

Original Research Article

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Correlation between Seed Germination (%) and Other Seed Quality under Different Environments in Upland Cotton (*Gossypium hirsutum* L.)

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ABSTRACT

Keywords

Cotton, Seed quality traits, Seed germination, Different environments, Correlation

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The present study was conducted to find out the correlation of seed germination (%) and other seed quality in three varieties H 1098 – I, H 1300 and H 1316 under six environments (three sowing periods i.e. early, normal and late sown conditions in year 2015 and 2016). Observations were recorded for seed germination and other seed quality parameters as Seedling Length, Seed Weight, Seedling Dry Weight, Vigor Index-I and Vigor Index-II. Tagging period started from June end when there were sizable amount of flowers. Seed germination was positively correlated with vigor index- I and vigor index – II and with protein (%). Seed germination (%) was high in early sown condition as compared to normal sown conditions. The period from 2nd week of July to mid-August was better of seed germination

Introduction

Cotton, *G. hirsutum* is grown in India under a wide range of climatic conditions. India has a pride place in the global cotton scenario due to several distinct features such as the largest area under cotton (105 lakh ha) representing about one-third of the global cotton area (330 lakh ha) with production of 560 kg/ha in the world (ICAR 2016-17).

Quality seed is an essential prerequisite to profitable crop production. Knowledge on effects of various elements of environment on crop growth, development and yield is important to harness good crop yield with better quality of seed and fiber. The standard

germination test is commonly used to evaluate seed quality and guide farmers to determine the quantity of seed to be sown. When field conditions are optimum, the standard germination test may predict relative emergence of the seed lot in the field.

However, under sub-optimal field conditions, standard germination test results, generally overestimate field emergence. In these cases vigor tests provide additional information on the relative performance of seed lots in the fields under wide range of environments. Since, the cost of seed is increasing seed producing agencies and farmers are becoming more interested in laboratory based seed quality test that can help them to predict the

performance of seed in the field (Wheeler *et al.*, 1997).

The physiological quality of a seed lot is evaluated by the standard germination test, which, however, frequently does not correspond to the performance presented by the seed lots when they are sown under field conditions. This has led seed growers and technologists to seek for methods which offer more reliable information about the physiological potential of a seed lot. Consequently, a great interest has arisen in viability and vigor tests which are used in an attempt to identify possible differences in physiological quality among seed lots that present a similar germinative potential.

Establishment of seedling is an important factor in crop production and largely depends on seed germination and seedling vigor. A number of parameters to evaluate seed quality have been developed. Some of these tests have been referred to as 'viability' and 'vigor' tests. These tests could be used reliably to predict seedling establishment under field conditions.

Seed quality aspects mainly seed vigor and viability plays an important role in seed germination. Seed germination in cotton is a big problem under North Indian conditions. It remains much below the standard germination because of poor seed development and its quality is very much affected by environment. To overcome these problems, the present investigation was planned.

Materials and Methods

The experiment was conducted during *kharif* 2015 & 2016 having three cultivars H 1098-I, H 1300 and H 1316 of upland cotton grown at CCS Haryana Agricultural University, Hisar in randomized block design replicated six times each in eight rows of 6 m length with a spacing of 67.5 x 30 cm. These varieties were

grown in six environments that comprises of three sowings periods (Early: first fortnight of April, normal: first fortnight of May and late: end of May/early June) during the year 2015 and 2016 (Table 1).

Data was recorded as in all the three replications in every week flowers were tagged and number of effective bolls formed from these flowers was counted and the week in which maximum and minimum bolls developed was identified. The data on seed quality traits was recorded from tagging period i.e. June, 24 to till the last picking of the experimental plots. Correlation was carried out by AI-Jibouri *et al.*, (1958).

