EFFECT OF SEED SIZE AND SPACING ON ECONOMIC RETURNS

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In 1970 and 1971, Thornton, Iritani, Weller, and O'Leary conducted experiments on seed size and seed spacing as it relates to a variety of characteristics. The information gained from that experiment can be used to make a further, more detailed, analysis of the effect of seed size and spacing on yield, the amount of U. S. No. 1's, 10 ounce or larger tubers, and returns. Not only can statistical significance be determined, it is possible to also estimate the direction and the magnitude of the effects.

This discussion presents that new information on the relationships between seed size and spacing as they relate to total yield, yield of U. S. No. 1's, yield of 10 oz. and larger tubers, and returns. This information can then be used to determine optimum seed size given spacing and seed costs.

Table 1 presents the directional relationships between total yield, the number of U. S. No. 1's, 10 ounce and larger tubers, and grower returns to seed size and spacing. The "+" signs in this table indicate that the relationship is positive. As the size of the seed piece increases, total yield increases. As the size of the seed piece increases, the amount of U. S. No. 1's, 10 ounce and larger tubers, and grower returns also increase.

On the other hand, seed spacing tends to reduce total yield and the amount of U. S. No. 1's as indicated by the (-) sign. However, spacing increases the amount of large tubers. In this case, it also appears that spacing reduces returns. In other words, the farther apart the seed pieces are located, the lower the grower returns. This, of course, will depend on the relationship among the various factors for which you are paid. In this particular case, the negative effect of spacing on yield of No. 1's is greater than the positive spacing effect on 10 ounce and larger tubers.

The size by size variable has the opposite effect of size. Beyond some point, it offsets the size effect and causes total yield, total returns, etc., to decline as size of seed piece continues to increase. The impact of this variable will be described in terms of the graphs presented below.

TABLE 1: DIRECTIONAL RELATIONSHIPS

	Total Yield	*No. 1*	*Ten Ounce*	*Returns*
Size	+	+	+	+
Size x Size	–	–	–	–
Spacing	–	–	+	–
Year	–	–	+	–

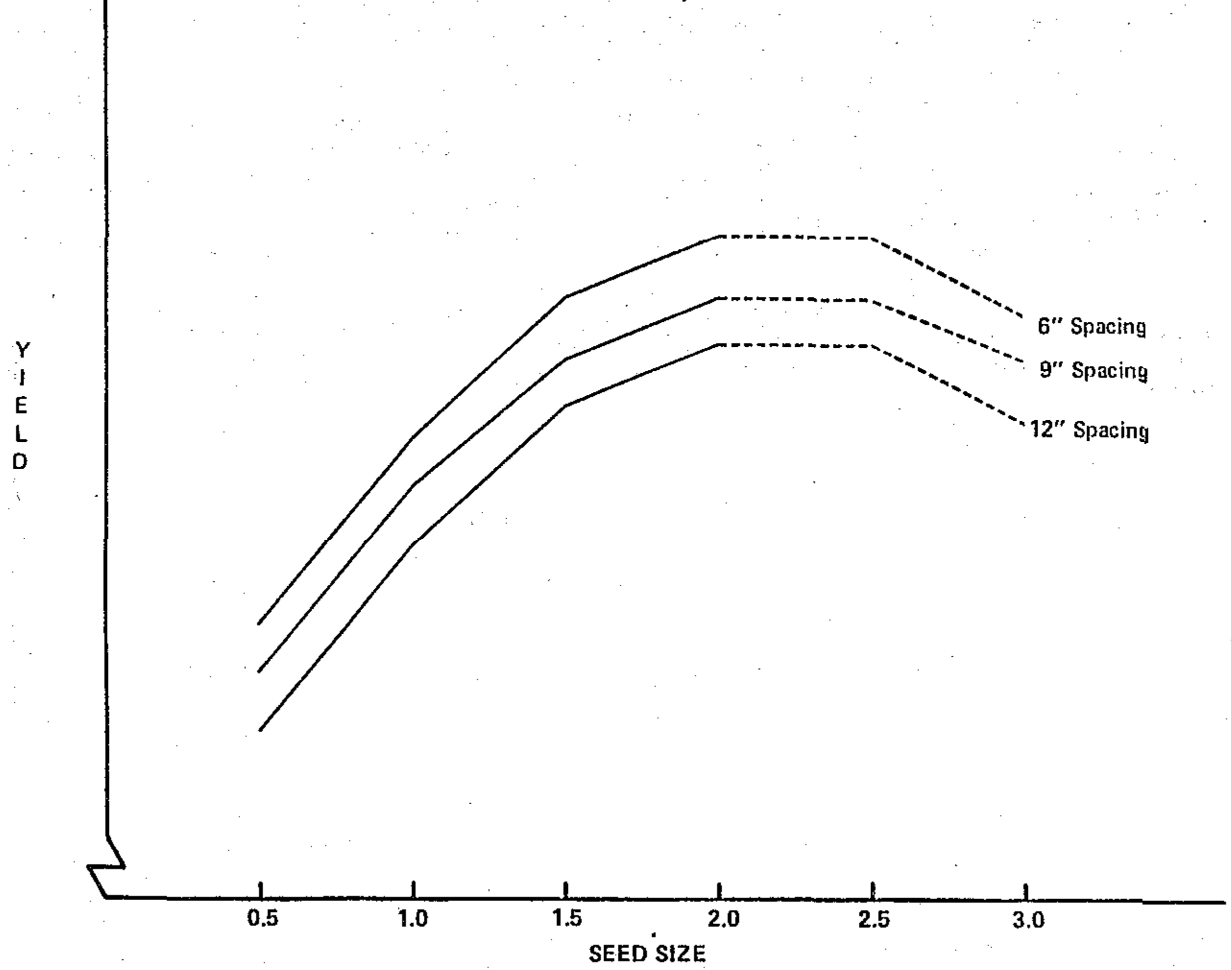
This Presentation is part of the Proceedings of the 1982 Washington Potato Conference & Trade Fair.

