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Studies on seed vigour tests and their correlation with field emergence in pigeonpea (*Cajanus cajan*)

K. KANAKA DURGA, N. MANOHAR REDDY, K. KESHAVULU, M. JYOTHI, R. ANKAIAH AND M. GANESH

Seed Research and Technology Center, Rajendranagar, Hyderabad 500 030
keshava_72@yahoo.com

ABSTRACT Studies on seed vigour tests and their association with field emergence in pigeonpea (*Cajanus cajan* L.) seed quality were conducted at Seed Research and Technology Center, Rajendranagar, Hyderabad. The studies were carried out on fresh and carry over seed lots of three cultivars for various vigour tests which includes germination test, first count, final count, total seedling length, seedling dry weight, seedling vigour index I and II. The results were correlated with field emergence. Irrespective of test media for germination, seed vigour tests of first count and final count showed that germination was higher in fresh seeds (FL) than carry-over (CL) seeds of all the genotypes. Germination decreased gradually with increased storage in all the varieties of pigeonpea in both between paper and sand media. Similar trend was noticed for seedling dry weight, seedling vigour index I and II. Fresh seed lots of Asha, Laxmi and Palnadu varieties recorded 23.56%, 29.0% and 9.98% increase in field emergence index over aged lots. The first and final counts of germination, seedling vigour index I and II, calculated under laboratory conditions, significantly correlated with field emergence index and field emergence. The results demonstrated that seedling vigour tests such as germination, seedling vigour index and electrical conductivity of seed leachates were the most sensitive indicators in prediction of field emergence of pigeonpea in fresh and carry-over seed lots.

Key words: Correlation, field emergence, pigeonpea and seed vigour tests

The most important facet for crop production and productivity is the availability of good quality seed of assured genetic and physical purity, germination, vigour and health of highest possible standard. The standard germination test is used widely for assessing the physiological quality of seeds. Germination test is an excellent measure of seed quality, provided seeds are planted in ideal conditions [1]. But such conditions rarely exist and hence germination test tends to over predict field emergence. Delouche [2] reported that germination test was insensitive to external environment and a misleading measure of seed quality, as it focuses primarily on final consequences of deterioration and fails to account for substantial loss in performance due to physico-chemical changes in the seed. Thus, seed lots that indicate similar quality during germination test may differ in terms of field performance. The relationship between laboratory tests and field emergence is hence, complex and the ability of laboratory tests to predict the field emergence is variable and strongly dependent on the vigour [3]. Germination, vigour index and field emergence potential of both unaged and aged seeds have been considered as most desirable traits to judge the ultimate seed quality and storage potential [4]. Though pigeonpea is one of the important pulse crops, the literature pertaining to seed vigour in relation to field emergence is scanty. With this back drop the present study was undertaken to study the seed vigour tests and their correlation with field emergence in pigeonpea.

MATERIALS AND METHODS

Three different varieties of pigeonpea *viz*. Palnadu (LRG 30), Laxmi (ICPL 85063) and Asha (ICPL 87119) were used for studying seed vigour and

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their correlation with field emergence. The study was conducted at SRTC, Rajendranagar, Hyderabad. Four seed lots of pigeonpea *viz.* fresh seed lots FL_1 and FL_2 with above 90% germination and carry-over seed lots CL_1 and CL_2 with above Minimum Seed Certification Standards (MSCS) level of germination were used for the study. The seeds of both the lots were tested for laboratory germination (Paper towel and sand method) in three replications as per the ISTA rules [5]. The first count and final count were recorded and expressed in percentage. After final germination count, ten normal seedlings were selected at random in each replication for recording seedling length in centimeters (cm) and the same seedlings were oven dried at 80°C for 17 hr and weighed (g) for seedling dry weight. Seed vigour index I and II were calculated by multiplying germination (%) with seedling length and dry matter content, respectively [6].

