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Recommendations for Effective Use of a Garden Seeder for Research Plots and Gardens

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ADDITIONAL INDEX WORDS. **vegetable, planting, seeding, seeding uniformity, seed metering**

SUMMARY. An Earthway garden seeder (model 1001B) is frequently used for seeding small research and demonstration plots as well as home gardens. Seeding uniformity tests were conducted with 18 species of vegetable in this seeder using the planter plates recommended by Earthway, alternate plates, and plates modified by taping off metering ports to change the seeding rates and spacings. Performance with the Earthway seeder with most vegetable seeds would not qualify it as a precision seeder, but the Earthway seeder can do an acceptable job of planting many vegetable seeds in small plots at less than 1/10th the cost of a commercial-quality precision seeder. A table giving specific recommendations for each of the 18 species has been prepared to aid research and extension personnel as well as home gardeners.

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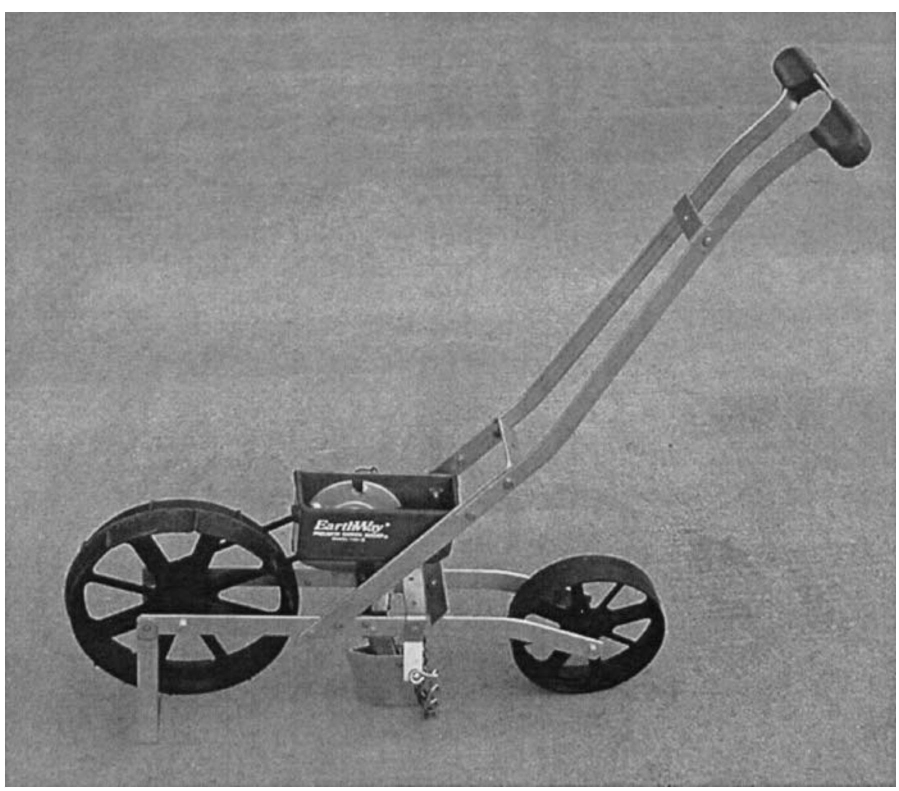
Earthway Products (Bristol, Ind.) sells a small, inexpensive garden seeder (model 1001B, Fig. 1) for use by home vegetable gardeners. It is also frequently used for seeding small research and extension plots and for seeding small areas for vegetable production. The seeder uses a vertical plate mechanism to meter vegetable seeds. Parish (1972) discussed the development and performance of a similar vertical-plate planter. The Earthway seeder is sold with a set of six metering plates with metering cells (holes) sized for several common vegetables (Fig. 2). Five other plates are available for purchase that extend the use of the seeder to other crops. All available plates as well as Earthway's recommended use for each are listed in Table 1.

