Evaluation of a Bulk Planting System for Low-cost Seeding of Cabbage

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ADDITIONAL INDEX WORDS. seeders, planters, precision seeding, cabbage, cultural practices

SUMMARY. Cabbage (*Brassica oleracea* L. Capitata) was direct-seeded with a precision seeder or with a bulk seeder. Treatments with the bulk seeder consisted of blending viable, hybrid cabbage seed with nonviable, open-pollinated seed at several ratios to reduce the cost of planting hybrid seed. The study demonstrated that farmers with small acreages can obtain equivalent net income per acre using bulk seeders compared to using more expensive precision seeders. The study also showed that the additional cost per acre of a precision seeder is small compared to other input costs (for the acreage assumptions used here). Low percentages of hybrid seed in the bulk seeder (10% to 50%) were not economical. Precision seeding to a stand reduced the need for thinning labor and resulted in equivalent yields and net income.

Commercial vegetable growers with large acreages have the option of transplanting or using precision seeders to direct-seed some vegetable crops; however, many vegetable growers in the southeastern

United States with small acreages feel that they cannot afford a precision seeder and, thus, are limited to transplanting many of their small-seeded crops or bulk seeding and thinning. Relatively inexpensive bulk seeders are available that will meter small-seeded vegetable crops, but they do not provide the uniform seed spacing or the controlled metering rate of the precision seeders.

Much of the research on precision seeding has been based on vacuum metering, although Parish (1972), using a vertical plate concept, developed a mechanical precision seeder that provided seeding uniformity and was suitable for use with vegetable crops. Short and Huber (1970) developed a vacuum metering system for cucumber seeds and demonstrated its effectiveness in the laboratory but did not experiment with a field machine. Hassan (1981) developed a precision drum seeder that used a vacuum system to singulate tree seeds.

Giannini et al. (1967) published a thorough discussion of the need for precision seeding in vegetable culture and discussed the development of a successful precision lettuce seeder that used vacuum principles for singulation. Compared with the then-standard "bulk-metering planter," their vacuum seeder used 90% less seed, thus reducing thinning time and resulting in improved yields. Inman (1968) discussed the development and adoption of precision seeders in the California vegetable industry and compared precision seeding with bulk seeding. Parish et al. (1991) compared vacuum and belt-type precision seeders and found no differences when planting uniform spherical seeds.

Sterrett et al. (1991) studied management techniques for broccoli using a systems approach. Using economic analyses, they compared transplant and direct-seeding techniques for broccoli. Their results showed that maximum profits could be obtained with direct-seeding for an early crop and with transplanting for the main season crop. Kahn (1990) evaluated the possibility of reducing seed requirements per acre through reduced plant populations of turnip greens. Kahn's study concluded that the plant populations of hybrid turnip greens could be decreased to about half of the recommended rate without a significant reduction in yield or quality. This reduced seeding rate

also resulted in seed cost savings. Orzolek (1991) noted that improved technologies of precision planters enable growers to avoid the costs of seeding at high densities and later thinning to a final expected plant stand.

Bracy et al. (1993, 1995) reported on field studies of directly seeding cabbage and cauliflower to a stand without thinning. Bergeron et al. (1992) conducted an economic analysis of directly seeding cabbage to a stand. They demonstrated that seeding directly to a stand was feasible and found that significant cost savings were possible. The work by Bergeron et al. (1992) was based on the assumption of large acreages (80 acres for one-row equipment to 540 acres for six-row equipment), where the cost per acre of a precision planter would be reasonable.

Our objective was to evaluate the effectiveness of bulk seeding blends of high-quality hybrid seed and inexpensive nonviable seed obtained by thermally destroying the viability of open-pollinated seed. It was hypothesized that blends could provide acceptable plant stands (after thinning) at a lower cost per acre than bulk seeding or precision seeding pure hybrid seed.