Results and Discussion

Correlation between germination (%) and other seed quality traits during 2015 was presented in table 2. Seed germination was positively correlated with seedling length (S.L.) 0.58^{**}, seed weight (S.W.) 0.69^{**}, seedling dry weight (S.D.W.) 0.53^{**}, vigor index- I (0.99^{**}) and vigor index- II (0.89^{**}). Seed weight was positively correlated with seedling length. Seedling dry weight was positively correlated with seedling length and seed weight.

Vigor index -I was positively correlated with seedling length, seed weight and seedling dry weight. Vigor index -II was positively correlated with seedling length, seed weight, seedling dry weight and vigor index - I. Correlation between germination (%) and other seed quality traits during 2016 was presented in table 3. Seed germination was highly and positively correlated with vigor index- I (0.98^{**}) and vigor index- II (0.88^{**}). Seed weight was positively correlated with seedling length. Vigor index -I was positively correlated with seedling length. Vigor index - II was positively correlated with seedling dry weight and vigor index - I.

Seed germination (%) was significantly and positively correlated with vigor index- I and vigor index- II during the year 2015 & 2016, whereas during the year 2015 as it was significantly and positively correlated with seedling length, seed weight, seedling dry weight also. Similar findings were reported by Yadav *et al.*, (2001) in okra, Dubey *et al.*, (1988) in pigeonpea, Dahiya *et al.*, (1997) in chickpea and Sinha *et al.*, (1988) in cowpea. Seed weight was positively correlated with seedling length. Seedling dry weight was positively correlated with seedling length and seed weight. Vigor index -I was positively correlated with seedling length, seed weight and seedling dry weight. Vigor index -II was positively correlated with seedling length, seed weight, seedling dry weight and vigor index - I. Similar results were reported by Dahiya *et al.*, (1997) in chickpea and Sinha *et al.*, (1988) in cowpea for seedling dry weight.

Differences in environmental conditions experienced between first flowering and harvest, the length of the seed filling period, seed weight and the concentrations of fat, water-soluble carbohydrate, protein and starch in the seeds were examined as potential causes of differences in seed vigor. However, none of these individual variables could alone explain the observed variations in seed vigor with sowing date (Siddique and wright, 2004).

Mean value of seed quality traits in different environments was presented in tables 4, 5 and 6. In the variety H 1098-I mean values of vigor index- I and vigor index -II were higher in environment E₁ and E₄ as compared to other environments. Although vigor index-I and vigor index- II were higher in 3rd week to 7th week in all the environments. In E₁ vigor index- I was 2123.40, 2207.70, 2318.29, 2385.26 and 2242.58 in 3rd to 7th week and vigor index -II was 22.79, 19.06, 27.31, 24.15 and 22.83. In E₂ vigor index- I was 1851.01, 1974.38, 2166.08, 2361.38 and 2027.35 while

vigor index- II was 16.06, 17.05, 25.43, 18.78 and 16.78 in week 3rd to 7th. In E₃ vigor index- I was 1344.20, 1570.83, 1804.20, 2012.73 and 2020 while vigor index- II was 7.59, 13.40, 14.63, 12.35 and 11.88 in 3rd to 7th week. In E₄ vigor index- I was 1340.51, 1299.45, 1195.57, 1693.87 and 1525.47 while vigor index -II was 7.52, 9.11, 8.74, 11.07 and 10.92 in 3rd to 7th week. In E₅ vigor index- I was 866.99, 987.57, 1165.12, 1080.06 and 1270.44 while vigor index -II was 6.98, 8.82, 9.32, 10.21 and 11.01 in 3rd to 7th week. In E₆ vigor index-I from 3rd to 7th week was 558.52, 601.39, 670.10, 745.92 and 867.27 while vigor index- II was 3.23, 4.12, 4.94, 5.82 and 6.82. The mean value of different quality traits in E₁ was 28.81 for seedling length(S.L.), 6.22 for seed weight (S.W), 0.27 for seedling dry weight (S.D.W), 1676.37 for vigor index- I (VI- I) and 16.56 for vigor index- II. The mean value of different quality traits in E₂ was 29.02 for S.L., 5.41 for S.W., 0.25 for S.D.W, 1518.91 for VI- I and 13.38 for VI- II. The mean value of different quality traits in E₃ was 27.74 for S.L., 5.42 for S.W., 0.17 for S.D.W, 1284.60 for VI- I and 8.42 for VI- II. The mean value of different quality traits in E₄ was 28.85 for S.L., 6.86 for S.W., 0.17 for S.D.W, 941.12 for VI- I and 5.93 for VI- II. The mean value of different quality traits in E₅ was 27.91 for S.L., 6.41 for S.W., 0.29 for S.D.W, 818.69 for VI- I and 7.38 for VI- II. The mean value of different quality traits in E₆ was 25.71 for S.L., 5.69 for S.W., 0.16 for S.D.W, 531.45 for VI- I and 3.64 for VI- II.

