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Seed Vigour Evaluation of Cucumber (*Cucumis sativus* L.) Seeds in Relation to Seedling Emergence*

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Abstract: The seedling emergence of 16 commercial seed lots (7 in 2005 and 9 in 2006) of cucumber (*Cucumis sativus* L.) were compared at low temperature (LTE), mechanical stress (MSE, 8 cm sowing) and salt stress (SSE, 200 mM NaCl) plantings. The emergence percentage ranged between 29-76% for LTE, 46-86%, for MSE and 59-92% in 2005 and 35-86% at LTE, 28-83% at MSE, 54-93% at SSE in 2006. The radicle emergence of the lots was determined after Controlled Deterioration (CD) at 45°C with 20 or 24% moisture content for 48, 72, 96, 120, 144 h. The accelerated ageing test was also conducted at the same temperature and durations in both years. Germination after large number of combinations of CD and AA was ($p<0.05$) correlated with LTE, MSE and SSE. Initial laboratory germination was significantly ($p<0.05$) related to LTE, MSE and SSE in 2005 but not in 2006 ($p>0.05$). The optimum CD conditions of 48 h and 20% mc at 45°C and AA conditions of 96 h at 45°C are suggested as a successful vigour test conditions for cucumber seeds.

Key words: *Cucumis sativus* L., seed vigour, seedling emergence

INTRODUCTION

High qnality seed is required for rapid and synchronous seedling emergence which is a prerequisite for successful stand establishment and uniform plant growth and development. The laboratory germination test provides information about the seedling emergence potential of seed lots under favorable sowing conditions (Perry, 1978). However, conditions in seed-bed are generally lower than optimal. Low temperature (in early spring sowing), mechanical stress (deep sowing) and salinity (saline water irrigation) are some abiotic stress factors that prevail in seed-bed and reduce seedling performance in cucumber seeds in open-field or transplant production in glasshouse (Robinson and Decker-Walters, 1997). Standard laboratory germination tests may fail to predict emergence under sub-optimal sowing conditions (Powell and Matthews, 2005; Demir *et al*., 2004; Basak *et al*., 2006). This promoted the development of vigour tests for more reliable assessment of emergence performance of the seed lots in wider range of planting enviroments (Hampton and TeKrony, 1995).

The Controlled Deterioration (CD), (Powell and Matthews, 2005) and Accelerated Ageing (AA) (Hampton and TeKrony, 1995) are common seed vigour tests. Both tests have been used to predict field emergence in various crops (Powell and Matthews, 1981; TeKrony, 2003, Demir *et al*., 2005; Mavi and Demir, 2007). CD and AA studies for evaluating seed vigour in cucurbit seeds are scarce. In the members of this family, the optimum vigour separation was obtained by ageing at 45°C for 192 h in the muskmelon (Pesis and Timothy, 1983) at 45°C for 120 h (Demir *et al*., 2004) and 41°C for 72 h (Torres and Marcos-Filho, 2005) in melon seeds. Dutra and Vieira (2006) reported that the combination of 41°C/ 96 h can be used to evaluate the physiological vigour potential of pumpkin and

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zucchini seeds. Little information is available for cucumber seeds. Our previous study, with only two lots, indicated that 45°C with 96 h gave a good separation in cucumber seed vigour (Demir *et al*., 2004). More recently, ideal vigour test conditions for watermelon seeds were reported to be 120 h at 45°C in AA and 48 h with 20% mc at 45°C in CD (Mavi and Demir, 2007). However, detailed work with larger number of lots in cucumber is needed for further confirmation of mentioned ageing enviroument in Demir *et al*. (2004). The first objective of the present study was to evaluate the efficiency of the accelerated aging and controlled deterioration tests to determine the physiological potential of cucumber seed lots. Secondly, to evaluate ability of various periods of AA and seed moisture combinations of CD tests to predict relative seedling emergence under low temperature, mechanical and salt stress envirouments in cucumber seed lots.

