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Prediction of seedling establishment in Coriander (*Coriandrum sativum* L.) based on laboratory tests

RK SINGH*, SS VERMA AND RAJESH KUMAR[2]

Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar, Haryana, India

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ABSTRACT

The relationship between various laboratory tests with field establishment (%) was studied in coriander. The field establishment had significant positive correlation with SG (r = 0.99), AA test (0.98) and tz test (r =0.92) while others were non-significant. Therefore, these three tests were found reliable in the prediction of field establishment. The tests like standard germination and the accelerated ageing test could predict field establishment to a reliable level (R^2=0.98) and (R^2=0.97), respectively. The importance and implications of these tests have been discussed in relation to field establishment.

Keywords: Coriander (*Coriandrum sativum* L.), seed vigour, seedling establishment

INTRODUCTION

Coriander (*Coriandrum sativum* L.) is an annual herb (2n=22), which belongs to the family Apiaceae and generally grown in winter season as main crop in India. All parts of the plant are edible, but the fresh leaves and the dried seeds are most commonly used in cooking (Choudhary *et al.*, 2017). This is mainly used as a spice for adding taste and flavour in different food stuff. It is widely used as a spice, in folk medicine and in the pharmacy and food industries. Coriander seed oil is one of the 20 major essential oils in the world market and it is known to exert antimicrobial activity (Burdock and Carabin, 2009).

Seed viability and vigour are the most important attributes of the seed which, with the passage of time, lead to a reduction in seed quality, performance and stand establishment. This is a major economic concern in agricultural production (McDonald, 1999). Therefore, a need always arises to have an idea about the quality of seed which is being purchased for crop production purposes.

The seed vigour as a quality attribute has gained wide significance as the germination test, sometimes, does not reflect field performance potential of a seed lot of any variety under varying field conditions. The loss of seed viability in storage is preceded by a wide range of symptoms which collectively contribute to the loss of seed vigour. The loss of seed vigour usually reflected in the lack of uniformity and decreased field emergence. However, seed vigour determines the performance potential of seed under varying field conditions. The advantages of high vigour seed are most often associated with the rapid and high rate of emergence and stand establishment. Generally, the germination standard alone does not give an actual estimate of field performance of any seed lot. So, there is need to have some reliable parameters for evaluation of the seed quality in coriander. In order to assess the seed quality of different varieties of coriander in terms of field performance, the seeds were subjected to a number of tests which can be used reliably to predict crop establishment under the field conditions.

MATERIALS AND METHODS

The factorial experiment in Completely Randomized Design (CRD) as well as in Randomized Block Design (RBD) has been conducted for laboratory and field parameters, respectively. Hundred seeds per replication for individual varieties were placed separately between two layers of moist germination paper (BP) and then kept in seed germination at 20^{0}C for a standard germination test. The final count of normal seedlings was made on the 21st day and expressed as per cent germination. The vigour indices were calculated according to the following formulae (Abdul Baki and Anderson, 1973).

Vigour Index–I: Standard germination (%) x Seedling length (cm)

Vigour Index–II: Standard germination (%) x Seedling dry weight (mg)

The seeds were aged at 40±1°C temperature and 100 percent RH for 96 h for accelerated ageing test and then tested for germination according to ISTA (1999). Viability test (Moore, 1973) based on three replications of 50 seeds were conducted by soaking seeds in 50 ml water for 16 h at 25^{0}C to activate dehydrogenase enzymes. After removal of the seed coat, the seeds were stained in 1.0 per cent tetrazolium solution (2, 3, 5-triphenyl tetrazolium chloride) for 4 h at 38^{0}C. The DHA test was carried by measuring tetrazolium reduction ability by the enzyme dehydrogenase. One gram seed of each coriander variety replicated thrice were ground to pass through a 20 mesh screen. The ground sample (200 mg) was soaked in 5 ml of 0.5% tetrazolium solution at 38^{0}C for 4 h. Then it was centrifuged at 10,000 rpm for 3 minutes and the supernatant was poured off. The formazan was extracted by adding 10 ml acetone for 16 h at room temperature. It was then again centrifuged for 3 minutes at 10,000 rpm. The acetone solution containing formazan was transferred to the cuvette. The absorbance reading of the solution was taken at 520 nm wavelength using Systronics Spectrophotometer 169. To measure the electrical conductivity, 50 normal and uninjured