Materials and methods

Field tests were conducted at the Hammond Research Station on Cahaba fine sandy loam soil (thermic Typic Hapludult) in Spring and Fall 1993 and Spring 1994. Two cabbage cultivars were used for this study: hybrid 'Headstart' and open-pollinated 'Flat Dutch'. The price of 'Headstart' seed was \$324.00 per pound, and the price of 'Flat Dutch' was \$4.60 per pound. Laboratory germination of the hybrid seed was 97% and 98% in 1993 and 1994, respectively. To obtain different seeding rates for the bulk seeder, various percentages of 'Headstart' were mixed with thermally killed 'Flat Dutch'. Seed viability was destroyed by heating open-pollinated seed in an oven at 350 °F for 30 min. Eight treatments were established as follows: 10%, 20%, 30%, 40%, 50%, or 100% hybrid by weight in a bulk-metering seeder or 100% hybrid seed in a precision seeder at 3.5- or 11.5-inch seed spacing. The seeds for each treatment were mechanically stirred and shaken to achieve visually homogenous blends. Minor nonuniformity in mixing would

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affect stand uniformity somewhat; this was expected in the experiment and would be expected if a grower were to use this method. There was an apparent visual difference in seed size between the two cultivars, with the 'Flat Dutch' being larger. This size difference contributed to the difference in seeding rates among treatments. A major size difference could have resulted in segregation in metering and should be avoided in selecting seeds. Each treatment was in a randomized complete-block design with four replications.

The two vegetable seeders used were a Stanhay model S870 precision seeder (Hestair Farm Equipment, Suffolk, England) and a Powell Planet Jr. (Powell Mfg., Bennettsville, S.C.) bulk-metering seeder. The Stanhay seeder used a rubber seed belt with 8.5/64-inch holes to singulate the seeds at a nominal spacing of 3.5 or 11.5 inches. The Planet Jr. seeder metered seeds gravimetrically through an orifice. The smallest orifice through which the seed would flow was used, thus it was not possible to obtain a lower seeding rate with the Planet Jr. at the operating speed used. Both seeders were tractor-mounted and operated at 1.5 mile/h.

The basic cultural system used was described by Bracy et al. (1991) and Parish et al. (1992). Before bedding, trifluralin [2,6-dinitro-*N,N*-dipropyl-4-(trifluoromethyl)benzenamine] at 1.5 pt./acre was incorporated. After bedding with a disk bedder, 8N-24P-24K fertilizer was applied at a rate of 500 lb./acre. Fertilizer was knifed into the center of the planting beds ≈2 inches below planting depth. After fertilization and rebidding with a disk bedder, the beds were shaped with a pan-type bed shaper before planting. Plots were sidedressed 4 and 6 weeks after planting with 100 lb./acre of ammonium nitrate banded between the drills on top of the bed.

The cabbage was seeded at ≈0.25 inches deep on 9 Mar. and 14 Sept. 1993 and 15 Mar. 1994 in two rows spaced 10 inches apart on beds 40 inches wide. The cabbage plants were thinned to a spacing of 12 inches 3 to 4 weeks after emergence. Labor time required to thin each plot was recorded. To obtain an objective measure of the thinning requirement, the laborers were timed on all plots, even those that a grower would not have thinned.

Table 1. Stand counts of 'Headstart' cabbage as influenced by percentage of hybrid seed and seeder type, 1993–94.

Percent hybrid seed	Seeder type	Stand count (1000 plants/acre)					
		Spring 1993		Fall 1993		Spring 1994	
		Initial	Thinned	Initial	Thinned	Initial	Thinned
10%	bulk	4.6 c ^z	5.2 d	3.3 d	2.9 c	2.9 d	2.9 c
20%	bulk	10.5 c	7.5 cd	4.6 cd	3.9 bc	6.5 cd	4.9 dc
30%	bulk	11.8 c	9.5 bc	7.8 cd	5.9 b	9.5 bc	7.5 c–e
40%	bulk	25.2 b	13.1 a	5.2 cd	4.6 bc	10.5 bc	9.1 bc
50%	bulk	30.1 b	12.4 ab	6.5 cd	4.2 bc	12.4 b	10.8 b
100%	bulk	50.7 a	15.4 a	20.3 a	9.8 a	26.8 a	14.0 a
100%	3.5 inch ^y	28.1 b	13.7 a	9.1 c	6.2 b	28.8 a	15.0 a
100%	11.5 inch ^y	23.3 b	13.1 a	15.0 b	8.8 a	7.8 c	7.8 b–d

^zMeans by (Duncan's multiple range test) followed by same letter are not statistically different at $P \leq 0.05$.