A light, walk-behind, inexpensive seeder can be advantageous for small plot seeding as well as its obvious uses for gardens and small commercial plots. Maneuvering larger tractor-mounted seeders in small plot areas is often difficult and unwieldy. Multirow seeders are sometimes inappropriate for single-row plots. Many commercial seeders require a significant amount of seeds to charge or prime the seeder; without a handful of seeds in the hopper, they meter erratically. This is a problem when planting small plots with limited quantities of seed. Changing seeds in larger commercial seeders when moving from plot to plot is also difficult. Shelton et al. (1997) developed a modification to a vacuum seeder to make seed changes easier, but the procedure is still not as uncomplicated as with the Earthway seeder. These concerns and aggravations have led some horticulturists to use the Earthway seeder for research and demonstration plots. Most people using the Earthway seeder recognize there will be a tradeoff in performance compared with using more expensive commercial seeders.

An important attribute of any seeder is the ability to singulate indi-

Fig. 1. Earthway model 1001B seeder.



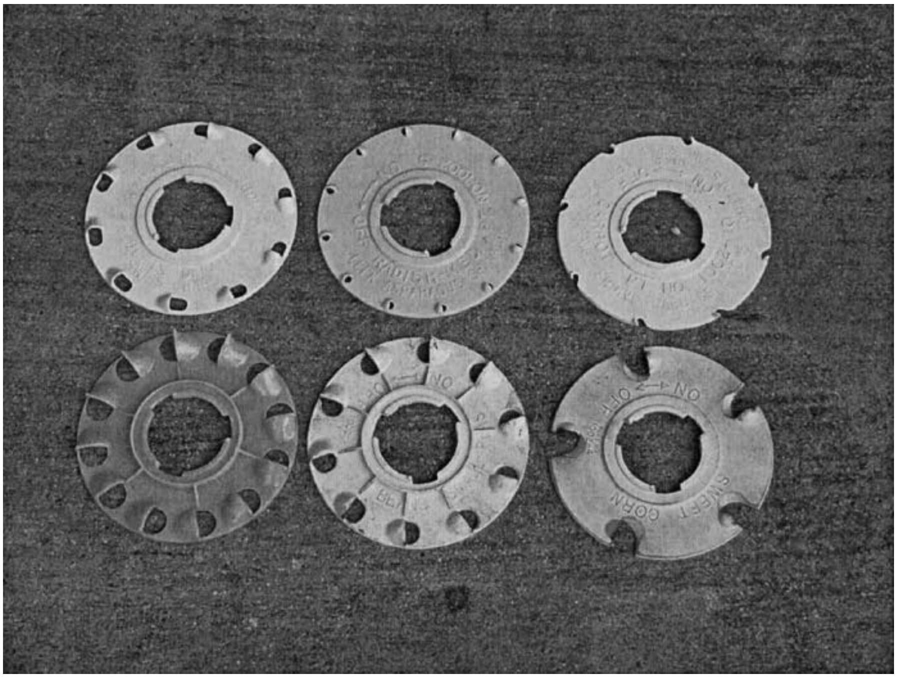


Fig. 2. Standard metering plates provided with Earthway seeder.

vidual seeds and space them uniformly in the seed furrow. This attribute is of great concern with precision vegetable seeders for large-scale commercial use. Recent studies evaluating seeding uniformity of vacuum and belt precision vegetable seeders (Bracy and Parish, 1998; Parish and Bracy, 1998) detected inconsistencies in the metering uniformity of precision seeders previously assumed to be very uniform (Parish et al., 1991). Bracy and Parish (1998) determined a belt seeder was as effective at singulating spherical seeds (cabbage) and nearly spherical seeds (onion) as the most precise vacuum seeder, but seeding uniformity of all seeders with elongated (carrot and cucumber) or angular (spinach) seeds was inadequate for precision seeding. The belt seeder was also more effective than the vacuum seeders at spacing the seeds uniformly within the target area when outliers (missed and multiple seed drops) were removed.

