SEED CUTTER OPERATION INSIGHTS [1]

by
Gary M. Hyde, Zhao Kai, Robert E. Thornton and Marvin J. Pitts
Departments of Agricultural Engineering and Horticulture and Landscape Architecture, Washington State University, Pullman, Washington

Abstract

This article discusses experimental analysis of potato seed cutting equipment and the resulting insights into how changes in sizer setting and blade spacings may effect to size distribution of seed pieces. Results with rotating disk blade cutters show that the sizer between the upper cutter and the lower cutter should be set no wider than to just drop 2 in. (50 mm) diameter tubers through. This setting was confirmed both by simulation and field experiment. Effect of varying blade spacing on these cutters is also discussed.

Preliminary results with fixed-blade cutters indicate that the 2-4 cut sizer should be set no wider than 1.75 in. (45 mm) to maximize the number of 1.25 to 2.50 ounce (35-70 g) seed pieces. Best setting for the 4-6 cut sizer is less clear, but should be in the range of 2-3/16 to 2-3/8 in. (55-60 mm). With any cutter, it is not possible to cut good seed pieces consistently from tubers that are larger than 10 ounces (280 g).

Introduction

The problem is that potato stands and crop uniformity in Washington (or almost anywhere, for that matter) are just not what they could be or should be. Potato plant stand is affected by a number of factors. Those that are determined by the seed cutting operation include: seedpiece size, cut surface, and shape; the one determined by the planter is seedpiece spacing. The number of eyes per seedpiece, mother tuber size, physiological age, cultivar, soil moisture, soil and seedpiece temperatures, disease, and maybe even seedpiece orientation also can influence stand; however, here we will discuss only those directly influenced by the seed cutter.

The seed cutting factors that most affect planter performance are seedpiece size and shape; and those two factors are determined in the seed cutter by: tuber size, tuber shape, sizer setting(s), blade spacing and blade type.

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Background

To achieve uniform potato stands and crop quality in the field, it is necessary to know the optimal seedpiece shape and size range. Earlier engineering research (Hyde et al, 1979, Hyde and Thornton 1980) convinced us that before the potato planter performance could be consistently improved, seed cutter output must be more consistent. Economic and horticultural research (Schotzko et al. 1983, Thornton et al. 1983 and 1985) showed that optimal seedpiece size was 1.5 to 2 ounces (43-57 g). In addition, Schotzko (1982) reported that the smaller the standard deviation of potato seedpiece size, the greater the economic return. The best seedpiece shape is blocky (cubic or spherical) because that shape provides the lowest surface area-to-weight ratio, and because such shapes are easiest to select and transport one-at-a-time.

With the criteria of blocky seedpieces in the 1.5 to 2-ounce range, we set out to:

1. Determine the best cutter performance that is possible with current machines.

2. Determine how to operate commercial seed cutters to maximize the amount of acceptable size seed and minimize undersize and oversize.

3. Find efficient methods for eliminating undersize from the cut seed.

4. Explore new, more efficient methods for cutting seed potatoes.

Methods

Rotary blade seed cutters

Commercial rotating blade seed cutters consist of top and bottom cutter systems and two sets each of sizing rolls and orientation rolls (Figure 1). Both cutter systems make several transverse cuts across the tubers, using rotating disk blades. In addition, the top cutter uses a stationary knife to make one, longitudinal cut. With careful adjustment, the end pieces from each tuber will drop out and not be cut by the stationary knife.

Sizing roller spacing is the most easily changed control variable that the cutter operator has. It is important to realize that:

1. The top sizing rolls determine the minimum diameter tuber that goes to the top cutter and the maximum diameter tuber that goes to the bottom cutter.

2. The bottom sizing rolls determine the minimum diameter tuber cut by the bottom cutter and the maximum diameter tuber that drops through and is not cut at all (single-drop).

In addition to sizing roll spacing, the other machine variable is the distance between disk blades, which determines seedpiece cut width. Cut width cannot be easily changed on the seed cutter; but it does influence seedpiece quality. So the two machine variables we can control are cut width and sizing roll spacing.