^yPrecision seeder spacing.

Table 2. Yield and average head weight of 'Headstart' cabbage as influenced by percentage of hybrid seed and seeder type, 1993–94.

Percent hybrid seed	Seeder type	Marketable yield (50 lb sacks/acre)			Mean head wt (lb/head)		
		Spring 1993	Fall 1993	Spring 1994	Spring 1993	Fall 1993	Spring 1994
10	Bulk	136 b ^z	63 d	193 c	3.0	2.1	3.4
20	Bulk	325 ab	152 cd	335 bc	3.3	2.5	3.5
30	Bulk	350 ab	299 b	308 bc	3.0	3.0	3.6
40	Bulk	523 a	187 c	369 b	2.9	2.8	3.3
50	Bulk	441 a	232 bc	374 b	2.9	2.8	3.2
100	Bulk	588 a	414 a	559 a	2.9	2.7	2.9
100	3.5 inch ^y	514 a	285 b	593 a	3.0	3.1	2.9
100	11.5 inch ^y	368 ab	327 ab	427 ab	2.6	2.7	3.4
					NS	NS	NS

^zMeans by (Duncan's multiple range test) followed by same letter are not statistically different at $P \leq 0.05$.

^yPrecision seeder spacing.

Selective harvests were made over the plots so heads were harvested individually when desired maturity was obtained, regardless of plant population. Head maturity was determined according to the criteria described by Boudreaux (1991) and involved a manual physical assessment of head firmness.

An economic analysis was conducted to compare the economic return from using the two seeders. This analysis considered only seed cost, labor to thin plants in the field, seeder cost, and gross returns from sale of the cabbage. It was assumed for purposes of this analysis that other production costs to the point of harvest would remain constant for all treatments.

Results and discussion

In Fall 1993 and Spring 1994 plantings, plant stand (Table 1) was lower than in the Spring 1993 crop

due to poor weather conditions. Plant stand was less than a desired stand of 26,000 plants/acre even before thinning in most cases. The stands after thinning were all below the desired stand due to numerous skips in the stands. Thinning consisted of removing plants that were closer than 12 inches, but skips in the stands remained. The counts after thinning reflect some late emerging plants that caused the after-thinning stand to exceed the before-thinning stand in a few cases.

In the Spring 1993 planting, marketable yields were similar for all hybrid seed ratios except the 10% ratio (Table 2). There was no difference in average head weight.

Yields in the Fall 1993 planting from 30%, 50%, and 100% hybrid seed were similar to the precision-seeded plots. Yield from the precision-seeded, 11.5-inch treatment was greater than some of the bulk seeder planted treat-

Table 3. Production costs and return of 'Headstart' cabbage using two seeder types, 1993–1994.