[1]*Present address: Central Potato Research Station, Sahaynagar, Patna-801506 (Bihar).*
[2]*Department of Vegetable Science CCS Haryana Agricultural University, Hisar, Haryana, India*
*Corresponding Author Email: rksingh.cprs@gmail.com

seeds in three replications were soaked in 250 ml deionized water. Seeds were immersed completely in water and beakers were covered with aluminium foil. Thereafter, these samples were kept at 20^{0}C for 24 h. The electrical conductivity of the seed leachates was measured using a direct reading conductivity meter.

The conductivity was expressed in µS/cm/g. The pH exudates test is based on the principle that as seed deterioration progresses, the cell membrane becomes less rigid and more water permeable, allowing the cell contents especially acidic and hydrogen ions to escape into solutions with water resulting in lower pH. Three replications of fifty seeds from each variety were imbibed in distilled water for 20 h at 25^{0}C constant temperature. After imbibition, the pH was determined using a digital pH meter.

The mean weight of three replicates of 1000 seeds of each variety was recorded in grams up to two decimal places on electronic balance for calculation of test weight (TW). For field emergence index, the number of seedlings emerged were counted on every alternate day up to seedling establishment (30th day) and the field emergence index (speed of emergence) was calculated as:

$$\text{Field emergence index} = \frac{\text{No. of seedlings emerged}}{\text{Day of First count}} + \text{----} + \frac{\text{No. of seedlings emerged}}{\text{Day of the last count}}$$

Using the daily counts, the mean emergence time (MET) was calculated for each lot using the formula (Ellis and Roberts, 1980)

MET = (Dn)/⊚n

Where n = number of seeds which emerged on day D

D= the number of days counted from the planting

In the field experiment, seeds of twenty coriander varieties were split and sown in shallow lines made in prepared beds. Five lines were maintained in each plot containing 100 seeds in each row. The seedling establishment (SE) per cent was determined by counting the total number of seedlings when the emergence was completed or when there was no further addition in the final emerged seedlings. The data obtained from experiments conducted in CRD and RBD were analyzed as per standard method (Panse and Sukhatme 1967).

RESULTS AND DISCUSSION

Growth and Vigour

In the present study, different seed lots of twenty coriander varieties were evaluated with a view to have substantial information on their vigour parameters. The mean sum of squares due to varieties was highly significant for all the parameters which indicated the presence of substantial amount of variability among the varieties. A perusal of data presented in revealed that coriander varieties showed variation in respect of different vigour parameters (Table 1). The maximum germination per cent was recorded with H. Surbhi (94.7%) and minimum (58%) with Swathi and Sadhana. Coriander varieties namely, H. Anand, H. Sugandh, H. Bhoomit and RCr-446 were at par with H. Surbhi. The maximum value for vigour index-I and vigour index-II was recorded in H. Surbhi while the minimum in Swathi. The maximum value for the accelerated ageing test was recorded in H. Anand (42.3%) and the minimum value in Swathi and Sadhana (26.3%) varieties. The coriander varieties like RCr-684, RCr-480, RCr-446, RCr-41, H. Bhoomit, H. Sugandh and H. Surbhi were found at par with H. Anand. The germination retention in all coriander varieties varied from 42.6 to 46.1% after the accelerated ageing test. H. Bhoomit recorded maximum viability (99%) whereas Swathi recorded minimum value (74%). However, all varieties were significantly superior over Sadhana and Swathi which were at par. The maximum value for Dehydrogenase activity was recorded in RCr-436 (1.72) and minimum in GC-1 (0.18) and all varieties were found significantly superior over GC-1. For pH, all varieties were found significantly superior over RCr-41. Coriander varieties such as GC-1 and H. Surbhi recorded maximum (0.48) value for EC while the minimum (0.24) was found in RCr-41, RCr-435 and RCr-446. All coriander varieties were significantly superior over RCr-446 except H. Bhoomit, RCr-41 and RCr-435 which were at par.