In the variety H 1300 mean values of vigor index- I and vigor index -II were higher in environment E₁ in 2015 and E₄ in 2016 as compared to other environments. Although vigor index-I and vigor index- II were higher in 3rd week to 7th week in all the environments. In E₁ vigor index- I was 1787.65, 1804.49, 1908.49, 2172.07 and 2207.61 in 3rd to 7th week and vigor index -II was 15.76, 19.24, 20.44, 21.13 and 18.73.

Table.1 Sowing dates and different environments in 2015 and 2016

Environment		Date of Sowing	Environment Designation
Year	Sowing period		
2015	Early	10 April	E ₁
	Normal	15 May	E ₂
	Late	5 June	E ₃
2016	Early	26 April	E ₄
	Normal	5 May	E ₅
	Late	2 June	E ₆

Table.2 Correlation of germination (%) with other seed quality traits and during 2015

	S.L.	S.W.	S.D.W.	VI-I	VI-II	Germination
S.L.	1					
S.W.	0.67**	1				
S.D.W.	0.62**	0.66**	1			
VI-I	0.68**	0.72**	0.58**	1		
VI-II	0.70*	0.77**	0.81**	0.92**	1	
Germination	0.58**	0.69**	0.53**	0.99**	0.89**	1

S.L. = Seedling Length; S.W = Seed Weight; S.D.W. = Seedling Dry Weight; VI-I = Vigor Index-I; VI-II = Vigor Index-II

Table.3 Correlation of germination (%) with other seed quality traits and during 2016

	S.L.	S.W.	D.W.	VI-I	VI-II	Germination
S.L.	1					
S.W.	0.39*	1				
S.D.W	0.12	0.16	1			
VI-I	0.44*	0.33	0.02	1		
VI-II	0.33	0.34	0.44*	0.88**	1	
Germination	0.29	0.32	0.02	0.98**	0.88**	1

S.L. = Seedling Length; S.W = Seed Weight; S.D.W. = Seedling Dry Weight; VI-I = Vigor Index-I; VI-II = Vigor Index-II

