Seed Quality and Seeding Technology[1]

Shinsuke Agehara and Bielinski M. Santos[2]

Seed

A seed is an encapsulated plant embryo developed from a fertilized ovule. Seed quality plays an important role in the production of agronomic and horticultural crops. High quality seeds are genetically and varietally pure with a high germination percentage, free from disease and disease organisms, and with a proper moisture content and weight.

High quality seeds insure good germination, rapid emergence, and vigorous growth. These aspects translate to a good stand (whether greenhouse or field). Poor quality seeds result in "skips," excessive thinning, or yield reductions due to overcrowding, all of which diminish profitability.

Vigor is often implied when discussing seed quality, and most growers have come to use the terms "quality" and "vigor" interchangeably. "Vigor" is defined as those properties that determine the potential performance of seed during germination and establishment. Seed vigor is generally related to yield in vegetables. Therefore, high-vigor seed should be used in all instances to ensure good stand establishment under varying field conditions.

Different seed lots sown in the same environment may act differently, and seedbed factors (temperature, water content, etc.) strongly affect seed performance. Fluctuations (airspace, moisture, temperature, etc.) in the seedbed environment are the most important factors in determining final seedling emergence. Furthermore, large seeds of a particular species frequently produce more vigorous plants and uniform stands than small seeds.

Most seeds are fairly hardy; however, seeds in the bean and pea family (snap, lima, southern pea, English pea, etc.) are fragile and should be handled with extreme care. Dropping these seeds from any height while loading or unloading or pouring into seed hoppers will crack their seed coats and decrease germination.

National and international seed companies strive to provide high-quality vegetable seed through various milling processes and stringent disease screening. These techniques reduce the total tonnage of raw seed but increase the overall quality. Federal minimum germination standards regulate the seed industry (Table 1). However, most companies attempt to exceed these minimum standards.

Organic Seed and Sources

Seed used for organic vegetable production must meet specifications of the USDA's National Organic Program. Recordkeeping is required for growers during all phases

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2. Shinsuke Agehara, assistant professor; and Bielinski M. Santos, former associate professor; Horticultural Sciences Department, UF/IFAS Gulf Coast Research and Education Center, Wimauma, FL 33598.

of organic production, as is certification by an accredited certifying agency. Use of conventionally produced seed is allowed only when preferred cultivars are not available from organic sources. In no case are seeds treated with non-approved substances, or seeds of genetically modified organisms or derived from artificial seed technologies, allowed in organic production.

Primed Seed

Improved seed quality and vigor may be obtained with primed or enhanced seed. Primed seed is biologically altered through the addition of just enough water (and often some hormones) to allow the seed to undergo the early stages of germination without actually germinating. In this "primed" state, seed will germinate more rapidly and emerge more uniformly over a greater range of tem- peratures and soil moisture conditions. This translates to greater seedling vigor, uniformity, and rapid establishment.

Primed seed is best suited for direct seeding where adverse conditions may prevail during germination and emergence. However, enhanced seed use in the greenhouse is also cost effective. Uniformity of emergence alleviates "playing catch-up" within a flat due to uneven emergence. Rapid emergence means production programs (fertilizer, pesticides, etc.) can be quickly implemented. The reduction in wasted space from poor germination and in labor for thinning overseeded flats increases production efficiency. Greater efficiency means greater profitability.

Seed Storage

Care must be taken with seed to avoid injury and provide proper storage. Unused seed is best stored if the hermetic seal has not been broken. However, if open cans are to be stored, it is best to seal these cans in ziplock bags and store at 40°F–50°F preferably in a refrigerator used solely for seed storage. High temperatures and humidity are very harmful to seed. Humid conditions lead to increases in seed moisture, which reduce shelf life. Under proper storage conditions, vegetable seeds can remain viable for several years. The relative life expectancy of vegetable seed is presented in Table 2.

Field Seeding

Prior to seeding, the field should be leveled and worked to obtain a fine textured soil, free of clods and debris. Seedbed firmness, depth of planting, and available moisture are important considerations. Treated seeds should be used for protection against soil-borne diseases and insects during germination and seedling development. New seed film-coating techniques apply fungicides and pesticides in "no dust" formulations, which decrease the potential for worker injury by reducing absorption and inhalation risk.