To determine the effects of sizing roll spacing, experiments were run using 5 model tubers with diameters ranging from 1-9/16 to 2-3/8 in. (40 - 60 mm) to precisely adjust the roll spacing. The single drop sizer was left at one setting to produce single drop tubers of 2 ounce maximum size. The weights of every seedpiece and weights and dimensions of every tuber were recorded for 20 tubers from each cutter for every setting. The experiment was repeated 4 times.

To determine the effects of cut width (blade spacing) together with sizing roll spacing, a computer simulation was created (Zhao et al. 1988), because running field experiments with a range of blade spacings would have been prohibitively expensive. The simulation was designed to predict the effects of changes in both cut width and sizer roll spacing.

Fixed-blade seed cutters

The fixed-blade cutter is more difficult to analyze because it has three cutting stages and three sizers rather than two of each. These components are arranged to cut the tubers into 6, 4 or 2 pieces or to not cut at all (Figure 2). For our experiment, the single-drop or 1-2 sizer was fixed at one setting as with the rotary cutter experiment. The 2-4 sizer was set successively to just drop 45, 50 and 55 mm diameter tapered tuber models through, and the 4-6 sizer was successively set to drop 50, 55 and 60 mm diameter tubers. All workable combinations of settings were run (Figure 3), with the experiment repeated 4 times. Ten-tuber samples were taken at each of the three cutter sections for each of the 6 sizer setting combinations for each replication.

Results

Rotary blade seed cutter

The experiments showed that the computer simulation of the rotary seed cutter predicted its behavior very well. Results of both experiment and simulation showed that with long tuber cultivars, the sizing roller spacing should be no greater than 2 inches (50 mm). The simulation showed also that the cut width (blade spacing) should be less than 2 inches (49 mm) (Figure 4). Further investigation showed that the upper cutter blade width should be 1.75 inches (45 mm), which is standard, but that the lower cutter width should be also 1.75 inches instead of the 2 inches (50 mm) which is standard. Figures 5 and 6 show machine performance with 2 inch and 1.75 inch lower cutter widths, respectively. A cutting operation which has tried the narrower blade spacing on the lower cutter is pleased with it and says that it doesn't cause more chips.

Fixed blade seed cutter

Figure 7 shows that 2-cutter output is very sensitive to 2-4 sizer setting. Figure 8 shows that overall seed cutter output is also fairly sensitive to 2-4 sizer setting, and that the 2-4 sizer ought to be set no wider than 45 mm (1.75 in.). Figure 9 indicates that overall output of acceptable size seedpieces is effected by 4-6 sizer setting, but not as strongly as it is by 2-4 sizer setting. Further data analysis showed that best cutter performance was obtained with the 2-4 sizer set no wider than 45 mm (1.75 in.). Figure 10 shows that, with the 2-4 sizer at 45 mm, overall cutter output runs at approximately 75% seedpieces in the 35-70 g (1.25 to 2.50 oz.) range, and that setting the 4-6 cutter at 55-to-60 mm (2-3/16 to 2-3/8) gives only slight improvement. In Figures 7-10, the top line is percent seedpieces in the 35-70 g (1.25-2.50 oz.) range, and the other lines indicate under and over size.

Conclusions

Rotary-blade cutter:

- Set sizer no wider than 50 mm (2 in.)

- Standard top cutter blade spacing of 1.75 in. (45 mm) works well.

- Standard bottom blade spacing of is 2 in. (50 mm) tends to produce oversize seedpieces; 1.75 in. (45 mm) may be better.

Fixed-blade cutter:

First conclusion: With the lot of seed tubers used, the 2-4 sizer should be set no wider than 45 mm (1.75 in.). That setting provided the maximum percentage of 35-70 g (1.25-2.50 oz) seedpieces from the 2- and 6-cutters. Wider settings resulted in high percentages of oversize (>70 g (>2.50 oz)) seed pieces from the 2-cutter.

Second conclusion: The best setting for the 4-6 sizer is less clear. With a large number of 4-cut tubers, the 4-6 sizer should probably be set at 60 mm (2-3/8 in.); with large numbers of 6-cut tubers, it should be set at 55 mm (2-3/16 in.). These data run contrary to the 50 and 55 mm settings for the 2-4 and 4-6 cutters, respectively, that appeared to be best during machine operate.

In summary:

- Set 2-4 sizer at 45 mm (1.75 in.)

- Set 4-6 sizer from 55 to 60 mm (2-3/16 to 2-3/8), depending on number of large tubers.