Table.4 Seed quality traits of H 1098- I in different environments

	S.L.	S. W	S.D. W.	VI- I	VI - II		S.L.	S. W	S.D. W.	VI- I	VI - II
H 1098 –I E₁						H 1098 –I E₄					
1	30.41	7.451	0.389	1135.32	14.50	1	31.03	8.1	0.139	372.32	1.67
2	29.91	6.344	0.219	2003.91	14.68	2	27.75	7.9	0.185	444.00	2.96
3	29.70	7.295	0.319	2123.40	22.79	3	31.92	7.1	0.179	1340.51	7.52
4	29.24	7.125	0.253	2207.70	19.06	4	28.25	6.3	0.198	1299.45	9.11
5	30.23	6.640	0.356	2318.29	27.31	5	24.91	7.4	0.182	1195.57	8.74
6	30.39	7.174	0.308	2385.26	24.15	6	33.21	6.8	0.217	1693.87	11.07
7	28.75	6.129	0.293	2242.58	22.83	7	28.78	6.6	0.206	1525.47	10.92
8	26.20	5.420	0.263	1283.58	12.89	8	26.48	6.1	0.154	661.95	3.85
9	26.50	4.528	0.221	662.53	5.53	9	29.12	5.4	0.126	553.23	2.39
10	26.74	4.102	0.125	401.15	1.88	10	27.07	6.9	0.089	324.79	1.07
Mean	28.81	6.22	0.27	1676.37	16.56	Mean	28.85	6.86	0.17	941.12	5.93
H 1098 –I E₂						H 1098 –I E₅					
3	31.11	6.081	0.270	1851.01	16.06	3	27.09	6.7	0.2180	866.99	6.98
4	30.38	5.991	0.262	1974.38	17.05	4	27.43	7.3	0.2450	987.57	8.82
5	31.85	6.579	0.374	2166.08	25.43	5	29.50	5.8	0.2360	1165.12	9.32
6	32.80	5.829	0.261	2361.38	18.78	6	26.34	6.5	0.2490	1080.06	10.21
7	27.15	5.268	0.225	2027.35	16.78	7	29.55	6.5	0.2560	1270.44	11.01
8	24.96	4.884	0.169	848.67	5.75	8	29.06	6.8	0.1460	610.31	3.07
9	27.53	4.277	0.193	605.57	4.25	9	26.08	5.1	0.1030	286.90	1.13
10	26.40	4.374	0.248	316.84	2.98	10	28.21	6.6	0.8500	282.12	8.50
Mean	29.02	5.41	0.25	1518.91	13.38	Mean	27.91	6.41	0.29	818.69	7.38
H 1098 –I E₃						H 1098 –I E₆					
3	25.85	5.369	0.146	1344.20	7.59	3	24.28	5.8	0.141	558.52	3.23
4	27.08	4.550	0.231	1570.83	13.40	4	24.55	5.6	0.168	601.39	4.12
5	29.1	6.570	0.236	1804.20	14.63	5	24.82	6.0	0.183	670.10	4.94
6	29.17	5.850	0.179	2012.73	12.35	6	24.86	5.7	0.194	745.92	5.82
7	28.06	6.250	0.165	2020.00	11.88	7	27.10	7.2	0.213	867.27	6.82
8	28.74	4.570	0.149	804.72	4.17	8	27.14	5.1	0.136	434.22	2.18
9	26.06	4.510	0.138	469.08	2.48	9	27.43	5.1	0.156	246.87	1.40
10	27.89	5.690	0.098	251.01	0.88	10	25.46	5.0	0.118	127.30	0.59
Mean	27.74	5.42	0.17	1284.60	8.42	Mean	25.71	5.69	0.16	531.45	3.64

S.L. = Seedling Length; S.W = Seed Weight; S.D.W. = Seedling Dry Weight; VI-I = Vigor Index-I; VI-II = Vigor Index-II

