AcademicPres

Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic ISSN 1842-4309

Not. Bot. Hort. Agrobot. Cluj 36 (1) 2008, 68-72

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

Relationship between Seed Germination Capacity of 10 Species of Vegetables and their Emergence in the Field

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Abstract

In the years 2001-2003, research was carried out to determine to what extent seed germination capacity of selected vegetable species indicates their field emergence potential. The experiment included 10 species: white head cabbage, garden carrot, red beet, onion, cucumber, tomato, radish, head lettuce, snap dwarf bean and garden pea. The seeds came from 4 commercial seed companies operating on the Polish market. The seeds of red beet and radish from different seed companies had different germination capacities, field emergence and ratio of emergence to germination capacity, but the other species did not differ. The highest ratios of emergences to germination capacity were found for radish (82.3%) and white head cabbage (81.2%), whereas the lowest were for carrot (44.6%) and head lettuce (45.1%). The species differed by the stability of the ratio in various years of the experiment, i.e. they responded differently in the given year to the weather conditions. The biggest variation over the years were found for onion (5.3-87.7%; or 16.5x), garden carrot (21.6-99.0%; or 4.6x) and head lettuce (19.9-67.3%; or 3.4x), whereas the smallest were for radish (67.1-95.8%; or 1.4 x) and white head cabbage (65.2-97.2%; or 1.5x).

Keywords: seed quality, seed germination, field emergence

Introduction

Germination capacity has been a basic parameter describing seed quality. The main purpose of this research was to find out to what extent the parameter describes real emergence of selected vegetable species in the field.

Materials and methods

The experiments were carried out in the years 2001-2003. Seeds were bought from 4 seed companies operating on the Polish market. There was one cultivar each of the following species: white head cabbage (*Brassica oleracea* L. ssp. *oleracea* convar. *capitata* L., Alef. var. *capitata* L. forma alba DC.), garden carrot (*Daucus carota* L. ssp. *sativus* Hoffm.), red beet (*Beta vulgaris* L. ssp. *vulgaris* convar. *vulgaris* var. *vulgaris*), onion (*Allium cepa* L. var. *cepa* Helm), cucumber (*Cucumis sativus* L.), tomato (*Lycopersicon esculentum* Mill. nom. cons. var. *esculentum*), radish (*Raphanus sativus* L. var. *sativus*), head lettuce (*Lactuca sativa* L. var. *capitata* L.), dwarf snap bean (*Phaseolus vulgaris* L. var. *nanus* L.) and garden pea (*Pisum sativum* L. ssp. *sativum*), except that company number 4 did not offer a dwarf snap bean, garden pea, radish or white head cabbage.

Seed germination tests were done following the national standards procedure PN-R-65950:1994 for the Seed Testing Station in Poznań. The evaluation of field emergence was done on plots at the Baranowo Agricultural Experiment Station of the Agricultural University of Poznań. The experiment was started in loss block separately for each species. One hundred seeds of each species from each company were sown on each plot. There were 4 replications. The seeds were sown in rows spaced 0.25 m apart, with guard rows not used in the experiment for protection from side effects. All seeds of cool season crops were sown after April 20, i.e. on April 30, 29 and 28 in 2001, 2002, and 2003, respectively. The seeds of tomato, cucumber and beans were sown after May 15, i.e. on May 18, 16 and 16 in 2001, 2002, and 2003, respectively. One week after sowing the seeds, and then at 7 day intervals, an assessment of field emergence was done. It consisted of counting the plants in the field and calculating the percentage emerged (in the case of red beet it could exceed 100%). The final field emergence numbers were counted 35 days after sowing the seeds.

The ratio of field emergence to germination capacity was calculated following the formula used by other researchers (Woyke et al., 1990) as: (field emergence/germination capacity) X 100. The statistical analyses and significant differences were calculated using the Duncan's Multiple Range Test at α=0.05.

Water and temperature conditions. In 2001 the monthly precipitation was close to the multiyear mean for the years 1957-2000. However, the May 2001 total was much lower than in previous years, and together with higher than normal temperatures, caused the seeds to germinate over

a longer period. The lack of rain was especially notable in the first and second weeks of the month. By June increased rainfall caused a mass emergence of seedlings.