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Figure 1. Rotary Disk Blade Cutter Concept (Zhao et al. 1988).

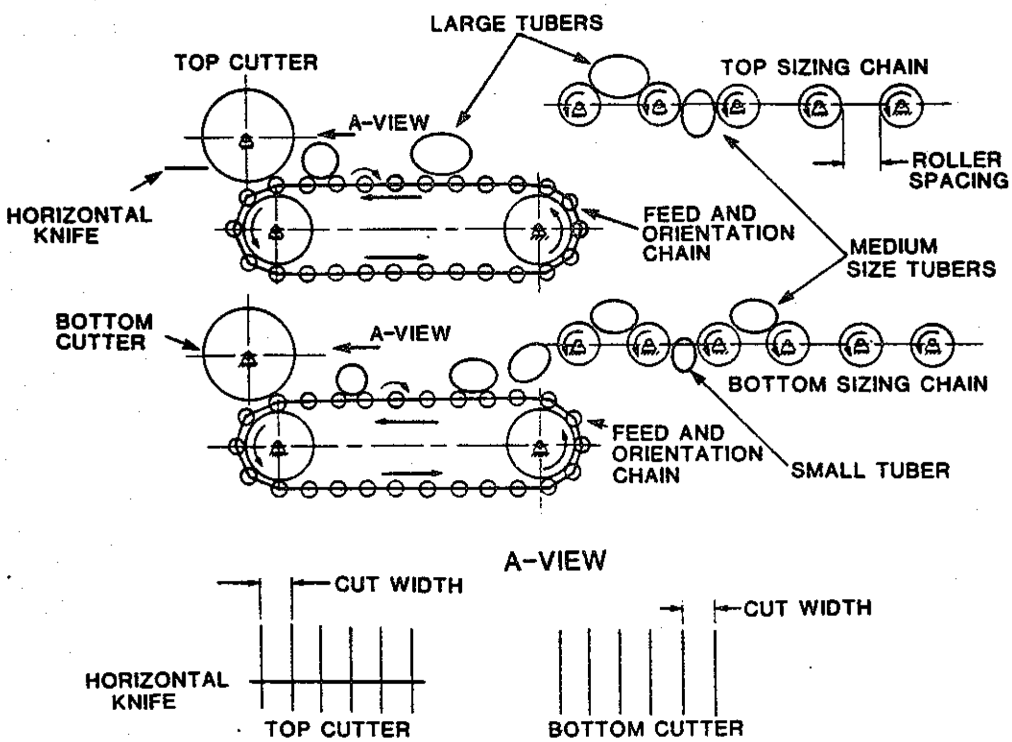

Figure 2. Fixed-blade cutter concept.

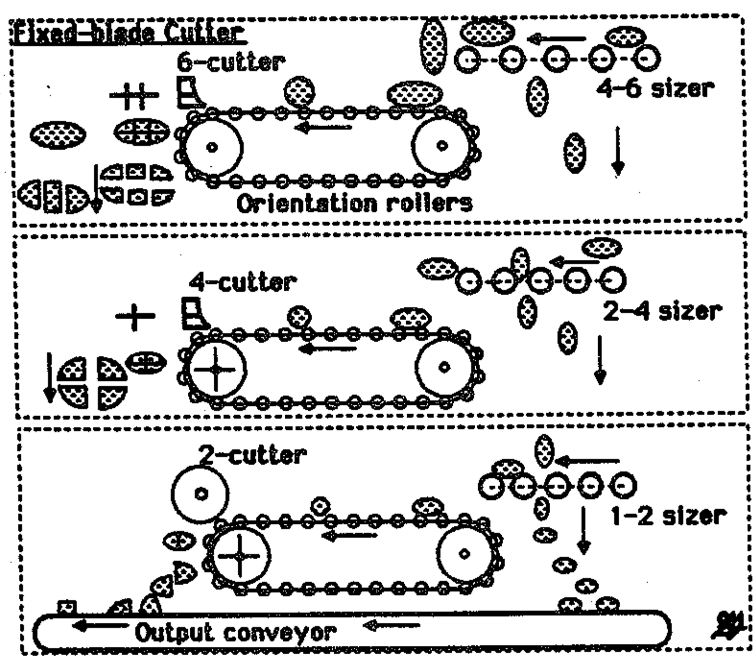

Figure 3. Fixed-blade cutter experiment design.