Table.5 Seed quality traits of H 1300 in different environments

	S.L.	S. W	S.D. W.	VI- I	VI - II		S.L.	S. W	S.D. W.	VI- I	VI - II
H 1300 E₁						H 1300 E₄					
1	30.00	5.626	0.065	840.00	1.82	1	27.87	7.70	0.1020	297.24	1.09
2	28.34	6.584	0.249	1643.61	14.46	2	28.22	7.40	0.1230	437.38	1.91
3	29.55	6.313	0.261	1787.65	15.76	3	29.42	6.30	0.1960	951.09	6.34
4	28.42	6.261	0.303	1804.49	19.24	4	25.94	6.00	0.1840	908.06	6.44
5	28.07	5.715	0.301	1908.88	20.44	5	27.73	7.30	0.1950	1053.61	7.41
6	30.17	5.577	0.294	2172.07	21.13	6	26.74	7.40	0.2180	1136.55	9.27
7	29.43	5.535	0.250	2207.61	18.73	7	28.39	6.00	0.2270	1220.91	9.76
8	28.55	4.632	0.239	885.13	7.42	8	24.11	6.80	0.1650	506.25	3.47
9	28.83	4.452	0.251	576.57	5.02	9	26.18	6.50	0.1114	418.86	1.78
10	27.27	4.100	0.210	245.44	1.89	10	26.67	7.60	0.0760	266.70	0.76
Mean	28.86	5.48	0.24	1407.14	12.59	Mean	27.87	7.70	0.1020	719.65	4.82
H 1300 E₂						H 1300 E₅					
3	26.82	6.037	0.198	1407.92	10.40	3	28.39	7.1	0.1420	643.47	3.22
4	25.37	4.495	0.226	1407.83	12.53	4	30.53	7.4	0.1650	717.40	3.88
5	24.95	4.994	0.229	1472.26	13.49	5	24.67	6.2	0.1380	641.41	3.59
6	27.52	4.641	0.295	1692.62	18.13	6	27.32	6.6	0.1690	819.60	5.07
7	27.06	4.882	0.318	1704.71	20.05	7	29.53	6.7	0.1790	974.60	5.91
8	24.21	4.812	0.170	677.76	4.76	8	24.31	6.3	0.1260	461.88	2.39
9	25.34	3.977	0.136	380.11	2.04	9	25.95	5.1	0.1130	389.22	1.70
10	26.07	4.416	0.154	208.59	1.23	10	29.53	6.5	0.0755	177.16	0.45
Mean	25.92	4.78	0.22	1118.97	11.02	Mean	27.53	6.49	0.14	603.09	3.28
H 1300 E₃						H 1300 E₆					
3	26.15	3.398	0.179	1176.56	8.06	3	27.30	5.4	0.123	373.07	1.68
4	26.82	5.640	0.189	1327.59	9.36	4	28.17	5.9	0.146	478.97	2.48
5	26.18	6.840	0.193	1361.36	10.04	5	25.45	5.3	0.124	509.02	2.48
6	27.43	5.230	0.216	1508.65	11.88	6	25.77	6.1	0.139	644.33	3.48
7	23.41	6.860	0.201	1404.60	12.06	7	25.53	5.7	0.168	714.72	4.70
8	21.44	4.210	0.174	471.68	3.83	8	25.03	6.1	0.148	450.50	2.66
9	27.79	5.540	0.143	333.48	1.72	9	28.16	6.2	0.135	394.24	1.89
10	26.65	6.580	0.101	159.90	0.61	10	26.11	5.1	0.084	78.33	0.25
Mean	25.73	5.54	0.17	967.98	7.19	Mean	26.44	5.73	0.13	455.40	2.45

S.L. = Seedling Length; S.W = Seed Weight; S.D.W. = Seedling Dry Weight; VI-I = Vigor Index-I; VI-II = Vigor Index-II