The year effect in Table 1 also shows the relationship between 1970 and 1971. These experiments were conducted over two years with 1971 having poorer growing weather than 1970. There are also other factors involved here in addition to weather, such as seed piece physiology and some difference in fertilization rate. These effects are all picked up by the year variable and it says that the year 1971 was a poorer year in terms of total yield, yield of U.S. No. 1's, and returns to the grower.

To get a better idea of what these relationships are, turn to the first figure. It shows the relationship between total yield and seed size. These experiments had observations on seed piece size ranging from 1/2 ounce to 2 ounces, so that anything shown outside that range is an extrapolation of what the actual data implies.

As you can see in Figure 1, increasing seed piece size increases total yield. But notice that it increases at a decreasing rate. In other words, the amount of increase in total yield in going from 1/2 ounce seed to 1 ounce seed is more than the increase in total yield in going from 1 ounce seed to 1-1/2 ounce seed. In fact, eventually total yield turns down. In other words, total yield is reduced as seed piece size increases beyond some optimal size.

FIGURE 1: **TOTAL YIELD by SEED SIZE**



Now you will recall from Table 1 the factor called size by size. That size by size factor pulls yield down. In other words, the relationship between seed size and total yield is not a straight-line relationship. You cannot continue to increase seed size and expect yield to continue to increase. At some point, total yield will be reduced and that reduction effect is measured by the size by size variable shown on the first table. Whenever that variable is negative, total yield (or the variable being measured) will eventually turn down.

The actual optimum seed size, looking only at total yield, is slightly over 2 ounces. Note also, that as spacing increases, total yield is decreased. Therefore, if seed was free and total yield was the only thing for which you were being paid, then 6 inch spacing would be the optimum seed piece spacing.

Figure 2 shows the same relationship between U.S. No. 1's and seed piece size. As seed piece size increases, total yield of U.S. No. 1's increases up to about 2 ounces. Beyond that point, it begins to turn down. Also note that as spacing increases, the yield of U.S. No. 1's decreases. Here again, if seed was free, and payment was based only on the amount of U.S. No. 1's, the narrow spacing would be most appropriate.