Bracy and Parish (2001) compared precision vegetable seeders with common agronomic seeders using soybean seeds (*Glycine max*) and found that a Stanhay model S870 belt seeder (Hestair Farm Equipment, Suffolk, England) delivered better precision than a finger-type agronomic seeder, but a Gaspardo model SV255 vacuum seeder (Gaspardo, Pordenone, Italy) did not. Parish and Bracy (2002) attempted to improve the seed spacing uniformity obtained with a Gaspardo vacuum seeder by adding a guide to reduce seed bounce in the delivery tube, but spacing uniformity was not improved.

Parish and Bracy (1998) assessed the uniformity of metering size-graded and ungraded turnip seeds with precision belt and vacuum seeders. They concluded that neither the belt nor the vacuum seeder gave the singulation and uniformity a grower would expect from a precision seeder.

Bracy et al. (1999) demonstrated that the uniformity of a precision seeder varies with theoretical spacing. Since the absolute variability is relatively constant, the variability expressed as a percentage of either nominal or mean spacing will decrease with increasing seed spacing.

Breece et al. (1981) stated that irregular seed placement in the row is often blamed on the seed metering mechanism when it is actually caused by the seed placement mechanism. They also speculated that the effect of seed bounce in a seed tube caused what appears to be skips and doubles but is really poor seed-to-seed spacing.

Wanjura and Hudspeth (1969) found that a 3-inch (7.6-cm) seed drop height consistently produced a better seed pattern than a 6-inch (15.2-cm) drop height with a cotton (G*ossypium hirsatum*) vacuum seeder. They recommended that the metering device on a planter should be located as low as practicable, and seeds should fall freely to the bottom of the soil trench.

Kachman and Smith (1995) compared alternative measures of accuracy in seed placement for planters and, based on the theoretical seed spacing, recommended using four measures for evaluating seeding uniformity. Their recommended measures (based on a

Table 1. Earthway planter plates and manufacturer's recommendations.

Plate ID no.	Standard (S) or optional (O)	Holes/ plate (no.)	Nominal seed spacing (inches)[z]	Seed types recommended by Earthway (information molded on plates)
1002-2	S	4	9.0	Sweet corn (medium)
1002-5	S	12	3.0	Radish (medium)
1002-9	O	8	4.5	Lettuce (light), rutabaga, kale, cabbage (light), mustard, carrot (light), turnip (light)
1002-10	S	8	4.5	Carrot
1002-14	S	10	3.6	Beans
1002-18	S	12	3.0	Peas
1002-22	S	10	3.6	Beet
1002-24	O	36	1.0	Cabbage, cauliflower, turnip, rutabaga, mustard, broccoli
1002-26	O	4	9.0	Cucumber
1002-27	O	3	12.0	Lima beans
1002-29	O	4	9.0	Popcorn

[z]1.0 inch = 25.4 mm.

Table 2. Vegetable seeds used in Earthway seeder evaluation.

Common name	Scientific name	Cultivar
Beet	*Beta vulgaris* Crassa group	Early Wonder
Broccoli	*Brassica rapa* Ruvo group	Green Sprouting
Cabbage	*Brassica oleracea* Capitata group	Headstart
Cantaloupe	*Cucumis melo* Reticulatus group	Hale's Best Jumbo
Carrot	*Daucus carota*	Caro Choice
Cucumber	*Cucumis sativus*	Thunder
Lima bean	*Phaseolus limensis*	Jackson Wonder
Mustard	*Brassica juncea*	Florida Broadleaf
Okra	*Abelmoschus esculentus*	Clemson Spineless
Onion	*Allium cepa* Cepa group	Granex
Pea	Pisum sativum	Alaska
Radish	*Raphanus sativus*	Long Brightest Scarlet
Snapbean	*Phaseolus vulgaris*	Contender Bush
Southernpea	*Vigna unguiculata*	Coronet
Spinach	*Spinacia oleracea*	Nobel Giant
Squash	*Cucurbita pepo var. melopepo*	Lemon Drop
Sweetcorn	*Zea mays*	Kandy Korn, Merit, Sterling
Turnip	*Brassica rapa* Rapifera group	Alamo