Electrical conductivity (EC) of the seed leachates was measured for seeds in each physical category. In this test, fifty seeds were selected at random from all the three replications and soaked overnight in 50 ml distilled water in a beaker covered with parafilm and kept at room temperature for 24 hr. Electrical conductivity of seed leachates was measured after 24 hr using a digital EC meter and expressed in μ mhos cm^{-1} [7]. Brick-gravel test was conducted as per the procedure of Fritz [8], and the count of normal emerged seedlings was taken up to 6 days from planting and expressed in percentage. The germination counts were taken daily to calculate the speed of germination *i.e.* field emergence index (FEI), as described by Maguire [9]. Total fungal colonies were counted at bimonthly intervals by adopting standard blotter method [11] and expressed in percentage (%). Correlations of seed vigour parameters with field emergence were subsequently computed [12].

RESULTS AND DISCUSSION

The analysis of variance for various seed quality traits of three genotypes of pigeonpea showed significant differences for germination, total seedling length, seedling dry weight, seedling vigour index I and II and field emergence. Mean values for different seed quality traits of fresh and carryover seed lots of the pigeonpea genotypes is summarized (Tables 1a and 1b).

Germination (%): Irrespective of the test media for germination, the seed vigour tests of first count and final count showed that the germination was higher in fresh seeds (FL) than carry-over (CL) seeds of all the genotypes. The difference in germination (first count) between BP method and sand media was 9.00 for Asha variety, 2.55 for Laxmi variety and 26.82 for Palnadu variety. Similarly the difference in germination (Final count) between BP method and sand media was 8.25 for Asha variety, 0.13 for Laxmi variety and 26.06 for Palnadu varieties. The difference between the two methods of testing was higher for Palnadu and least for Laxmi variety indicating that vigour of Palnadu seeds was low despite high germination capacity. However, seeds of Laxmi had higher germination as well as seedling vigour.

The germination percentage decreased gradually with storage in all the varieties of pigeonpea in both between paper and sand media (Table 1). Such decline in germination was more in Laxmi (78.25 to 65.75), followed by Palnadu (82.15 to 76.00) and Asha (81.50 to 75.00) using BP method. On the other had, Palnadu variety showed rapid decline in germination with sand media (70.60 to 34.50), followed by Laxmi (78.13 to 68.60) and Asha (81.50 to 75.00).

Seedling vigour Index I and II: Data on total seedling length indicated highest values for Palnadu (18.88 cm), followed by Asha (17.33 cm) and Laxmi (17.18 cm). Similarly fresh seed of Asha recorded highest seedling dry weight of 0.87 g, followed by Laxmi (0.79 g) and Palnadu (0.65 g). On the other hand, carry-over seed lots of Asha, Laxmi and Palnadu reported 0.78 g, 0.68 g and 0.64 g of seedling dry weight, respectively. Sand media recorded higher seed vigour index I (1717.92 for fresh lots and 1317.67 for carry-over lots) and seed vigour index II (66.73 for fresh lots and 53.05 for carry-over seed) compared to BP method (1090.48 for fresh lots and 976.41 for carry-over seed for SVI I and 66.38 for fresh lots and 52.05 for carry-over seed for SVI II).

Thus, the seed quality parameters *viz.* germination (%), seedling length, seedling dry