The maximum test weight was recorded for Sindhu (17.5 g) and minimum for H. Bhoomit (7.4 g). All varieties were found significantly superior to H. Bhoomit for test weight. The maximum value for field emergence index was recorded in JD-1 (42.9) and the minimum in H. Bhoomit (12.1). All varieties were found significantly superior to H. Bhoomit except NRCSS ACr-1, Sadhana, Sindhu and Sugandh which were at par.

The maximum value for mean emergence time was recorded in H. Bhoomit (20.2) and minimum in JD-1 (16.9). All varieties were found significantly superior over JD-1 except RCr-684 which was at par. The maximum seedling establishment per cent was recorded in H. Sugandh (43.1) and the minimum in Sadhana (43.1). All coriander varieties were found significantly superior over Sadhana except Swathi and Sudha which were at par. Overall maximum vigour potential was shown by GC-2, CS-6, H. Anand, H. Surbhi, RCr-435, RCr-436 and RCr-480 varieties, which showed superiority for almost all vigour parameters. It is reported by researchers that varieties subjected to vigour tests showed variation for different vigour parameters and that could be correlated for the evaluation of field performance of the varieties (Chauhan, 2003 and Lal *et al.*, 2017).

Correlation

The correlation study among various vigour parameters such as accelerated ageing test, standard germination, tetrazolium test and seedling establishment was found informative in quality assessment of the seed lots of coriander varieties. Standard germination and tetrazolium test were found positively associated with the seedling establishment (Table 2). It is well known and widely accepted that a seed lot with high vigour and viability will also give better performance in field conditions. The accelerated ageing test provided the information in respect of storability and capacity of seeds to tolerate stress. In the present study, a gradual reduction in normal seedling was observed which declined faster with the advancement of stress period when seeds were subjected to the accelerated ageing test. Further, it was also observed that small seeds showed less reduction compared to big seeds that showed their capability to retain germinability longer. The accelerated ageing was positively and significantly associated with the seedling establishment and standard germination.

Table 1: Mean values for various vigour parameters in different varieties of coriander (*Coriandrum sativum* L.)