seeder standard issued by the International Organization for Standardization, 1984) included multiple index, miss index, quality of feed index, and precision. Multiple index (MULT) indicated multiple seed drops and was the percentage of seed spacings that were less than or equal to one-half of the theoretical seed spacing. Miss index (MISS) indicated missed seed locations or skips and was the percentage of spacings greater than 1.5 times the theoretical spacing. Quality of feed index (QFI) indicated single seed drops and was the percentage of spacings that were more than half but no more than 1.5 times the theoretical spacing. QFI was an alternative way of presenting the information contained in MISS and MULT. Precision (PREC) was the coefficient of variation of the spacings after omitting the missed and multiple seed drops (outliers). PREC was a measure of the uniformity of spacings classified as singles, whereas MULT, MISS, and QFI were measures of singulation or lack thereof. A more complete discussion of these terms and examples of calculations was given by Kachman and Smith (1995).

Although mean (MEAN) and coefficient of variation (CV) have been used in research publications to describe spacing uniformity (Hudspeth and Wanjura, 1970; Parish, 1972; Parish et al., 1991; Wilkins et al., 1992), Kachman and Smith (1995) judged MEAN and CV as inappropriate measures of seeder accuracy. MEAN does not reflect variation in spacing, and CV does not identify the types of nonuniformity (e.g., misses, multiples, or nonuniform basic spacing). Nevertheless, MEAN is the easiest criterion of performance to measure and is an appropriate criterion for a nonprecision seeder such as the one made by Earthway.

The objectives of this study were to evaluate seed metering performance of the Earthway seeder with seeds of 18 vegetable crops first using Earthway's recommendations, then to optimize seed metering by using alternate and/or modified plates. A further objective was to evaluate the effects of cultivar on sweetcorn metering. Development of a table of recommendations for optimal use of the Earthway seeder with each of the 18 vegetable crop seeds as an aid to researchers, extension workers, small commercial growers, and home gardeners was the fundamental objective.

Materials and methods

An Earthway model 1001B seeder was tested using 18 vegetable seeds (Table 2) with the eleven plates (Table 1). Due to differences in size of sweetcorn seeds, three cultivars were tested to determine if seed size had an effect on seeder performance.

The tests were conducted by operating the seeder on a grooved wooden track. The groove was used to simulate the seed furrow and guide the seeder. The flat bottom of the groove was coated with common chassis grease so that the seeds would stick where they landed and not bounce. Individual seed spacings were measured over a test run of either 4 or 10 ft (1.2 or 3.0 m), depending on nominal seed spacing. Small seeds with close spacings (e.g., carrot) were evaluated in 4-ft runs and larger seeds with wider spacings (e.g., sweetcorn) were evaluated using 10-ft runs to obtain more data points. Each test was replicated four times. If the seed spacing delivered by the plate recommended by Earthway did not appear optimum, additional testing was done with another plate or with a modified plate. When it was visually obvious that the cell size in a recommended plate did not match the seed size, the recommended plate was not run and we went directly to an alternate plate. If the cell or hole size appeared correct but seed spacing was too close, number of holes in the plate were modified [blocked with masking tape (Fig. 3)] to reduce seed number and increase spacing.

The seed spacings were analyzed using the methods (MULT, MISS, QFI, and PREC) described by Kachman and Smith (1995). Acceptable QFI values were established at 85% or greater, indicating that 85 or more of every 100 drops were singulated seed. Researchers have indicated greater than 95% accuracy with agronomic planters, indicating the metering accuracy (ACCU) to be within 5% of the theoretical seeding population (Bateman, 1972; Synder and Hummel, 1985; Halderson, 1983). ACCU, like MEAN, gives an indication of total seed metering but does not measure singulation. The Prairie Agricultural Machinery Institute (1984) indicated a QFI of 95% or better was considered to be excellent.