Table 1a. Seed vigour parameters in different seed lots of pigeonpea

Variety/Seed lot	Germination (%)					Total seedling length (cm)					Seedling dry weight (g)				
	BP method		Sand media			BP method		Sand media			BP method		Sand media		
	First	Final	First	Final	Mean	First	Final	First	Final	Mean	First	Final	First	Final	Mean
Asha (ICPL 87119)															
Fresh lot 1	79.00	84.00	73.00	77.00	78.25	11.08	16.93	18.60	22.82	17.36	0.72	0.89	0.96	0.89	0.87
Fresh lot 2	78.00	85.00	66.00	75.00	76.00	7.92	17.02	26.50	26.77	19.55	0.79	0.85	0.91	0.91	0.87
Carry-over lot 1	72.00	78.00	63.00	71.00	71.00	7.88	17.74	17.71	20.84	16.04	0.65	0.73	0.81	0.79	0.75
Carry-over lot 2	71.00	79.00	62.00	70.00	70.50	7.69	17.83	14.89	25.03	16.36	0.67	0.72	0.78	0.81	0.75
G. Mean	75.00	81.50	66.00	73.25	73.94	8.64	17.38	19.43	23.87	17.33	0.71	0.80	0.87	0.85	0.81
Laxmi (ICPL 85063)															
Fresh lot 1	78.00	82.00	74.00	80.00	78.50	11.13	19.28	19.73	28.93	19.77	0.63	0.92	0.84	0.80	0.80
Fresh lot 2	74.00	79.00	74.00	84.50	77.88	9.21	18.78	23.58	25.68	19.31	0.64	0.85	0.81	0.82	0.78
Carry-over lot 1	56.80	73.00	66.50	72.00	67.08	7.69	16.90	14.36	23.65	15.65	0.49	0.71	0.74	0.78	0.68
Carry-over lot 2	60.50	73.00	65.00	71.00	67.38	7.90	15.40	12.45	20.13	13.97	0.52	0.71	0.67	0.83	0.68
G. Mean	67.33	76.75	69.88	76.88	72.71	8.98	17.59	17.53	24.60	17.18	0.57	0.80	0.77	0.81	0.74
LRG-30 (Palnadu)															
Fresh lot 1	75.00	87.25	68.50	78.50	77.31	12.22	20.34	20.75	28.12	20.36	0.66	0.81	0.58	0.63	0.67
Fresh lot 2	77.00	90.00	64.50	72.00	75.88	10.42	19.59	22.50	28.76	20.32	0.74	0.66	0.55	0.51	0.62
Carry-over lot 1	72.80	79.00	33.50	42.00	56.83	9.28	18.73	16.42	26.39	17.71	0.60	0.64	0.56	0.58	0.60
Carry-over lot 2	71.00	81.00	22.00	40.50	53.63	10.25	17.00	15.14	26.17	17.14	0.66	0.75	0.59	0.59	0.65
G. Mean	73.95	84.31	47.13	58.25	65.91	10.54	18.92	18.70	27.36	18.88	0.67	0.72	0.57	0.58	0.63
		CD		CD			CD		CD			CD		CD	
Genotypes (G)		1.26		0.84			0.46		0.56			0.03		0.03	
Methods (M)		1.02		0.68			0.37		0.46			0.03		0.03	
Lots (L)		1.45		0.97			0.53		0.65			0.04		0.04	
G x M		1.78		1.10			0.64		0.79			0.05		0.04	
G x L		2.52		1.67			0.21		1.12			0.07		0.06	
M x L		2.06		1.37			0.74		0.92			0.06		0.05	
G x M x L		3.56		2.37			1.29		1.59			0.09		0.09	