Varieties	SG	VI-I	VI-II	AAT	Tz	DHA	pH	EC	TW	FEI	MET	SE
GC-1	65.7 (54.11)	2050	320	29.7 (32.98)	81	0.18	5.74	0.38	13.5	21.5	18.6	52.3 (46.29)
GC-2	79.7 (63.33)	2256	263	36.0 (36.85)	95	0.3	5.56	0.30	12.6	20.6	18.8	63.7 (52.94)
JD-1	83.0 (66.38)	1953	266	36.0 (37.62)	98	0.25	5.83	0.28	10.0	42.9	16.9	67.8 (55.42)
CS-6	74.3 (59.64)	2367	366	33.7 (35.44)	90	0.31	5.82	0.33	15.7	23.9	18.9	61.1 (51.38)
NRCSSACr-1	77.0 (61.52)	2147	268	34.7 (36.04)	94	0.37	5.60	0.30	8.8	15.6	19.0	62.0 (51.96)
Swathi	58.0 (49.59)	1471	155	26.3 (30.86)	74	0.4	5.61	0.29	16.4	26.8	18.4	47.8 (43.72)
Sadhana	58.0 (49.58)	1529	205	26.3 (30.85)	75	0.43	5.70	0.27	16.9	18.3	18.6	43.0 (40.95)
Sindhu	76.3 (61.01)	2150	265	34.3 (35.84)	91	0.48	5.79	0.32	17.5	17.6	18.5	58.7 (49.98)
Sudha	64.0 (53.11)	1705	166	29.0 (32.55)	83	0.55	5.54	0.28	16.5	24.1	18.6	50.2 (45.10)
H Anand	94.3 (76.21)	2902	343	42.3 (40.57)	97	0.51	5.71	0.32	14.8	20.9	18.8	77.7 (61.79)
H surbhi	94.7 (76.80)	3280	417	40.3 (40.78)	98	0.36	5.59	0.38	13.1	30.6	17.9	76.3 (60.86)
HSugandh	91.7 (73.37)	2678	388	41.7 (40.19)	96	0.38	5.75	0.32	15.2	18.3	19.2	78.1 (62.16)
HBhoomit	94.0 (76.19)	1998	263	40.7 (40.76)	99	0.36	5.58	0.25	7.4	12.1	20.2	77.6 (61.79)
RCr- 20	66.0 (54.33)	1546	215	29.7 (32.98)	84	1.24	5.64	0.32	14.7	22.1	18.9	53.4 (46.94)
RCr- 41	86.7 (68.58)	2137	179	39.0 (38.63)	96	1.08	5.46	0.24	8.8	23.2	18.9	71.1 (57.59)
RCr- 435	68.7 (55.96)	1890	314	31.0 (33.80)	86	0.25	5.81	0.24	10.9	20.5	18.5	53.7 (47.11)
RCr- 436	75.0 (60.05)	2421	364	34.0 (35.65)	91	1.72	5.83	0.27	13.9	27.2	18.4	60.0 (50.80)
RCr- 446	88.3 (70.35)	2332	192	39.0 (39.21)	95	1.15	5.75	0.24	10.9	20.5	18.2	69.7 (56.64)
RCr- 480	86.7 (68.84)	2669	288	40.0 (38.62)	95	0.42	5.58	0.30	10.3	19.9	18.7	71.7 (57.91)
RCr- 684	85.3 (67.51)	2533	355	38.3 (38.23)	95	0.51	5.83	0.33	14.8	27.5	17.8	68.1 (55.78)
Range	58.0-94.7	1471-3280	155-417	26.3-42.3	74-99	0.18-1.72	5.46-5.83	0.24-0.48	7.4-17.5	12.1-42.9	16.9-20.2	43.0-78.1
Over all mean	78.37	2200.80	280.00	35.10	90.65	0.56	5.69	0.30	13.13	22.70	18.59	63.20
CD at 5%	7.943	315.3	53.15	4.212	4.641	0.017	0.040	0.017	0.068	6.377	0.988	8.372

SG= Standard germination, VI-I= Vigour index-I, VI-II= Vigour index-II, AAT= Accelerated ageing test, Tz= Tetrazolium test, DHA= Dehydrogenase activity test, EC= Electrical conductivity, TW= Test weight, FEI= Field emergence index, MET= Mean emergence time, SE=Seedling establishment

Table 2: Correlation coefficients (r) among various vigour parameters in coriander (*Coriandrum sativum* L.)

Vigour parameters	SG	VI-I	VI-II	AAT	Tz	DHA	pH	EC	TW	FEI	MET	SE
SG	1.000	0.797**	0.468*	0.991**	0.940**	0.003	-0.065	0.169	-0.482*	-0.007	0.079	0.990**
VI-I		1.000	0.765**	0.808**	0.718**	-0.035	0.096	0.341	-0.116	0.078	-0.095	0.781**
VI-II			1.000	0.473*	0.449*	-0.178	0.480*	0.391	0.055	0.118	-0.076	0.473*
AAT				1.000	0.933**	0.019	-0.061	0.131	-0.459*	-0.058	0.117	0.987**
Tz					1.000	0.033	-0.016	0.085	-0.565**	0.071	0.008	0.923**
DHA						1.000	0.008	-0.304	-0.007	0.043	0.003	-0.011
pH							1.000	0.016	0.308	0.279	-0.424	-0.089
EC								1.000	0.311	0.230	-0.219	0.167
TW									1.000	0.068	-0.161	-0.484*
FEI										1.000	-0.859**	0.002
MET											1.000	0.121
SE												1.000