Kachman and Smith (1995) reported a practical upper limit of 29% for the value of PREC, since a 29% value would be obtained with any random scattering of seeds within the target

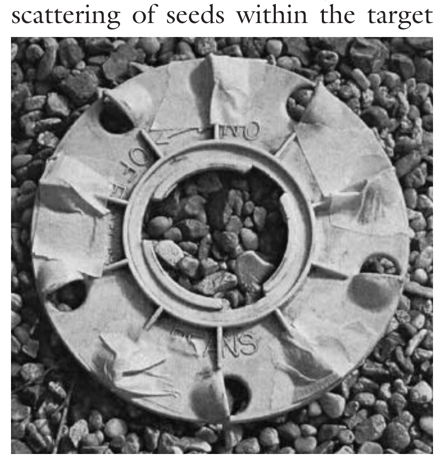


Fig. 3. Method of blocking metering holes with masking tape.

Table 3. Results of greased-board tests with vegetable seeds in an Earthway model 1001B seeder; MISS = percent skips, MULT = percent multiple seed drops, QFI = percent single seed drops, PREC = coefficient of variation of seed spacings after removing outliers (i.e., MISS and MULT removed).

Vegetable seed	Plate	Modifications	Nominal spacing (inches)[z]	MEAN (inches)	MISS (%)	MULT (%)	QFI (%)	PREC (%)
Beet	22	Standard	3.6	0.7	0.0	92.0	8.0	21.9
	22	Block every other hole	7.2	1.2	0.4	92.5	7.1	23.4
Broccoli	24	Standard	1.0	1.4	35.2	35.7	29.1	28.2
	24	Block 3 of 4 holes	4.0	3.5	12.6	26.2	61.2	25.3
Cabbage	9	Standard	4.5	4.0	12.6	26.8	60.6	23.7
Cantaloupe	26	Standard	9.0	5.9	6.8	45.6	47.6	22.1
Carrot	10	Standard	4.5	0.4	0.0	95.9	4.1	11.5
	24	Block every other hole	2.0	0.9	2.9	68.2	28.9	22.3
Cucumber	26	Standard	9.0	4.1	0.8	57.9	41.2	18.9
Lima bean	27	Standard	12.0	4.1	0.0	69.9	30.1	17.1
Mustard	9	Standard	4.5	1.3	0.8	75.9	23.4	21.6
	24	Block 2 of 3 holes	3.0	1.0	0.0	75.6	24.4	20.9
Okra	22	Standard	3.6	1.4	1.2	71.8	27.0	24.3
	29	Standard	9.0	7.2	1.5	22.3	76.2	21.6
Onion	10	Standard	4.5	1.4	2.4	78.0	19.6	21.7
	24	Standard	1.0	1.9	48.1	21.2	30.7	27.5
	24	Block every other hole	2.0	2.9	37.4	23.9	38.7	24.3
Pea	14	Standard	3.6	2.9	11.6	32.0	56.4	25.6
Radish	5	Standard	3.0	1.7	3.5	58.6	37.9	25.3
Snapbean	14	Standard	3.6	4.7	32.9	11.0	56.1	22.8
Southernpea	14	Standard	3.6	1.7	2.8	65.6	31.6	21.8
	22	Standard	3.6	4.1	31.2	16.0	52.8	28.1
Spinach	5	Standard	3.0	3.2	18.6	23.9	57.5	26.4
Squash	26	Standard	9.0	11.3	28.2	15.2	56.6	19.0
Sweetcorn ‘Kandy Korn’	14	Block every other hole	7.2	3.0	1.3	65.3	33.4	22.5
	22	Block every other hole	7.2	8.9	27.6	14.5	57.9	25.5
Sweetcorn ‘Merit’	2	Standard	9.0	9.2	19.1	22.0	58.9	19.7
	18	Block 2 of 3 holes	9.0	3.9	2.6	60.3	37.1	19.1
Sweetcorn ‘Sterling’	2	Standard	9.0	5.3	3.8	45.5	50.7	22.9
	14	Block every other hole	7.2	5.5	6.9	32.0	61.1	23.8
Turnip	24	Standard	1.0	0.8	13.8	50.4	35.7	25.6
	24	Block 2 of 3 holes	3.0	2.2	9.0	43.4	47.6	28.3