Table 1b. Seed vigour parameters in different seed lots of pigeonpea

Variety/Seed lot	Germination (%)					Total seedling length (cm)					Field emergence index	Field emergence
	BP method		Sand media			BP method		Sand media				
	First	Final	First	Final	Mean	First	Final	First	Final	Mean		
Asha (ICPL87119)												
Fresh lot 1	875.32	1422.12	1357.80	1757.14	1218.41	56.88	74.76	70.08	68.53	67.56	18.3	77.5
Fresh lot 2	617.76	1446.70	1749.00	2007.75	1271.15	61.62	72.25	60.06	68.25	65.55	20.5	82.6
Carry-over lot 1	567.36	1383.72	1115.73	1479.64	1022.27	46.80	56.94	51.03	56.09	52.72	15.1	58.0
Carry-over lot 2	545.99	1408.57	923.18	1752.10	959.25	47.57	56.88	48.36	56.70	52.38	16.3	57.6
G. Mean	651.61	1415.28	1286.43	1749.16	1117.77	53.22	65.21	57.38	62.39	59.55	17.6	68.9
Laxmi (ICPL 85063)												
Fresh lot 1	868.14	1580.96	1460.02	2314.40	1555.88	49.14	75.44	62.16	64.00	62.69	19.19	70.25
Fresh lot 2	681.54	1483.62	1744.92	2169.96	1520.01	47.36	67.15	59.94	69.29	60.94	14.35	56.47
Carry-over lot 1	436.79	1233.70	954.94	1702.80	1082.06	27.83	51.83	49.21	56.16	46.26	13.71	52.90
Carry-over lot 2	477.95	1124.20	809.25	1429.23	960.16	31.46	51.83	43,55	58.93	46.44	12.28	46.60
G. Mean	616.11	1355.62	1242.28	1904.10	1279.53	38.95	61.56	53.72	62.10	54.08	14.88	56.56
LRG-30 (Palnadu)												
Fresh lot 1	916.50	1774.67	1421.38	2207.42	1579.99	49.50	70.67	39.73	49.46	52.34	18.50	72.00
Fresh lot 2	802.34	1763.10	1451.25	2070.72	1521.85	56.98	59.40	35.48	36.72	47.14	16.75	69.80
Carry-over lot 1	675.58	1479.67	550.07	1108.38	953.43	43.68	50.56	18.76	24.36	34.34	16.57	63.57
Carryover lot 2	727.75	1377.00	333.08	1059.89	874.43	46.86	60.75	12.98	23.90	36.12	15.49	60.70
G. Mean	780.54	1598.61	938.94	1611.60	1232.42	49.26	60.35	26.74	33.61	42.49	16.83	66.52
		CD		CD			CD		CD			
Genotypes (G)		38.02		47.67			3.06		2.71		0.78	0.88
Methods (M)		31.04		38.92			2.50		2.22			
Lots (L)		43.90		55.04			3.53		3.13		0.88	1.01
G x M		53.77		67.41			4.32		3.84			
G x L		76.04		95.34			6.11		5.43		1.60	1.75
M x L		62.09		77.84			4.99		4.43			
G x M x L		107.54		134.83			8.64		7.68			

Table 2. Seed vigour parameters in different seed lots of pigeonpea

Variety/Seed lot	Paper exhaustion test		Total no. of fungal colonies	Brick gravel test	Electrical conductivity (μ mho cm^{-1})
	Low vigour (%)	High vigour (%)			
Asha (ICPL 87119)					
Fresh lot 1	12.50	82.50	0.50	67.0	554
Fresh lot 2	3.80	91.30	0.50	70.0	564
Carry-over lot 1	7.50	66.30	4.00	84.5	762
Carry-over lot 2	10.00	63.80	2.00	84.5	686
Mean	8.40	75.90	1.80	76.5	642
Laxmi (ICPL 85063)					
Fresh lot 1	7.50	83.75	0.25	80.5	485
Fresh lot 2	3.75	87.50	0.25	83.5	329
Carry-over lot 1	6.25	80.00	1.00	72.0	520
Carry-over lot 2	11.25	78.75	0.50	80.5	485
Mean	7.20	82.50	0.50	79.1	455
LRG-30 (Palnadu)					
Fresh lot 1	6.25	85.00	1.50	71.5	286
Fresh lot 2	2.50	92.50	0.00	80.5	296
Carry-over lot 1	8.75	77.50	3.00	74.0	352
Carry-over lot 2	7.50	87.50	1.50	81.0	323
Mean	6.30	85.60	1.50	76.8	314
CD (0.05)	0.98	1.11	0.09	1.67	20.19

weight and seedling vigour index recorded low values in all three pigeonpea genotypes in the carry-over seed loss due to storage. This might be due to changes that include impairment or shift in metabolic activity, decline in enzyme activity, cytological and cellular changes during storage and also differences in initial seed vigour. Further, the reduction in seedling length, drymatter and vigour index may be due to loss of membrane integrity of cellular membranes, leaching of solutes and intercellular disorganization impairing the growth of seedling by slowing down the metabolic activity. Similar findings were reported in barley [12], sorghum [13], okra [14] and mustard [15].