Table.6 Seed quality traits of H 1316 in different environments

	S.L.	S. W	S.D. W.	VI- I	VI - II		S.L.	S. W	S.D. W.	VI- I	VI - II
H 1316 E₁						H 1316 E₄					
1	22.77	4.590	0.046	478.17	0.97	1	26.36	7.8	0.0941	210.90	0.75
2	25.81	5.670	0.096	1342.12	4.99	2	27.40	8.2	0.1230	328.84	1.48
3	26.428	6.870	0.146	1479.97	8.18	3	31.60	7.0	0.1460	970.06	4.48
4	21.71	6.840	0.165	1259.18	9.57	4	25.15	7.2	0.1530	804.86	4.90
5	22.41	5.230	0.189	1344.60	11.34	5	26.44	7.5	0.1480	912.33	5.11
6	27.04	4.870	0.218	1676.48	13.52	6	30.18	6.4	0.1560	1086.61	5.62
7	26.65	5.690	0.234	1732.25	15.21	7	28.47	6.5	0.1760	1095.91	6.78
8	24.35	5.780	0.184	681.80	5.15	8	26.85	7.9	0.1520	537.02	3.04
9	25.49	3.614	0.156	458.75	2.81	9	25.12	7.3	0.1130	376.74	1.70
10	20.11	4.650	0.085	180.99	0.77	10	31.00	8.5	0.0796	279.04	0.72
Mean	24.28	5.38	0.15	1063.43	7.25	Mean	27.86	7.43	0.13	660.23	3.46
H 1316 E₂						H 1316 E₅					
3	27.63	5.991	0.260	1381.65	12.98	3	28.99	7.4	0.1360	521.80	2.45
4	25.05	5.415	0.218	1340.19	11.68	4	26.56	6.6	0.1480	504.64	2.81
5	26.30	5.247	0.180	1525.35	10.46	5	26.57	6.7	0.1650	557.90	3.47
6	26.80	5.316	0.260	1608.16	15.62	6	28.20	6.7	0.1780	676.92	4.27
7	25.00	4.879	0.215	1574.78	13.56	7	28.73	7.6	0.1860	761.28	4.93
8	25.31	4.078	0.106	658.13	2.76	8	26.41	5.8	0.1630	475.34	2.93
9	24.43	3.963	0.092	390.83	1.48	9	27.53	7.1	0.1340	302.85	1.47
10	24.52	3.880	0.094	196.17	0.75	10	24.12	6.5	0.0674	96.48	0.27
Mean	25.63	4.85	0.18	1084.41	8.66	Mean	27.14	6.80	0.15	487.15	2.83
H 1316 E₃						H 1316 E₆					
3	27.99	3.920	0.199	1105.57	7.86	3	27.50	6.4	0.1028	284.18	1.06
4	30.22	5.099	0.249	1269.25	10.46	4	28.23	7.4	0.1230	338.77	1.48
5	26.77	5.163	0.245	1218.04	11.15	5	27.88	7.8	0.1490	446.10	2.38
6	24.66	4.696	0.202	1196.24	9.80	6	27.61	6.9	0.1570	496.93	2.83
7	28.13	3.954	0.141	1420.31	7.12	7	29.56	5.7	0.1830	606.05	3.75
8	26.98	4.024	0.131	539.64	2.61	8	29.22	7.9	0.1520	350.61	1.82
9	21.35	3.212	0.093	213.49	0.93	9	26.17	6.1	0.0856	157.02	0.51
10	20.87	5.560	0.078	104.35	0.39	10	23.84	5.9	0.0690	71.52	0.21
Mean	25.87	4.45	0.17	883.36	6.29	Mean	27.50	6.76	0.13	343.90	1.76

S.L. = Seedling Length; S.W = Seed Weight; S.D.W. = Seedling Dry Weight; VI-I = Vigor Index-I; VI-II = Vigor Index-II

In E₂ vigor index- I was 1407.92, 1407.83, 1472.26, 1692.62 and 1704.71 while vigor index- II was 10.40, 12.53, 13.49, 18.13 and 20.05 in week 3rd to 7th. In E₃ vigor index- I was 1176.56, 1327.59, 13601.36, 1508.65 and 1404.60 while vigor index- II was 8.06, 9.36, 10.04, 11.88 and 12.06 in 3rd to 7th week. In E₄ vigor index- I was 951.09, 908.06,

1053.61, 1136.55 and 1220.91 while vigor index –II was 6.34, 6.44, 7.41, 9.27 and 9.76 in 3rd to 7th week. In E₅ vigor index- I was 643.47, 717.40, 641.41, 819.60 and 974.60 while vigor index –II was 3.22, 3.88, 3.59, 5.07 and 5.91 in 3rd to 7th week. In E₆ vigor index-I from 3rd to 7th week was 373.07, 478.97, 509.02, 644.33 and 714.72 while