4-6 sizer settings	45 mm	50 mm	55 mm
50 mm	X		
55 mm	X	X	
60 mm	X	X	X

Figure 4. Graph of percentage desired size seedpieces vs. roller spacing and cut width for rotary blade seed cutter (Zhao 1986).

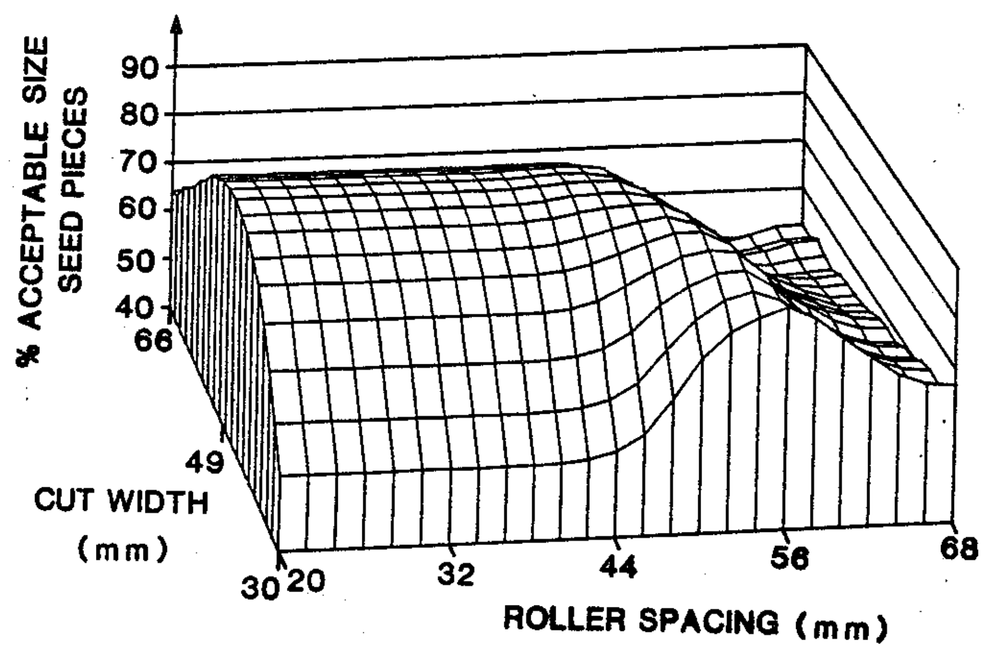

Figure 5. Graph of upper cutter (solid lines) and lower cutter (dashed lines) performance vs. tuber size for 1.75 inch upper and 2 inch lower cutter cut widths (standard blade spacings).

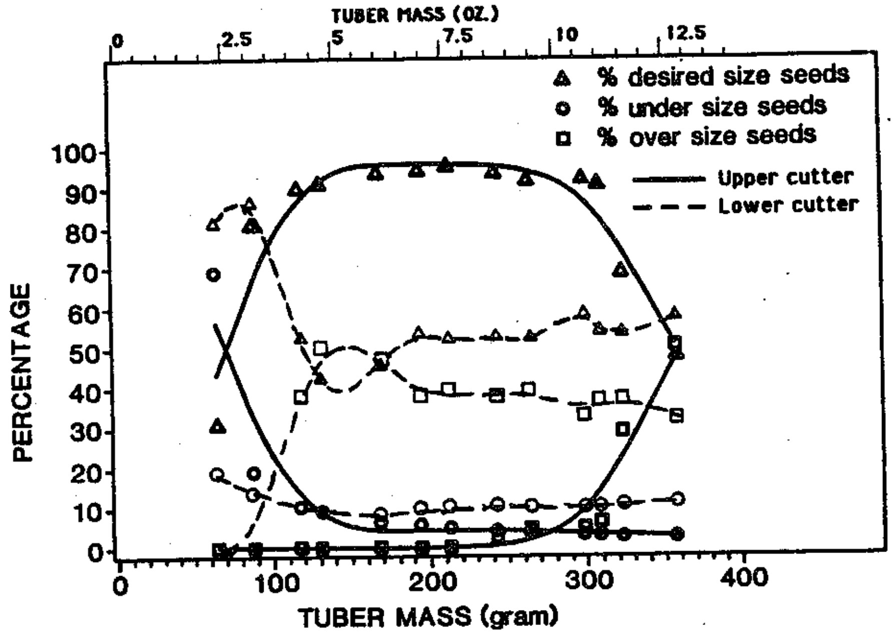

Figure 6. Graph of upper cutter (solid lines) and lower cutter (dashed lines) performance vs. tuber size for 1.75 inch upper and lower cutter cut widths.

