentage in the field ranged from 35% to 63% for these seed lots. The correlation coefficient of following laboratory vigour tests *viz*., standard germination, speed of germination, brick gravel test, paper-piercing test and controlled deterioration were significantly and positively correlated with field emergence. The vigour index I, vigour index II and dehydrogenase activity test were not significant with field emergence. Determination coefficient of seed lots for standard germination, speed of germination, brick gravel test, paper-piercing test and controlled deterioration were found significant and explains 49%, 50%, 52%, 83% and 87% of variation in field emergence, respectively. The regression analysis result for vigour indices (I and II), dehydrogenase activity test and cold test explains 4%, 9%, 2% and 7% of the variation in field emergence, respectively. The correlation coefficient and determination coefficient of controlled deterioration test and paper-piercing test were found highly significant among all other vigour tests in predicting seedling emergence of okra seed lots.

The results suggest that controlled deterioration and paper-piercing test can be successfully used to predict seedling emergence in okra seed lots.

1. Introduction

High quality seed is a critical input for profitable vegetable production and seed quality is also essential for obtaining good crop stand. Vegetable seed quality is also important due to their high price resulting from high quality control, maintenance and high production cost. Vegetable growers are becoming more interested in laboratory based seed tests that can help in predicting emergence so that crop production schedule can be precisely matched to meet market demand. Poor quality seed sources can result in suboptimal crop stand and considerable loss in production. The standard germination test is commonly used to evaluate seed quality and guide farmers in deciding the quantity of seed to be sown. Under optimum field conditions, standard germination test may predict seedling emergence in the field. Field conditions are often suboptimal and vigour tests provide additional information on rate and uniformity of seedling emergence under wide range of environmental conditions (Mavi and Demir, 2007; Powell and Matthews, 2005).

The evaluation of vigour tests to predict seed-planting value has gained importance in recent years and many seed companies use one or more vigour tests in their quality control performances. Many vigour tests for different crop species have been proposed (AOSA, 1983; ISTA, 1995, 2006, 2013). Of the many vigour tests studied, accelerated ageing (Hampton and Tekrony, 1995) and controlled deterioration (Powell and Matthews, 2005) have been successfully used to predict field emergence potential of seed lots of various crops such as onion, carrot (Matthews, 1980). melons (Mavi and Demir, 2007), pumpkin and zucchini (Dutra and Vieira, 2006). Compared to standard germination test, electrical conductivity test was most reliable for predicting seedling emergence of radish (Demir et al., 2012) and cabbage in transplant modules (Matthews et al., 2009). Electrical conductivity (EC) test for garden pea (*Pisum sativum*) is one of the vigour tests included in the ISTA Rules for Seed Testing (ISTA, 2006). Brick gravel test (Perry, 1981) showed significant and positive coefficient of correlation with field

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emergence in muskmelon (Pandey et al., 1990). Jha et al. (1986) concluded that paper-piercing test is an excellent guide to evaluate vigour differences among different seed lots.

Seed vigour is now accepted as an important seed quality component but vigour testing on a regular basis is carried out for only a few species. According to Kolasinska et al. (2000), seed quality tests should relate to field emergence. Although a number of vigour tests have been used to assess the vigour status of seed lots based on physical, physiological and biochemical characters of the seed, no single test has given satisfactory reproducible results with regard to field emergence or yield. No single test has yet been identified for rating the seed vigour across the crops. Researchers also have had limited success in predicting the germination performance of okra seed lots in the field.

Therefore, in the present study, attempts have been made to identify dependable vigour test for predicting seedling emergence potential of okra seed lots.

2. Materials and methods

Twenty-one seed lots of okra (*Abelmoschus esculentus* (L.) Moench) variety Pusa Sawani (lot 1–7), Pusa A-4 (lot 8–14) and Arka Anamika (lot 15–21) were collected from public and private seed producing agencies for evaluation of vigour tests. The seed lots were hermetically sealed in aluminium foil and stored at room temperature. Standard germination was performed according to ISTA (1993) protocols, using 100 seeds per replicate and 4 replicates. Seeds were incubated in growth cabinets (Sanyo, Japan) maintained at 25 °C. Daily germination counts were performed until no further germination occurred for three consecutive days. Speed of germination was estimated by the method suggested by Maguire (1962). The seedling vigour index I was calculated by multiplying the sum of root and shoot length (cm) by standard germination per cent and vigour index II was calculated by multiplying mean seedling dry weight (g) and germination per cent (Abdul-Baki and Anderson, 1973). The brick gravel test was conducted as per the procedure given by Perry (1981). Seeds from each lot were placed on uniform layer of moist brick grit of 3 cm thickness in a plastic box. Seeds were then covered further with a layer of gravel. The boxes were covered with lids and held in dark at 20 °C for 7 days. The lids were removed after the seedlings have emerged. Germination potential of seed lots were compared on the basis of the percentage of seeds that produce seedlings.