MATERIALS AND METHODS

The experiment was conducted in Seed Science Laboratory of Ankara University, in 2005 and 2006. Seven seed lots in 2005 and nine in 2006 of cucumber (*Cucumis sativus* L.), variety Beith Alpha, were purchased from several commercial sources. Laboratory germination test and seed moisture content were determined when lots were received (ISTA, 2003).

The Controlled Deterioration (CD) test was conducted on samples of the seed lots at 20% and 24% seed moisture contents (mc) for 48, 72, 96, 120, 144 h at 45°C. In 2006, the same durations and moisture contents were used. For temperature and seed moisture combination of each lot, two batches of eight hundred (2005) or nine hundred (2006) seeds of known initial moisture content were placed on moist paper and allowed to imbibe to the weight calculated to achieve a 20% mc. in one batch and 24% mc in the other. Sub-samples of 150 seeds/lot/moisture/temperature, were sealed in laminated foil bags and incubated at 45°C in both years. Germination was then tested.

The accelerated ageing test was conducted according to the procedure described by Hampton and TeKrony (1995).

For the Low Temperature Emergence (LTE) test, seeds (four replicates of 50 seeds/lot) were sown 2 cm deep in the experimental field of the Department of Horticulture, University of Ankara on 17 April in 2005 and 22 April in 2006. The soil was a sandy loamy. Daily minimum and maximum soil temperatures were recorded throughout the test and these varied between 9 and 27°C. The number of seedlings emerged (assessed by unfolding of cotyledons on the surface) was counted daily and finally after 30 days in LTE (Low Temperature Emergence), 20 days in MSE (Mechanical Stress Emergence) and 25 days in SSE (Salt Stress Emergence) tests.

The Mechanical Stress Emergence (MSE) test was determined by sowing seeds 8 cm deep on 15 May 2005 and 1 June 2006 in the same field. Daily minimum and maximum soil temperatures varied between 18 and 30°C during the test.

Seedling emergence under salt stress (SSE) was determined by sowing seeds 4 cm deep in compost (Plantaflour, Humus-Verkanfs GmbH, Germany) in plastic seedling trays (32×6×16 cm). The electrical conductivity of the saturated extract of the compost was 0.8 mS cm^{-1} before sowing. The trays were placed on a bench in a growing cabinet in which the temperature was maintained at 20±2°C and were watered with saline solution (200 mM, NaCl). Light was provided at seedling level by cool fluorescent lamps (72 μM $m^{-1}sec^{-1}$). Trays were inspected daily and the relative humidity in the cabinet was kept over 75% in order to reduce evaporation. Trays were watered with the same amount of saline solution (100 mL) as needed. The experiment was terminated 25 days after sowing.

Statistical analysis was conducted using Statistical Package for Social Sciences (SPSS). Means were compared using the Duncan Multiple Range test at 5% level. Correlation coefficients (R) of vigour tests with seedling emergence under stress conditions were calculated.

RESULTS

Initial standard germination percentages of all lots in both years ranged between 94 to 100% and seed moisture content ranged between 4.9 and 8.6% (Table 1).

In 2005, emergence at the low temperature (LTE) sowing ranged from 29% (lot 1) to 76% (lots 5, 6) (Table 2). Although, the range of emergence changed from 46% to 86% in the mechanical (MSE) and from 59% and 92% salt stress sowings (SSE) the lowest (lot 1) and highest (lot 6) emerging seed lots were the same in both tests (Table 2). Several lots showed differences in emergence which were significant ($p<0.05$) but lots 5, 6 and 7 in MSE and 3, 5 and 6 in SSE had significantly higher emergence than any other seed lot. Generally, the lowest emergence percentages were found in LTE and the highest in SSE; MSE values were between them except in two lots in 2005 (Table 2).

In 2006, the lowest emerging lot was lot 1 and the highest one was 5 in LTE, MSE and SSE sowings (Table 2). Lot 1 showed 35, 28 and 54% of emergence in LTE, MSE and SSE, respectively. Corresponding values for lot 5 were 86, 83 and 91%, respectively. The rest of the lots in all three stress environments showed differences in emergence that were significant ($p<0.05$).