* Significant at 5%
** Significant at 1%
SG= Standard germination, VI-I= Vigour index-I, VI-II= Vigour index-II, AAT= Accelerated ageing test, Tz= Tetrazolium test, DHA= Dehydrogenase activity test, EC= Electrical conductivity test, TW= Test weight, FEI= Field emergence index, MET= Mean emergence time and SE= Seedling establishment

Table 3: Relationship between actual and estimated values of seedling establishment (%) based on various laboratory tests in coriander (*Coriandrum sativum* L.)

Kind of test	Actual value	Estimated value	Correlation (r)	Regression equation (Y= a + bx)	R^2
Standard germination (%)	78.37 (58.0-94.7)	63.20 (45.1- 77.7)	0.990**	-6.2883 + 0.8866 (x_1) (58.0-94.7)*	0.980
Tetrazolium test (%)	90.65 (74- 99)	63.20 (41.5- 74.1)	0.923**	-54.7260 + 1.3009 (x_3) (74- 99)*	0.851
Accelerated ageing test (%)	35.10 (26.3- 42.3)	63.20 (44.9- 78.2)	0.987**	-9.9200 + 2.0832 (x_4) (26.3- 42.3)*	0.974
Pooled	--	63.24 (45.4- 77.9)	--	-3.3859 + 0.6459(x_1) + (-0.0011) (x_2) + (-0.1124) (x_3) + 0.8153 (x_4)	--
Seedling establishment (%)	63.20 (43.0- 78.1)	--	--	--	--

* Range in various laboratory tests value over which Regression equation can be applied
** Significant at 1%
*** Seedling establishment is dependent parameter while others are independent Figures in parentheses indicate range

Kavak *et al.* (2008) found the highest correlation among controlled deterioration, germination and field emergence. Mor *et al.* (2009) reported that field emergence index and seedling establishment were significantly and positively correlated with standard germination, speed of germination, seedling length, seedling vigour index, accelerated ageing

test, Dehydrogenase activity, respiration rate and test weight (g) whereas significant and negative correlation was observed with EC and seed density (g/cc). Field emergence exhibited significant correlation with germination at first count in the majority of cultivars, thus can be used to predict field emergence (Lal *et al.*, 2017).

Regression analysis

The regression analysis among standard germination and different vigour parameters revealed that tetrazolium test and the accelerated ageing test could be used as reliable predictors for standard germination (Table 3). The highest R^2 value was obtained for accelerated ageing test followed by tetrazolium test. Similarly, accelerated ageing test, tetrazolium test and standard germination could be used as reliable predictors for prediction of seedling establishment. The maximum R^2 value was recorded for standard germination (0.980) and accelerated ageing test (0.974) followed by tetrazolium test (0.851), endorsing the reliability of tests. Samarah *and* Abu-Yahya (2008) also found standard germination, seedling dry weight and accelerated ageing test as the best test to assess seed quality of chickpea.

CONCLUSION

It can be concluded that maximum vigour potential was shown by GC-2, CS-6, H. Anand, H. Surbhi, RCr-435, RCr-436 and RCr-480 varieties which showed superiority for almost all vigour parameters. Standard germination, Tetrazolium test and the Accelerated ageing test could be the most suitable predictors for seedling establishment in coriander. The maximum R^2 value was recorded for standard germination (0.980) and accelerated ageing test (0.974) followed by tetrazolium test (0.851), endorsing the reliability of tests. Highly significant but negative correlation was found between test weight and Tz test of coriander varieties, which indicated that bigger seeds lost viability sooner than smaller.

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