The rains in April and May 2002 were very similar to multiyear means for the period for the years 1957-2000. There was no rain in the third week of April, but rain from the beginning of May created favorable conditions for seed germination and emergence during the month. In June, although most of the rain occurred in the first and second weeks of the month, the mean precipitation was lower than the multiyear value. Altogether though, the conditions were favorable for seed germination and plant growth; the daily mean air temperatures were higher and more stable than the multiyear values.

Soil conditions. The experiment was carried out on III b class soil. This is a gray soil created from clay and sand strongly placed on light clay. The humus content was 0.9 to 1.0%.

Results and discussion

The comparison of germination capacity of the tested vegetable seed samples showed differences in terms of their quality only in the case of 2 species: red beet and radish. The red beet seeds from the company No. 3 and the radish seeds from the company No. 2 germinated more poorly than those from the other companies (Table 1).

Despite differing field emergence values in the test years during 5 weeks from sowing the seeds, means for 2001-2003 indicated no differences among the companies for garden carrot, onion, white head cabbage, cucumber, tomato, snap bean, garden pea and head lettuce. Differences in emergence after 35 days were found only for red beet and radish, similar to their germination capacities. In the case of red beet, differences were found between companies No. 2 and 3, with higher values for the first. The mean red beet seed emergence after 35 days ranged from 76.0 to 123.1%. The highest emergence was for radish seed from the company No. 1. The mean emergence of radish ranged from 57.2% (company No. 2) to 71.8% (company No. 1) (Table 2).

There were differing ratios of plant emergence to seed germination capacity amongst the individual species (Table 3). The highest ratios were calculated for radish (82.3%) and white head cabbage (81.2%) whereas the lowest were for garden carrot (44.6%) and head lettuce (45.1%). The species also differed by the stability of this parameter in the individual years, i.e., they responded differently to different weather conditions in the individual years. The biggest differences amongst the individual years occurred with onion (5.3 – 87.7%, or 16.6x), garden carrot (21.6 – 99.0%, or 4.6x) and head lettuce (19.9 – 67.3%, or 3.4x), whereas the smallest was for radish (67.1 – 95.8%, or 1.4x), cucumber (59.3 – 85.7%, or 1.4x) and white head cabbage (65.2-97.4%, or 1.5x). Other species

Table 1 Germination capacities of seeds of 10 species of vegetables from selected companies operating on the Polish market

Species	Germination capacity (%)															
	Company															
	No. 1				No. 2				No. 3				No. 4			
	Year			Mean	Year			Mean	Year			Mean	Year			Mean
	2001	2002	2003		2001	2002	2003		2001	2002	2003		2001	2002	2003	
Red beet	85	95	94	91.3 b*	87	92	90	89.7 b	78	78	81	79.0 a	91	93	82	88.7 b
Garden carrot	81	80	69	76.7 a	82	77	82	80.3 a	75	70	57	67.3 a	82	53	81	72.0 a
Onion	86	65	80	77.0 a	84	61	96	80.3 a	92	84	68	81.3 a	81	76	82	79.7 a
White head cabbage	91	91	72	84.7 a	62	95	70	75.7 a	83	77	66	75.3 a	96	98	88	94.0 a
Cucumber	96	88	85	89.7 a	88	91	100	93.0 a	85	94	88	89.0 a	95	98	99	97.3 a
Tomato	65	88	69	74.0 a	61	91	93	81.7 a	92	96	79	89.0 a	96	95	95	95.3 a
Snap bean	97	90	86	91.0 a	78	80	84	80.7 a	95	84	80	86.3 a	x	x	x	x
Garden pea	91	90	92	91.0 a	92	96	92	93.3 a	93	78	86	85.7 a	x	x	x	x
Radish	94	71	84	83.0 b	66	63	68	65.7 a	92	91	77	86.7 b	x	x	x	x
Head lettuce	77	53	89	73.0 a	69	52	97	72.7 a	75	61	52	62.7 a	x	x	x	x

Explanation: * Means in the lines followed by the same letter are not significantly different according to Duncan`s test at $\alpha = 0.5$; X – no sample