In both years, the Controlled Deterioration (CD) test produced a wide range of germination percentages amongst the seed lots, indicating considerable differences in seed vigour (Table 3). As the duration, temperature and seed moisture content during the test were increased, the germination spread between the lots also increased. It was higher at longer deterioration at both moisture contents than shorter durations (Table 3). As in the CD test, mean AA germination percentages also decreased as deterioration time increased. The lowest (51-52%) was observed at 45°C for 144 h in 2006 (Table 3). The final seedling emergence percentages of the lots at low temperature, mechanical and salt stress in both years were correlated with CD germination (Table 4). All R values were significant at 0.5% level in 2006 except three cases (45°C 24% mc 144 h).

Table 1: Initial standard germination (SG%) and seed moisture (mc, f.wt.,%) of cucumber seed lots used in 2005 and 2006

2005			2006		
Lots	SG (%)	S.mc (%)	Lots	SG (%)	S.mc. (%)
1	94	5.8	1	96	7.7
2	95	6.2	2	96	6.8
3	97	6.9	3	97	7.2
4	98	4.9	4	96	5.3
5	100	7.2	5	98	6.7
6	100	7.0	6	97	6.8
7	97	6.7	7	98	8.6
NA			8	100	7.0
NA			9	99	6.3

SG: Standard Germination, S.mc.: Seed moisture content NA: No seed available

Table 2: Seedling emergence at low temperature (LTE), mechanical stress (MSE) and salt stress sowings (SSE) in 2005 and 2006, of cucumber seed lots

2005					2006			
Lots	LTE	MSE	SSE	Storage	Lots	LTE	MSE	SSE
1	29d	46c	59c	37e	1	35d	28f	54c
2	42bc	60b	72b	81c	2	76ab	58c	73b
3	45bc	67b	91a	67d	3	45cd	40e	60bc
4	38c	56bc	75b	63d	4	45cd	46de	65bc
5	76a	86a	83a	92b	5	86a	83a	91a
6	76a	86a	92a	97a	6	68b	74b	88a
7	51b	80a	72b	71d	7	79ab	74b	87a
NA					8	80ab	79ab	93a
NA					9	53c	53cd	67bc

Means with different letters are significantly different at 5% level in the same column; LTE: Low Temperature Emergence (%), MSE: Mechanical Stress Emergence (%), SSE: Salt Stress Emergence (%), NA: No seed available

Table 3: Maximum, minimum and mean germination percentages of the cucumber seed lots after CD at 20 and 24% moisture contents and AA tests at 45°C after various ageing periods (h) in two consecutive years

CD (h)	20% Range	Mean	24% Range	Mean	AA (h)	Range	Mean
2005							
48	18-91	65	76-97	89	48	87-99	92
72	4-86	49	72-100	88	72	43-96	81
96	2-95	56	51-97	81	96	35-93	69
120	12-86	52	23-93	70	120	18-91	55
144	0-85	35	9-75	49	144	14-92	51
2006							
CD (h)	20% Range	Mean	24% Range	Mean	AA (h)	Range	Mean
48	53-98	82	54-96	83	48	63-98	87
72	11-92	70	28-96	73	72	62-100	87
96	0-96	66	3-86	53	96	42-98	79
120	0-91	43	1-79	38	120	29-95	72
144	0-62	22	0-40	8	144	26-91	68

Table 4: Correlation coefficient values calculated for laboratory germination (SG) and CD test as predictors of cucumber seedling emergence percentages at low temperature (LTE), mechanical (MSE) and salt stresses (SSE) sowings in both years