Field emergence: The field emergence (%) varied from 56.56 % (Laxmi) to 68.9% (Asha). There was reduction in field emergence in aged seeds of all pigeonpea genotypes compared to fresh seeds. The percentage of field emergence was high in Asha (68.9%) and is significantly different from Palnadu (66.52%) and Laxmi (56.56%). Similar to other seed quality parameters,

Table 3. Correlations between seed vigour parameters and field emergence for different lots of pigeonpea

Character			Germination (%)				Total seedling length (cm)				Seedling dry weight (g)				Seedling vigour index I				Seedling vigour index II				Electrical conductivity	Field emergence index	Field emergence
			BP	Sand	BP	Sand	BP	Sand	BP	Sand	BP	Sand	BP	Sand	BP	Sand	BP	Sand	BP	Sand					
			FL		CL		FL		CL		FL		CL		FL		CL		FL		CL				
Germination (%)	BP	First count	1.0000	0.1144	0.8273**	0.1611	0.5798**	0.7190**	0.5488**	0.5614**	0.8587**	0.2445	0.5048*	-0.0578	0.7863**	0.5185**	0.7230**	0.4166*	09381**	0.2243	0.7406**	0.0758	-0.1335	0.8101**	0.8125**
	Sand	First count		1.0000	0.1016	0.9786**	0.0298	0.3858	0.1421	-0.0713	0.0726	0 5665**	0.5069	0.5780**	0.0878	0.8160**	0.1463	0.8174**	0.1163	0.8799**	0.4502*	0.8621**	0.2771	0.1559	0.1524
	BP	First count			1.0000	0.1543	0.6752**	0.7048**	0.6266**	0.7023**	0.8384**	-00941	0.2625	-03615	0.7978**	0.4893*	0.8755**	0.4815*	0.8678**	0.0133	0.6144**	-01251	-0.3758	0.7564**	0.8228**
	Sand	First count				1.0000	0.0756	0.4642*	0.1842	-0.0102	0.1364	0.5559**	0.5795**	0.5633**	0.1348	0.8596**	0.1973	0.8648**	0.1720	0.8612**	0.5289**	0.8665**	0.2119	0.1679	0.1600
Total seedling length (cm)	BP	First count					1.0000	0.2809	0.6220**	0.5818**	0.2998	-0.2186	0.4134*	-0.4146	0.9585**	0.2036	0.7200**	0.3523	0.4175*	-00718	0.6110**	-0.1891	-0.6064	0.4923*	0.5181**
	Sand	First count						1.0000	0.4916*	0.5606**	0.7355**	0.2819	0.4845*	0.0849	0.4630*	0.8459**	0.6362**	0.6779**	0.7684**	0.3834	0.6720**	0.3198	-0.2224	0.6465**	0.7026**
	BP	First count							1.0000	0.7671**	0.2923	-0.3295	0.0931	-05264	0.6592**	0.3836	0.9234**	0.5443**	0.3907	-0.0940	0.3231	0.2040	-0.4623	0.4418*	0.3509
	Sand	First count								1.0000	0.4364*	-0.2888	0.1947	-0.4878	0.6300**	0.3084	0.8119**	0.4926*	0.4997*	-0.0188	0.4367*	-0.2779	-0.5921	0.6323**	0.5496**
Seedling dry weight (cm)	BP	First count									1.0000	0.2663	0.3410	0.0037	0.5236**	0.4970*	0.5741**	0.3308	0.9813**	0.1913	0.6119**	0.0844	0.0100	0.7468**	0.8123
	Sand	First count										1.0000	0.7098**	0.9098**	-0.0604	0.5162**	-0.2744	0.3372	0.2861	0.8872**	0.5403**	0.8502**	0.6563**	0.3079	0.2974
	BP	First count											1.0000	0.5910**	0.4996*	0.6239**	0.1702	0.5984**	0.4293*	0.7098**	0.9220**	0.6852**	0.0777	0.5449**	0.5040*
	Sand	First count												1.0000	-0.3172	0.3996	-0.5155	0.2463	-0.0027	0.8340**	0.3405	08984**	0.6704**	0.0658	0.035
Seedling vigour index I	BP	First count													1.0000	0.3490	0.7945**	0.4277*	0.6419**	0.0495	0.7287**	-0.0955	-0.4903	0.6591**	0.6800**
	Sand	First count														1.0000	0.4730*	0.8986**	0.5448**	0.7549**	0.6985**	0.7090**	0.0118	0.4846*	0.5155**
	BP	First count															1.0000	0.5763**	0.6474**	-0.0614	0.4872*	-0.1924	-0.4835	0.6264**	0.6055**
	Sand	First count																1.0000	0.3939	0.6547**	0.6744**	0.6143**	-0.1028	0.4651*	0.4117
Seedling vigour index II	BP	First count																	1.0000	0.2356	0.6957**	0.1057	-0.0432	0.8079**	0.8585**
	Sand	First count																		1.0000	0.5812**	0.9629**	0.4976*	0.2710	0.2665
	BP	First count																			1.0000	0.5072*	-0.0840	0.7580**	0.7504**
	Sand	First count																				1.0000	0.4916**	0.1415	0.1207
Electrical conductvity																							1.0000	-0.0117	-0.0952
Field emergence index																								1.0000	0.9481**
Field emergence																									1.0000