vigor index- II was 1.68, 2.48, 2.48, 3.48 and 4.70. The mean value of different quality traits in E₁ was 28.86 for seedling length(S.L.), 5.48 for seed weight (S.W), 0.24 for seedling dry weight (S.D.W), 1407.14 for vigor index- I (VI- I) and 12.59 for vigor index- II. The mean value of different quality traits in E₂ was 25.92 for S.L., 4.78 for S.W., 0.22 for S.D.W, 1118.97 for VI- I and 11.02 for VI- II. The mean value of different quality traits in E₃ was 25.73 for S.L., 5.54 for S.W., 0.17 for S.D.W, 967.98 for VI- I and 7.19 for VI- II. The mean value of different quality traits in E₄ was 27.87 for S.L. 7.70for S.W., 0.10 for S.D.W, 719.65 for VI- I and 4.82 for VI- II. The mean value of different quality traits in E₅ was 27.53 for S.L., 6.49 for S.W., 0.14 for S.D.W, 603.09 for VI- I and 3.28 for VI- II. The mean values of different quality traits in E₆ was 26.44 for S.L., 5.73 for S.W., 0.13 for S.D.W, 455.40 for VI- I and 2.45 for VI- II.

In the variety H 1316 mean values of vigor index- I in E₁ was 1342.12, 1479.97, 1259.18, 1344.60 and 1732.25 in 3rd to 7th week and vigor index –II was 4.99, 8.18, 9.57, 11.34, 13.52 and 15.21. In E₂ vigor index- I was 1381.65, 1340.19, 1525.35, 1608.16 and 1574.78 while vigor index- II was 12.98, 11.68, 10.46, 15.62 and 13.56 in week 3rd to 7th. In E₃ vigor index- I was 1105.57, 1269.25, 1218.04, 1196.24 and 1420.31 while vigor index- II was 7.86, 10.46, 11.15, 9.80 and 7.12 in 3rd to 7th week. In E₄ vigor index- I was 970.06, 804.86, 912.33, 1086.61 and 1095.91 while vigor index –II was 4.48, 4.90, 5.11, 5.62 and 6.78 in 3rd to 7th week. In E₅ vigor index- I was 521.80, 504.64, 557.90, 676.92 and 761.28 while vigor index –II was 2.45, 2.81, 3.47, 4.27 and 4.93 in 3rd to 7th week. In E₆ vigor index-I from 3rd to 7th week was 284.18, 338.77, 446.10, 496.93 and 606.05 while vigor index- II was 1.06, 1.48, 2.38, 2.83 and 3.75. The mean value of different quality traits in E₁ was 24.28 for seedling

length(S.L.), 5.38 for seed weight (S.W), 0.15 for seedling dry weight (S.D.W), 1063.43 for vigor index- I (VI- I) and 7.25 for vigor index- II. The mean value of different quality traits in E₂ was 25.63 for S.L., 4.85 for S.W., 0.18 for S.D.W, 1084.41 for VI- I and 8.66 for VI- II. The mean value of different quality traits in E₃ was 25.87 for S.L., 4.45 for S.W., 0.17 for S.D.W, 883.36 for VI- I and 6.29 for VI- II. The mean value of different quality traits in E₄ was 27.86 for S.L., 7.43 for S.W., 0.13 for S.D.W, 660.23 for VI- I and 3.46for VI- II. The mean value of different quality traits in E₅ was 27.14 for S.L., 6.80 for S.W., 0.15 for S.D.W, 487.15 for VI- I and 2.83 for VI- II. The mean value of different quality traits in E₆ was 27.50 for S.L., 6.76 for S.W., 0.13 for S.D.W, 343.90 for VI- I and 1.76for VI- II.

Seed germination (%) in all the three varieties H 1098- I, H 1300 and H 1316 was higher in early sown conditions during both the years and it was reduced in normal sown conditions compared to early sown conditions and further reduced to late sown conditions during both the years. These finding indicated that environmental factors were favorable for seed development in early sown conditions during both the years. These results confirm the earlier findings of Bange and Milroy, 2004.

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