Table 2 Field emergence (in the years 2001-2003) of the seeds of 10 species of vegetables from selected seed companies operating on the Polish market

Species	Number of days after sowing	Field emergence (%)							
		Company							
		No 1		No 2		No 3		No 4	
Red Beet	7	6.1	a	6.1	a	2.9	a	3.6	a
	14	60.4	a	75.4	a	40.9	a	65.4	a
	21	71.2	a	80.7	a	44.0	a	70.6	a
	28	76.4	a	81.9	a	47.6	a	72.7	a
	35	102.1	ab	123.1	b	76.0	a	92.6	ab
Garden Carrot	7	0.0	a	0.0	a	0.0	a	0.0	a
	14	15.3	a	19.5	a	14.5	a	21.0	a
	21	25.1	a	29.5	a	25.1	a	28.3	a
	28	28.8	a	31.8	a	27.0	a	33.4	a
	35	31.1	a	35.1	a	30.6	a	38.4	a
Onion	7	0.0	a	0.0	a	0.0	a	0.0	a
	14	10.9	a	10.7	a	22.7	a	20.1	a
	21	21.2	a	33.7	a	37.2	a	36.6	a
	28	23.7	a	42.3	a	40.2	a	39.8	a
	35	26.1	a	45.0	a	43.1	a	45.4	a
White Head Cabbage	7	22.8	a	19.6	a	14.9	a	25.9	a
	14	50.6	a	48.2	a	40.7	a	59.9	a
	21	52.6	a	50.6	a	41.9	a	62.5	a
	28	55.8	a	52.5	a	44.1	a	63.8	a
	35	68.3	a	64.8	a	56.3	a	74.1	a
Cucumber	7	14.6	a	18.8	a	16.4	a	21.9	a
	14	28.2	a	40.2	a	34.3	a	39.1	a
	21	50.8	a	59.9	a	56.7	a	66.0	a
	28	56.5	a	66.1	a	61.2	a	71.6	a
	35	60.3	a	68.6	a	64.4	a	74.0	a
Tomato	7	0.2	a	0.4	a	0.5	a	0.8	a
	14	9.2	a	33.1	a	26.6	a	31.2	a
	21	32.1	a	50.9	a	45.7	a	63.6	a
	28	45.4	a	70.9	a	67.0	a	79.3	a
	35	48.6	a	72.1	a	68.5	a	81.1	a
Snap Bean	7	2.8	a	2.3	a	0.8	a	2.8	a
	14	27.9	a	34.0	a	23.3	a	27.9	a
	21	47.0	a	50.0	a	47.6	a	47.0	a
	28	68.6	a	59.8	a	61.6	a	68.6	a
	35	70.2	a	63.7	a	62.8	a	70.2	a
Garden Pea	7	16.6	a	11.1	a	11.6	a	16.6	a
	14	48.3	a	43.7	a	37.8	a	48.3	a
	21	53.2	a	48.8	a	40.6	a	53.2	a
	28	55.0	a	50.7	a	42.2	a	55.0	a
	35	76.6	a	69.3	a	53.5	a	76.6	a
Radish	7	18.8	a	18.2	a	17.0	a	18.8	a
	14	46.7	a	34.3	a	40.6	a	46.7	a
	21	50.9	a	36.1	a	46.6	a	50.9	a
	28	54.1	a	41.2	a	48.3	a	54.1	a
	35	71.8	b	57.2	a	62.4	a	71.8	b
Head Lettuce	7	6.5	a	4.8	a	4.9	a	6.5	a
	14	16.4	a	20.1	a	13.6	a	16.4	a
	21	18.3	a	24.7	a	15.9	a	18.3	a
	28	20.3	a	29.4	a	20.1	a	20.3	a
	35	28.1	a	36.3	a	24.5	a	28.1	a

Explanation: * Means in lines followed by the same letters are not significantly different according to the Duncan's test at $\alpha = 0.05$

Table 3 Ratio of field emergence to germination capacity of 10 species of vegetables coming from selected seed companies operating on the Polish market