**Significant at 1% level; *Significant at 5% evel

field emergence was high in fresh seed (80.05% for Asha, 63.36% for Laxmi and 70.90% for Palnadu) compared to carry-over seed (57.8% for Asha, 49.75% for Laxmi and 62.14% for Palnadu). Significant differences were noticed between fresh and carry over seed lots of 3 varieties of pigeonpea. The fresh seed lot of Asha recorded 23.56% increase in field emergence index over aged lots, whereas Laxmi and Palnadu recorded 29% and 9.98% increase over aged lots, respectively.

The data presented on paper exhaustion test (Table 2) indicated that fresh lots were found more vigorous than carry-over seed. The fresh seed lots of LRG 30 were more vigorous (88.75) than aged lots followed by Asha (86.90) and Laxmi (85.63) varieties.

Electrical conductivity: The electrical conductivity of seed leachates gradually increased with storage in all the three genotypes (Table 2). The increase in electrical conductivity of seed leachates was higher in carry-over seed of Asha (724), followed by Laxmi (502.50) and LRG-30 (337.50). Electrical conductivity of seed leachates was higher especially in untreated aged seeds which might be due to destructive changes in cellular membrane resulting in more leakage of organic solutes (Free sugars, fatty acids and amino acids).

The total fungal colonies were more in carry over seeds as company to fresh lots (Table 2). These were highest in carry-over seeds of Asha (3.0), followed by LRG-30 (2.25) and Laxmi (0.75) as compared to fresh seeds lots of LRG 30 (0.75), Asha (0.50) and Laxmi (0.25). Similar findings were reported in cotton [16].

Corrleation: Correlation data (Table 3) showed that both first (0.8125) and final (0.8228) counts of germination, using between paper method and field emergence index (0.9481) exhibited highly significant positive correlation with field emergence. Similarly significant positive relationship was noticed between first count (0.5181) of total seedling length, first (0.8123) and final counts (0.5040) of seedling dry weight, first (0.6800) and final counts (0.6055) of seedling vigour index I, first (0.8585) and final counts (0.6055) of seedling vigour index II using P method and field emergence. Likewise, first (0.7026) and final (0.5496) counts of total seedling length and first count of seedling vigour index I using sand media (0.5155) exhibited significant correlation with field emergence. Distinct negative correlation (≥ -0.0952) was obtained with respect to electrical conductivity and field emergence. This indicates that as the leachates of the electrolytes from the seed were reduced, seedling vigour was increased which was reflected in terms of field emergence. Dubey *et al.* [17] obtained similar results on correlation of seed germination, seedling vigour index and electrical conductivity with field emergence in pigeonpea.

The present study indicated that field performance of pigeonpea can be predicted through standard germination when seeds were planted only under ideal soil conditions. Ram [18] in the study of association of seed vigour tests in greengram confirmed that standard germination test can be used as prediction criterion for field emergence. Thus, germination test, seedling vigour index I and II and field emergence index can be used as the criterion for determining the seedling vigour of different genotypes in pigeonpea.

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