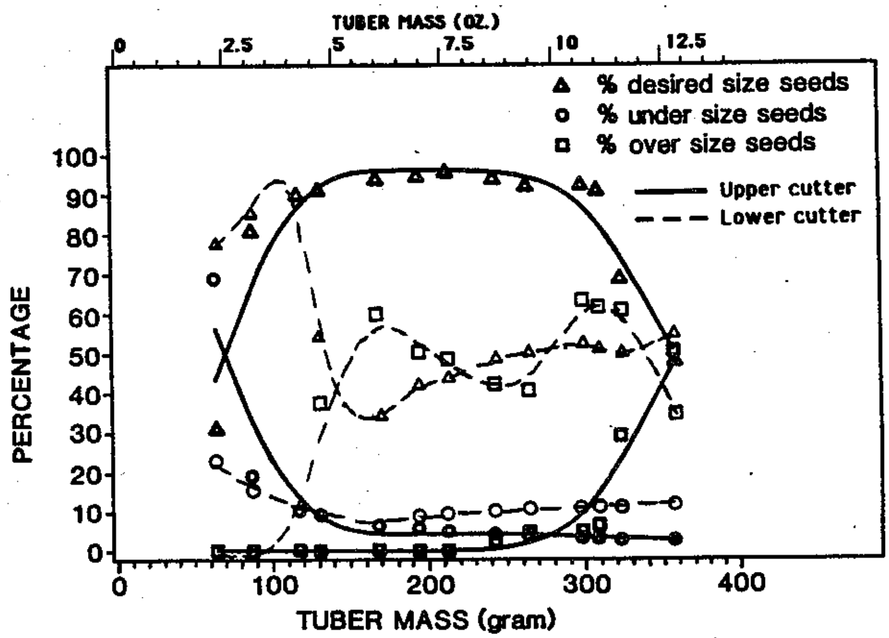

Figure 7.

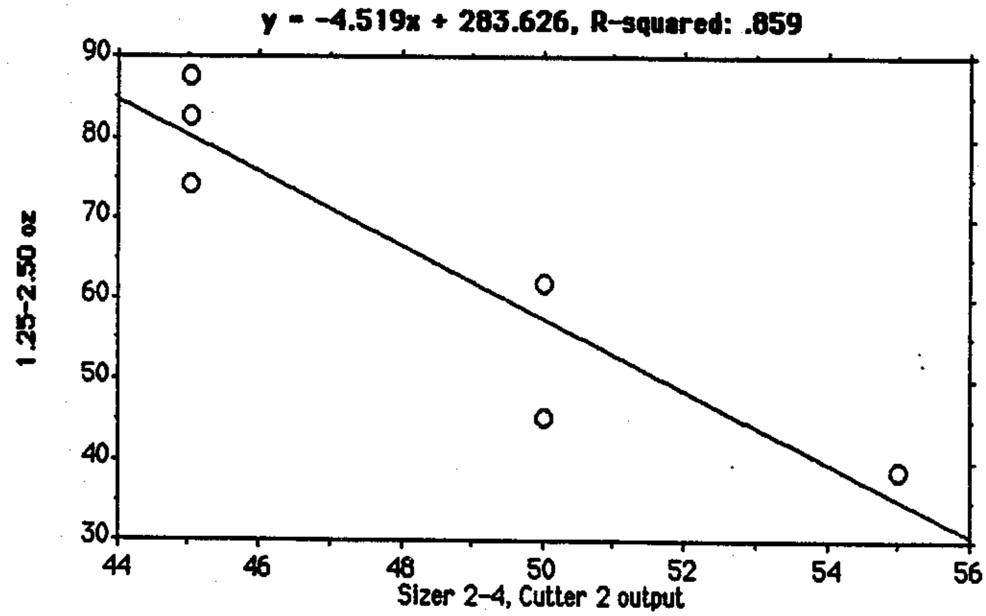

Figure 8.