Species	Overall means for species	Field emergence / Germination capacity x 100 (%)																			
		Company																			
		No. 1					No. 2					No. 3					No. 4				
		Year			Mean		Year			Mean		Year			Mean		Year			Mean	
		2001	2002	2003			2001	2002	2003			2001	2002	2003			2001	2002	2003		
Red beet	112.2	93.2	142.1	97.9	111.1	ab*	119.0	129.0	163.3	137.1	b	97.7	106.0	84.8	96.4	a	92.0	115.0	106.3	104.4	ab
Garden carrot	44.6	21.6	69.0	30.0	40.2	a	22.2	68.2	42.1	44.2	a	16.3	78.6	43.3	46.1	a	28.9	99.0	48.1	58.7	a
Onion	51.9	20.0	86.1	6.5	37.5	a	5.3	87.7	80.2	57.7	a	20.1	78.6	65.7	54.8	a	18.8	85.1	68.5	57.5	a
White head cabbage	81.2	74.7	73.6	97.2	81.8	a	97.9	68.9	97.4	88.1	a	70.7	65.2	90.9	75.6	a	67.2	73.7	97.1	79.3	a
Cucumber	72.3	63.2	69.9	69.0	67.4	a	59.3	85.7	75.5	73.5	a	64.3	72.9	79.5	72.2	a	81.0	74.2	72.9	76.0	a
Tomato	78.8	33.1	79.5	78.5	63.7	a	95.4	96.7	75.5	89.2	a	66.0	82.0	83.8	77.3	a	92.7	92.1	70.2	85.0	a
Snap bean	79.0	60.3	100.0	72.3	77.5	a	40.4	98.4	96.4	78.4	a	56.0	91.3	95.9	81.1	a	x	x	x	x	
Garden pea	73.9	83.2	73.3	95.6	84.0	a	77.7	58.5	87.2	74.5	a	41.6	68.6	79.1	63.1	a	x	x	x	x	
Radish	82.3	81.1	95.8	84.8	87.2	b	87.4	87.3	86.8	87.2	b	67.1	70.0	80.1	72.4	a	x	x	x	x	
Head lettuce	45.1	43.1	63.2	19.9	42.1	a	44.5	67.3	44.5	52.1	a	19.3	53.6	50.4	41.1	a	x	x	x	x	

Explanations: * Means in lines followed by the same letters are not significantly different according to the Duncan's test at $\alpha = 0.05$; „x" – no sample

differed from 2.3 to 2.9x The red beet ratio was 112.2% (84.8 – 163.3%, or 1.9x). This phenomenon, germination > 100%, came from the fact that one red beet seed may produce a few seedlings.

Despite big differences amongst the individual years, significant differences of the ratio of the emergence to germination capacity were observed only for red beet and radish (Table 3). The value was the highest for red beet seeds coming from the company No. 2 (137.1%) and the lowest for the seeds from company No 3 (96.4%). The value was, however, much lower for radish seeds coming from the company No. 3 (72.4%) then for the seeds from the other tested companies (87.2% and 72.4%).

Except for red beet and radish, emergence results were not significantly different in individual years. This was also confirmed by others (Woke et al., 1990), indicating the importance of weather conditions in such trials. The biggest differences were recorded for the onion, carrot and lettuce seeds, confirming earlier results with onion (Peplińska, 1967; Kraak et al., 1984; O`Sullivan and Tiernan, 1990), carrot (Peplińska, 1967; Szafirowska 1990a; Woyke et al., 1990) and lettuce (Sokołowska, 1990; Woyke et al., 1990), in which the species were susceptible to field conditions for germination and emergencies. Radish, cucumber and white head cabbage were most resistant to these factors.

Conclusions

The seeds of red beet and radish coming from different seed companies had different germination capacities, field emergence and ratio of field emergence to germination capacity values. The seeds of white head cabbage, garden carrot, onion, cucumber, tomato, head lettuce, snap bean and garden pea did not differ amongst by these parameters.

The most susceptible species to field conditions during germination and emergence were onion, carrot and lettuce, and the least susceptible were the seeds of radish, cucumber and white head cabbage.

The highest ratio of emergence to the germination capacity was found for radish and cabbage, and the lowest were for carrot and lettuce.

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