2005						2006					
Temp	m.c.	Hours	LTE	MSE	SSE	Temp	m.c.	Hours	LTE	MSE	SSE
	20%	48	0.81*	0.87**	0.89**		20%	48	0.88**	0.93***	0.88**
		72	0.69	0.59	0.86*			72	0.76*	0.85**	0.80**
		96	0.71	0.73	0.88**			96	0.81**	0.89**	0.83**
		120	0.54	0.45	0.86*			120	0.71*	0.85**	0.83**
		144	0.49	0.33	0.72			144	0.81**	0.79*	0.80**
45°C	24%	48	0.58	0.68	0.86*	45°C	24%	48	0.87**	0.94***	0.90***
		72	0.67	0.67	0.95***			72	0.85**	0.92***	0.88**
		96	0.54	0.53	0.89**			96	0.94***	0.93***	0.90***
		120	0.71	0.74	0.86*			120	0.86**	0.90***	0.92***
		144	0.32	0.34	0.77*			144	0.45	0.43	0.42
		SG	0.88**	0.82*	0.76*			SG	0.48	0.60	0.58

Significance *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 5: Correlation coefficients calculated for laboratory germination (SG) and AA test as predictors of cucumber seedling emergence percentages at low temperature (LTE), mechanical (MSE) and salt stresses (SSE) sowings in both years

2005					2006				
Temp.	Hours	LTE	MSE	SSE	Temp.	Hours	LTE	MSE	SSE
	48	0.60	0.56	0.79*		48	0.70*	0.85**	0.81**
	72	0.67	0.66	0.85*		72	0.84**	0.87**	0.82**
45°C	96	0.90**	0.88**	0.76*	45°C	96	0.84**	0.92***	0.89***
	120	0.71	0.53	0.36		120	0.63	0.76*	0.72*
	144	0.80*	0.60	0.30		144	0.76*	0.89**	0.86**
	SG	0.88**	0.82*	0.76*		SG	0.48	0.60	0.58

Significance *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

A large number of time and temperature combinations after AA were also correlated with emergence (Table 5). The highest values were observed 96 h in 2005 and in 2006.

The standard germination provided separation in 2005 ($p<0.05$), however, the level of correlation of standard germination test in 2006 was lower than most combinations of ageing tests (Table 5).

Germination after CD (45°C, 24%, 48 h) and AA (45°C, 96 h) were related to LTE, MSE and SSE. The lower the CD and AA germination, the lower emergence at low temperature, mechanical and salt stress conditions. Laboratory germination showed low R^2 values in most of the cases (Fig. 1).

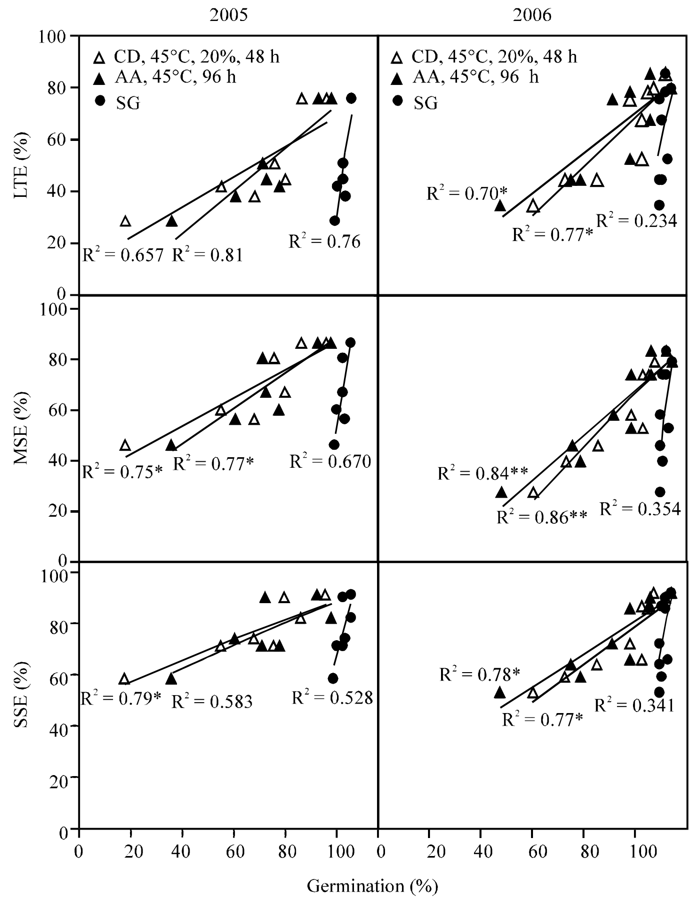

Fig. 1: Relationship between germination after CD at 45°C with 20% mc, for 48 h (Δ), AA at 45°C for 96 h (▲) and seedling emergence percentage at low temperature (LTE), mechanical stress (MSE) and salt stresses (SSE) and laboratory germination (SG, ●) of cucumber seed lots in 2005 and 2006