For paper-piercing test, seeds were planted on moist sand layer of 2 cm in the plastic boxes (30 × 21 × 9 cm) and were covered with selected dry filter paper. These filter papers were again covered with 3 cm moist sand. Boxes were then kept at 25 °C for 21 days to take final count. The seedlings, which are able to penetrate the paper, were considered vigorous (Fritz, 1965). The controlled deterioration test was conducted on samples of the seed lots held at 20% moisture content before they were aged at 45 °C (Powell and Matthews, 1981, 2005). The seed moisture content was raised by placing seeds of known moisture content on moist germination papers and allowed to imbibe water until they reach the required moisture content. The achievement of this raised moisture content was checked by frequent re-weighing. Final seed moisture content was calculated from the initial seed weight by following the formula:

$$\text{Seed weight at desired m.c.} = \frac{100 - \text{initial m.c.}}{100 - \text{desired m.c.}} \times \text{weight of seed}$$

The seeds were then sealed in aluminium foil packets. The packets were then held overnight at 10 °C for the moisture to equilibrate throughout the seed. These were then incubated for 72 h. Subsequently germination test was conducted and seeds showing radical emergence were considered as germinated. The accelerated ageing test was conducted according to the procedure described by Hampton and Tekrony (1995). Samples from each seed lot were drawn and spread out in thin layer in nylon net bag. These bags were kept in ageing chamber, subjecting the seeds to 40 °C and 100% RH. Seeds were removed after 7 days and germination test was carried out after drying the seed for 3–4 h at room temperature. Seed producing an identifiable seedling regardless of their size was criterion of germination.

Four replicates of 50 seeds were soaked in 250 ml of distilled water for 24 h at 20 °C. The conductivity was measured using a digital conductivity metre (Systronics, India) and expressed as $\mu S\,cm^{-1}\,g^{-1}$ seed weight. Dehydrogenase activity was estimated following the method given by Kittock and Law (1968). Twenty seeds for each replication were preconditioned and prepared before staining in 1% TZ solution (2,3,5-triphenyl tetrazolium chloride) for 5 h in dark at 25 °C. Excess solution was drained out and seeds were washed thoroughly. To the stained seeds 5 ml of methyl cellosolve was added and left for 4–6 h with occasional stirring to extract the red colour formazan. The red coloured formazan containing methyl cellosolve was decanted into the test tubes. The intensity of decanted solution was read at 480 nm in a spectrophotometer (Beckmann DU-640, USA) using methyl cellosolve as blank.

Three replicates of 100 seed each of 21 seed lots were sown in the experimental field of the Seed Production Unit, Indian Agricultural Research Institute, New Delhi, for field emergence studies. Emerged seedlings were counted daily until emergence ceased. Data were subjected to analysis of variance and means were compared using Statistical Package for Social Sciences (SPSS). All the replicated data were subjected to Duncan's multiple range test. Correlation coefficients (r) of various vigour tests with field emergence were calculated. The significance of the fitted model was assessed by R^2 (coefficient of determination).

Table 1
Initial standard germination (SG%) and field emergence (FE%) of okra seed lots.

Lot	SG%	FE%	Lot	SG%	FE%
1	73	39efg	12	67	37fg
2	82	47cde	13	84	53bc
3	67	39efg	14	73	44cdefg
4	73	49bcd	15	93	63a
5	71	46cdef	16	89	57ab
6	71	50bcd	17	87	50bcd
7	77	41defg	18	89	47bcde
8	67	36 g	19	87	38efg
9	69	36 g	20	87	52bc
10	73	35 g	21	88	50bcd
11	74	49bcd	NA	NA	NA

Means with different letters are significantly ($P = 0.05$) different.

3. Results and discussion

Field emergence of 21 okra seed lots ranged from 35% (Lot 10) to 93% (Lot 15) with significant ($P < 0.05$) differences among lots (Table 1). There were vigour differences among seed lots and vigour tests were able to identify seed lots with differing physiological potential as indicated by differences in germination and other physiological parameters after performing these tests in okra (Table 2). The ranking of lots was not always the same between different vigour tests. The relationship between various vigour tests results and field emergence of twenty-one seed lots of okra was studied by determining simple correlation coefficient (Table 3). Germination tests have long been established as standard means to evaluate seed quality. The laboratory germination test provides information about the seedling emergence potential of seed lots under favourable sowing conditions. Standard laboratory germination tests may fail to predict emergence under suboptimal