Percent hybrid seed	Seeder type	Seed/acre ×1000	Seed cost \$/acre ^a	Spring 1993 (\$/acre)			Fall 1993 (\$/acre)			Spring 1994 (\$/acre)		
				Labor cost ^b	Gross return ^c	Net return ^w	Labor cost ^b	Gross return ^c	Net return ^w	Labor cost ^b	Gross return ^c	Net return ^w
10%	Bulk	202	51.40	5.90 e ^v	544 b	486 b	4.54 c	252 d	192 d	4.39 d	772 c	711 c
20%	Bulk	179	85.39	9.25 de	1300 ab	1200 ab	5.67 c	608 cd	510 cd	4.46 d	1340 bc	1245 bc
30%	Bulk	198	138.41	11.92 de	1400 ab	1244 ab	11.57 bc	1196 b	1042 a	7.26 cd	1232 bc	1081 bc
40%	Bulk	186	170.78	15.21 c–e	2092 a	1900 a	9.98 bc	748 c	563 b–d	7.26 cd	1476 b	1293 a–c
50%	Bulk	187	213.28	21.62 bc	1764 a	1524 ab	10.21 bc	928 bc	698 bc	8.62 c	1496 b	1269 bc
100%	Bulk	141	318.09	40.63 a	2352 a	1988 a	33.80 a	1656 a	1300 a	19.89 a	2236 a	1893 ab
100%	3.5 inch ^u	66	148.52	24.69 a	2056 a	1868 a	17.47 b	1140 b	960 ab	15.13 b	2372 a	2193 a
100%	11.5 inch ^u	28	63.54	21.00 bc	1472 ab	1372 ab	29.27 a	1308 ab	1199 a	4.61 d	1708 ab	1624 ab

^aSeed cost are based on 144,000 cabbage seed/lb, \$2.25/1000 seed for 'Headstart' hybrid and \$4.60/lb. for 'Flat Dutch' open pollinated.

^bCosts of hoe labor for thinning are based on actual hoe time per plot extrapolated to an acre at \$5.00/h rate.

^cReturns per acre are based on a cabbage price of \$160/t.

^wNet income refers to returns from sale of produce less costs of seeds and labor plus depreciation of planter units. Planter depreciation determined on 10-year life, 10% salvage, used on 10 acres per year. Depreciation cost is \$15.12 and \$5.40/acre for the precision seeder and bulk seeder, respectively.

^vMeans by (Duncan's multiple range test) followed by same letter are not statistically different at $P \leq 0.05$.

^uPrecision seeder spacing.

ments even though fewer seed were planted. This result may have been due to better seed placement and covering by the precision seeder. There was no difference in average head weight.

In the Spring 1994 planting, yields were greatest for the 100% bulk and both precision-seeded treatments, although the yield of the precision-seeded, 11.5-inch treatment was not significantly different from the yield of the 50% bulk treatment. There were no differences in average head size among treatments.

Seed cost was the greatest production expense and was highest with the higher percentages of hybrid seed in the bulk seeder (Table 3). Theoretical seed count per acre did not correspond exactly to the actual seed counts because of differences in seed size of the hybrid and nonhybrid seeds. The hybrid seeds were larger as shown by a lower seed count in the 100% bulk treatment. Hoe labor varied from \$6 to \$40 per acre in the Spring 1993 crop, with the higher plant populations requiring more thinning labor. For the Fall 1993 crop, plant stand was poor due to unfavorable weather after planting, and labor cost ranged from \$5 to \$34 per acre. Spring 1994 labor costs ranged from \$4 to \$20 per acre. Treatments resulting in a labor cost of \$5 per acre or less needed no thinning but included the cost of the time to walk through the field. A farmer would not have thinned fields with that few plants.

Net returns were determined by subtracting the labor cost to thin the crop, depreciation of the seeders, and seed cost from the gross value of the

cabbage harvested from each treatment (Table 3). In the Spring 1993 crop, net income for 20% bulk and greater was similar to the precision seeded, 11.5-inch spacing treatment, although there were numerical differences. The best return was obtained with the 100% bulk treatment.

The bad weather after the Fall 1993 planting indicated the desirability of planting excess seeds. Net return for 30% hybrid seeds was similar to the precision seeded and 100% bulk treatments. However, 40% and 50% bulk seeding rates were not similar.

For the Spring 1994 planting, the net income from the 40% and 100% bulk treatments were similar to that obtained from the precision seeders. Net income for bulk seeder rates from 10% to 50% was similar.

Total costs, returns, and net income varied a great deal among treatments and years; however, in 2 of 3 years, the highest net income came from the 100% bulk treatment. Highest net income tended to come from planting with a precision seeder or using 100% hybrid seed in the bulk seeder followed by thinning. Of primary importance is obtaining an adequate, uniform stand of seedlings.