DISCUSSION

The combinations of 20% mc. for 48 h in CD and 96 h in the AA test at 45°C consistently gave higher correlation values with emergence in all three stress sowings in both years. Prediction of standard laboratory germination was not consistent (Table 4 and 5).

Various abiotic stress factors influence seed germination and stand establishment in seedling development stage of cucumber (Robinson and Decker-Walters, 1997). The optimum temperature range for cucumber seed germination in this species is reasonably high, between 25 and 30°C and is inhibited below 15°C (Jennings and Saltveit, 1994). Seeds are often direct sown in the field in early spring (end of February-beginning of March) in open-field or in modules in unheated plastic tunnels to produce transplants in Mediterranean region. Temperatures during that period are usually sub-optimal (14-17°C) for germination (Robinson and Decker-Walters, 1997). Seeds may also encounter a mechanical resistance particularly when sown deep in open-field until they emerge to soil surface. Salinity can also be inhibitory in seedling emergence in semi-arid parts of the Mediterranean region during summer or when ground water with high salt levels is used for irrigation. It reduces the rate and increases the spread of seed germination (Foolad and Lin, 1997). Mentioned vigour test conditions estimated potentially better seed lots under these stressful plantings.

Information about the estimates of potential stand establishment in the field or transplant production in plastic tunnels is great value for producers when planting conditions are not optimal. Laboratory germination is relatively successful under optimum field conditions (Perry, 1978). However, vigour tests provide additional information on the rate and uniformity of seedling growth under wide range of enviroumental conditions (TeKrony, 2003; Powell and Matthews, 2005). Successful prediction of cucumber seedling emergence percentages in trays by ageing tests were in agreement with the conclusions of previous studies (Powell and Matthews, 1981; Powell *et al*., 1991; Strydom and Venter, 1998; Demir *et al*., 2005; Basak *et al*., 2006, Mavi and Demir, 2007).

AA has been successfully used in ranking the seed vigour of various crops (Hampton and TeKrony, 1995; TeKrony, 2003; Hampton *et al*., 2004). The basic difference between AA compared to CD is that seed moisture is not pre-set in AA so that seeds may attain different moisture contents during ageing due to the differences in their chemical composition, i.e., hygroscopic, hydrophobic seed storage material. Moreover, AA is used for larger seeds unlike CD which was recommended for small-seeded species. Powell (1995) reported that variation in seed moisture contents after traditional accelerated ageing affect extend of ageing between and among the seeds.

Hampton and TeKrony (1995) recommended 41-43°C ageing temperature for 24 -72 h as acceptable combinations in a large number of species. This study indicates that somewhat longer ageing periods (96 h) are required for vigour assessment in cucumber seeds. We previously indicated that 45°C with 96 h ageing in cucumber can be used for vigour assessment (Demir *et al*., 2004). Present results with 16 seed lots in two years confirmed our previous findings (45°C, 96 h in AA) concerning the optimum vigour conditions in limited number (two) of cucumber lots. Similarly watermelon seeds also need longer ageing periods than most of the crop seeds. More recently, optimum CD enviroument for watermelon was reported to be 48 h with 24% mc at 45°C and AA enviroument of 120-144 h at 45°C (Mavi and Demir, 2007). Pesis and Timothy (1983) reported that vigour of the two muskmelon varieties were separated by ageing at 45°C, 100% relative humidity for 192 h. More recently, Torres and Marcos-Filho (2005) recommended the traditional AA test of 41°C for 72 h to separate five melon seed lots in two cultivars each. However, our previous experience indicated that particularly in AA, temperatures lower than 45°C and durations shorter than 96 h were not successfully separated cucurbit seed lots.

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