See Table 3 for the number of seeds per unit weight for the individual crops.

Direct seeding can be accomplished with a variety of planters. The particular type of planter used will depend on the grower's preference, field conditions, equipment, and experience. Tractor speed is the key to success or failure of many stands. Lower speeds reduce injury to seeds (especially bean and pea) as they pass through the planter. A planting speed of 2–3 miles per hour is preferable.

In precision seeding, a single seed is planted at an exact plant spacing to achieve a uniform stand. Precision seeders vary in their approach to seed singulation (punched belts, vacuum plates, cups on armatures, etc.), and, again, choice depends on grower preference, seed to be planted, and seedbed conditions. See Table 4 for the number of plants per acre at various row spacings.

Precision seeding requires uniformity in seed size both between species and within species. For example, large seed (snap bean) cannot be planted with the same belt/plate/cup as small seed (broccoli). Within species, two small seeds may be picked up where only one seed should fall. Sizing within seed lots may be accomplished during commercial separation or through pelletizing techniques. Pelletizing, where a seed is encased in a material that can be formed to produce a uniformly sized pellet, has improved over the years to reduce the occurrence of slow and erratic germination compared to raw seed.

While pelletized seed is required by some precision seeders, many planters are capable of planting raw seed. Sized raw seed used in these planters has been an advantage for some growers. Plants from large seed will emerge first and grow faster than from small seed.

Table 1. Minimum official federal germination standards.[1]

Seed	(%)	Seed	(%)	Seed	(%)
Artichoke	60	Corn, Sweet	75	Onion	70
Asparagus	70	Corn salad	70	Onion, Welsh	70
Bean, Asparagus	75	Cowpea (Southern pea)	75	Pak-choi	75
Bean, Broad	75	Cress, Garden	75	Parsley	60
Bean, Garden	70	Cress, Upland	60	Parsnip	60
Bean, Lima	70	Cress, Water	40	Pea	80
Bean, Runner	75	Cucumber	80	Pepper	55
Beet	65	Dandelion	60	Pumpkin	75
Broccoli	75	Dill	60	Radish	75
Brussels sprouts	70	Eggplant	60	Rhubarb	60
Cabbage	75	Endive	70	Rutabaga	75
Cardoon	60	Kale	75	Sage	60
Carrot	55	Kohlrabi	75	Salsify	75
Cauliflower	75	Leek	60	Sorrel	65
Celery/celeriac	55	Lettuce	80	Spinach	60
Chard, Swiss	65	Muskmelon	75	Spinach, New Zealand	40
Chicory	65	Mustard	75	Squash	75
Chinese cabbage	75	Mustard, Spinach	75	Tomato	75
Chives	50	Mustard, Vegetables	75	Tomato, Husk	50
Citron	65	Okra	50	Turnip	80

[1]Adapted from Donald N. Maynard and George J. Hochmuth, *Knott's Handbook for Vegetable Growers*, 5th Edition (2006). Reprinted by permission of John Wiley & Sons.

Table 2. Approximate life expectancy of vegetable seeds stored under favorable conditions.[1]

Vegetable	Years	Vegetable	Years	Vegetable	Years
Asparagus	3	Corn salad	5	Parsnip	1
Bean	3	Cress, Garden	5	Pea	3
Beet	4	Cress, Water	5	Pepper	2
Broccoli	3	Cucumber	5	Pumpkin	4
Brussels sprouts	4	Dandelion	2	Radish	5
Cabbage	4	Eggplant	4	Roselle	3
Cardoon	5	Endive	5	Rutabaga	4
Carrot	3	Fennel	4	Salsify	1
Cauliflower	4	Kale	4	Scorzonera	2
Celeriac	3	Kohlrabi	3	Sea kale	1
Celery	3	Leek	2	Sorrel	4
Chard, Swiss	4	Lettuce	6	Southern pea	3
Chervil	3	Martynia	2	Spinach	3
Chicory	4	Muskmelon	5	Spinach, New Zealand	3
Chinese cabbage	3	Mustard	4	Squash	4
Ciboule	2	Okra	2	Tomato	4
Collards	5	Onion	1	Turnip	4
Corn, sweet	2	Parsley	1	Watermelon	4

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Table 3. Number of seeds per unit weight.