Conclusion

Our study demonstrated that farmers with small acreages can obtain equivalent net income per acre with bulk seeders if labor to thin plants is available, thus avoiding the capital expense of a precision vegetable seeder. However, the study also showed that the additional cost of a precision seeder is small [\$9.72 per acre per year for the

acreage assumptions used here (10 acre/year)] compared with the cost of other inputs. Based on net returns, growers can obtain good results from either system.

Low percentages (10% to 50%) of hybrid seed in the bulk seeder were not economical in terms of yield and net income. Any inexpensive *Brassica* seed of similar diameter (such as collard) could have been used for the bulk blending with the hybrid cabbage.

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Potential Use of Sucrose as a Feeding Deterrent for Frugivorous Birds

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ADDITIONAL KEY WORDS. blueberry, table sugar, *Vaccinium corymbosum*

SUMMARY. A mixed cultivar blueberry planting was treated with a concentrated sucrose solution before fruit ripening and after episodes of rain during the harvest season. Fruit losses due to birds were monitored throughout the season in this planting and in the same cultivar in a separate nontreated planting ≈ 200 m (650 ft.) away. Fruit loss to birds was $\approx 50\%$ greater in the nontreated planting over the first 3 weeks of harvest. In addition, bird activity was monitored between 0600 and 0700 hr on two occasions in each planting during the early harvest season. Bird activity was many times higher in the nontreated planting. These observations suggest that sucrose should be tested more widely for potential activity on bird feeding behavior.

Birds cause considerable losses in fruit plantings throughout the world. In 1989, 10% of the highbush blueberry crop was lost to birds (Avery et al., 1992), costing growers \$8.5 million. Birds cause losses for grape growers as well, estimated to be \$4.4 million in 1972 (Crane et al., 1976). Cherry growers also suffer losses from birds (Tobin et al., 1991). 'Fuji' apple growers lose considerable amounts of fruit to bird damage every year (E. Fallahi, personal communication).

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Fruit that experience bird depredation consist mainly of simple sugars, such as fructose and glucose (Chapman et al., 1993; Gardiner et al., 1993; Kader et al., 1994; Kondo and Gemma, 1993; Ranwala et al., 1992; Shaw, 1988; Woodruff et al., 1960). Many frugivorous bird species lack the enzymes necessary to digest polysaccharides and other complex sugars (Brugger and Nelms, 1991; Martinez del Rio et al., 1988; Schuler, 1983) or cannot maintain a positive energy balance feeding on a high sucrose diet (Avery et al., 1995). When the former eat sucrose, they experience intestinal discomfort from fermentative diarrhea and develop a learned aversion to the food containing the sucrose (Martinez del Rio et al., 1988). Many birds show a clear preference for fruit containing hexose sugars, such as glucose and fructose (Avery et al., 1995; Schuler, 1983), and artificial feeding trials suggest a concentration threshold of $\approx 11\%$ sucrose for repellency (Brugger et al., 1993).

Darnell et al. (1994) suggest that blueberry fruit could be genetically engineered to produce sucrose to deter feeding. However, growers might be able to directly treat ripening fruit with sucrose to achieve the same effect. Sucrose is readily available, cheap, and safe to apply and consume.

Our objectives were to determine if sucrose sprays have potential as a bird feeding deterrent and, if so, to identify any negative consequences of treating with sucrose.

Materials and methods

Two blueberry plantings in Ithaca, N.Y., separated by ≈ 200 m (650 ft.) were selected for study. Both plantings contained a mixture of cultivars in five plant plots and were bordered on at least three sides by fences or trellises. Trees were abundant in the area, and both plantings were 300 m (1000 ft.) from the nearest highway. The smaller planting, consisting of 160 plants (two cultivars), was treated with a concentrated sucrose solution before fruit ripening and after each significant rain event for 3 weeks. The larger planting, containing 300 plants (20 cultivars), was not treated.

In each planting, two inflorescences in each of 15 bushes of 'Berkeley' were marked and the number of unripe fruit were counted. One fruit cluster was located in the top half of