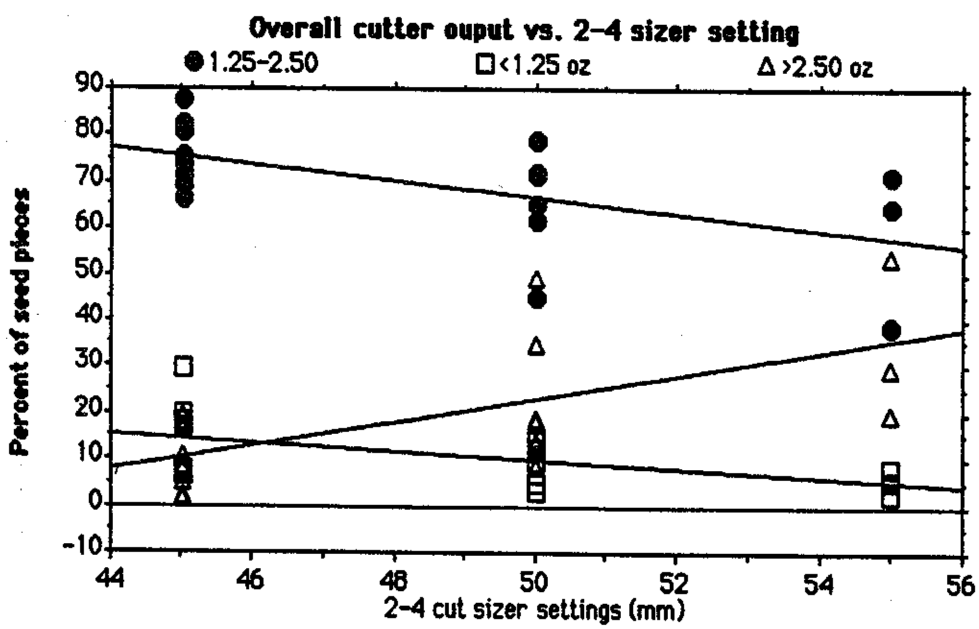

Figure 9.

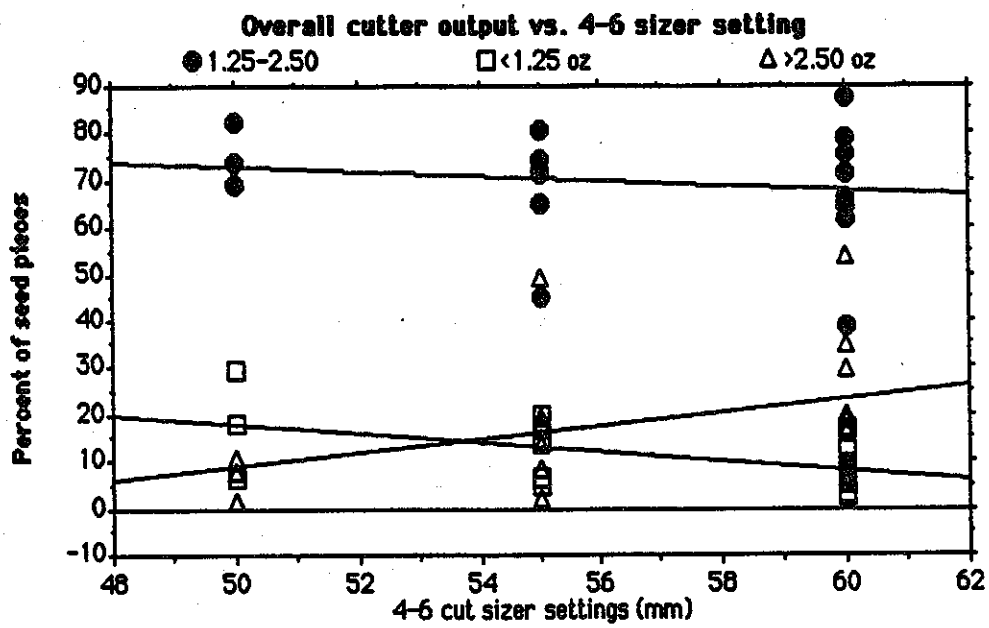

Figure 10.