[z]1.0 inch = 25.4 mm.

range. An acceptable PREC for seed measurements taken in the lab should fall below 10%, which would mean that the standard deviation of spacings within the target region would be 10% or less of the theoretical spacing.

Although not considered a valid measure of uniformity for precision seeders by Kachman and Smith (1995), MEAN is the only measure that an operator can readily use to determine seeder performance, and thus is reported in this study. MEAN does have value in evaluating nonprecision seeders. Data were analyzed using the GLM statistical procedure (SAS, 1995). MEAN was calculated using PROC MEAN procedure (SAS, 1995). A table of recommendations for optimal use of the seeder was prepared.

Results

The results of this study are summarized in Table 3. For some seeds (cabbage, cantaloupe, cucumber, lima bean, pea, radish, snapbean, and small-seeded squash), the plates recommended by Earthway were found to be acceptable. Alternative plates and/or modified plates were used for other seeds to improve seeding quality. In each case, the plate (and modification, if needed) that came closest to delivering single seeds at the desired seed spacing was recommended.

PREC was poor in all cases, again pointing out that the Earthway seeder is not intended to be a precision seeder. Recommendations were based on the premise that this is not a precision seeder. In making the recommendations, primary emphasis was placed on mean spacing (MEAN) and minimizing skips (MISS). QFI was low in most cases because a high percentage of multiples (MULT) is present with many of the plate/seed combinations. Some thinning will be necessary when using this seeder with some species of vegetable as noted in Table 3.

Seed size affected metering performance with sweetcorn. ‘Merit’, a smaller-seeded variety, had the best uniformity and rate with plate #1002-18, but ‘Sterling’ and ‘Kandy Korn’ were metered more effectively by plate #1002-14.

Discussion

Furrow opening, closing, and firming are important seeder functions that were not evaluated in this study. Past experience with the Earthway seeder has shown that furrow opening, closing, and firming can be effectively achieved in soil with good tilth.

Seed placement uniformity with the Earthway seeder was not as good as can be expected with a commercial precision seeder such as the Stanhay model S870 with most seeds (Bracy and Parish, 1998; Bracy and Parish, 2001) and does not quality it as a precision seeder, but with proper selection/modification of the meter-

Comments
Too heavy
Recommended, but will need to be thinned
Too heavy
Recommended
Recommended
Recommended
Too heavy
Recommended, but will need to be thinned
Recommended, but may need to be thinned
Recommended, but somewhat erratic
Multiples at wide spacing
Recommended
Too heavy
Recommended
Heavy, recommended for green Onions
Recommended for bulbing Onions, some holes plugged with seed
Too light; some holes plugged with seed
Recommended
Recommended
Recommended
Too heavy
Recommended
Recommended
Recommended
Recommended
Too many skips
Too many skips
Recommended, but slightly heavy
Recommended
Recommended
Too heavy
Recommended

ing plates its performance is adequate for many purposes—and at less than 1/10th the cost . If precise seed spacing is needed, a precision seeder should be used. In situations where correct mean spacing is of primary importance with spacing uniformity less important, the Earthway seeder can do an acceptable job. It can also be used very effectively to seed at a higher rate and then thin to a desired stand. The table of recommendations should be useful for those planting research and demonstration plots, small production fields, and home gardens.

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