Crop	Seeds/unit weight	Crop	Seeds/unit weight
Asparagus	13,000–20,000/lb	Onion	
Bean		Bulb	105,000–144,000/lb
Baby lima	1,150–1,450/lb	Bunching	180,000–200,000/lb
Fordhook lima	440–550/lb	Parsley	240,000–288,000/lb
Snap	1,600–2,200/lb	Parsnip	7,500–12,000/lb
Beet	24,000–26,000/lb	Pea	1,440–2,580/lb
Broccoli	8,500–9,000/oz	Pepper	4,000–4,700/oz
Brussels sprouts	8,500–9,000/oz	Pumpkin	1,900–3,200/lb
Cabbage	8,500–9,000/oz	Radish	40,000–50,000/lb
Carrot	300,000–400,000/lb	Rutabaga	150,000–192,000/lb
Cauliflower	8,900–10,000/oz	Southern pea	3,000–4,200/lb
Celery	60,000–72,000/oz	Spinach	40,000–50,000/lb
Collards	7,500–8,500/oz	Squash	
Cucumber	15,000–16,000/lb	Summer	3,500–4,800/lb
Eggplant	6,000–6,500/oz	Winter	1,600–4,000/lb
Endive, Escarole	22,000–26,000/oz	Sweet corn	
Kale	7,500–8,900/oz	Normal, sugary enhanced	1,800–2,500/lb
Leek	170,000–180,000/lb	Supersweet	3,000–5,000/lb
Lettuce		Tomato	
Leaf	25,000–31,000/oz	Fresh	10,000–11,400/oz
Head	20,000–25,000/oz	Processing	160,000–190,000/lb
Muskmelon	16,000–19,000/lb	Turnip	15,000/oz
Mustard	15,000–17,000/oz	Watermelon	
Okra	450–550/oz	Small seed	8,000–10,400/lb
		Large seed	3,200–4,800/lb

Table 4. Plants per acre at various between and in-row spacings.

Distance between rows (inches)	In-row spacing (inches)												
	2	4	6	8	10	12	14	16	18	24	30	36	48
	Number of plants per acre												
7	448,046	224,022	149,348	112,011	89,609	74,674	64,006						
12	261,360	130,680	87,120	64,340	52,272	43,560	37,337	32,670	29,040	21,780	17,424	14,520	10,890
18	174,240	87,911	58,080	43,560	34,848	29,040	24,891	21,780	19,360	14,520	11,616	9,680	7,260
21	149,354	74,675	49,782	37,337	29,870	24,891	21,335	18,669	16,594	12,446	9,957	8,297	6,223
24	130,860	65,405	43,560	32,670	26,136	20,908	17,424	16,335	15,520	10,890	8,712	7,260	5,445
30	104,544	52,272	34,848	26,136	20,908	17,424	14,934	13,068	11,616	8,712	6,970	5,808	4,356
36	87,120	43,560	29,040	21,780	17,424	14,520	12,445	10,890	9,680	7,260	5,808	4,840	3,630
42	74,674	37,337	24,891	18,668	14.934	12,446	10,667	9,334	8,297	6,223	4,978	4,148	3,111
48	65,340	32,673	21,780	16,335	13,068	10,890	9,334	8,167	7,790	5,445	4,356	3,630	2,723
60			17,424	13,068	10,538	8,712	7,467	6,534	5,808	4,356	3,484	2,901	2,178
72			14,520	10,890	8,712	7,260	6,223	5,445	4,840	3,630	2,904	2,420	1,815
84			12,455	9,334	7,467	6,222	5,334	4,667	4,148	3,111	2,489	2,074	1,555
96			10,890	8,167	6,534	5,445	4,667	4,084	3,630	2,722	2,178	1,815	1,361