FIGURE 2: **No. 1 YIELD by SEED SIZE**

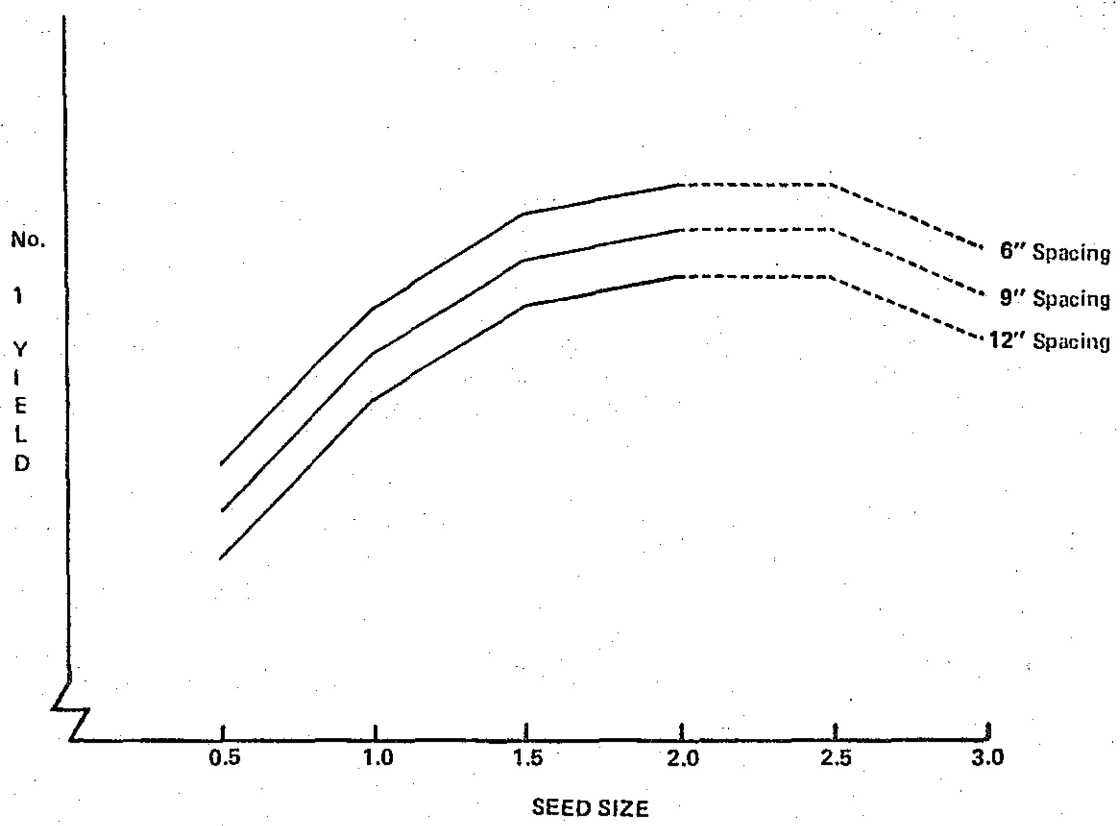
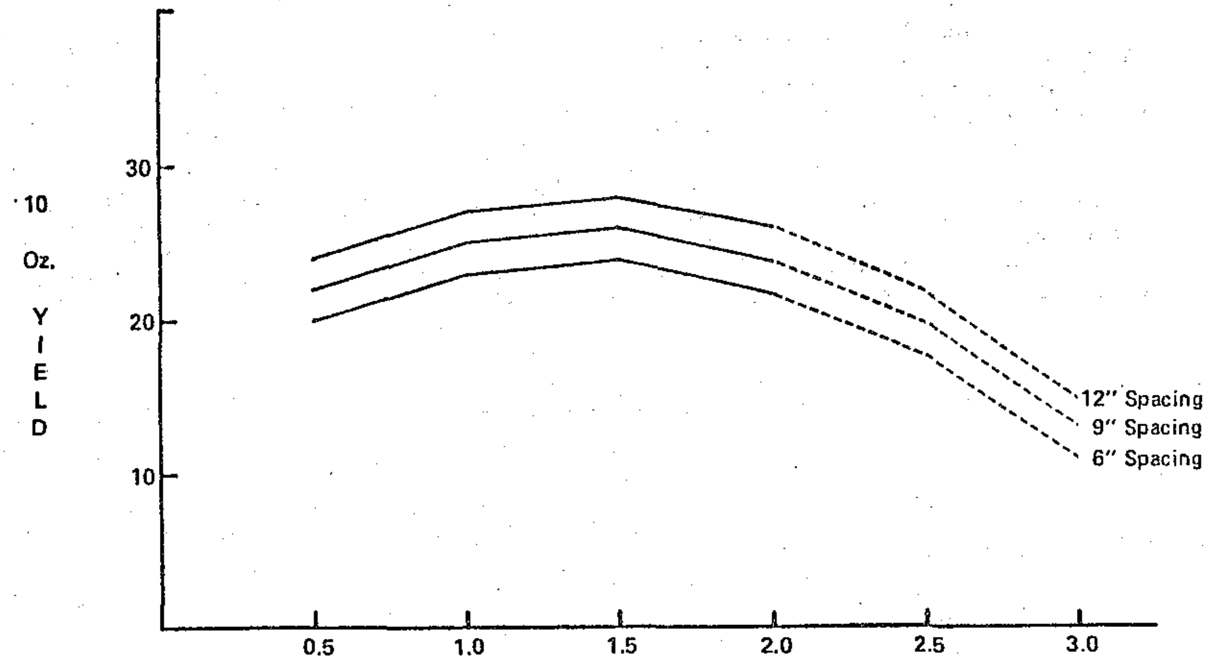


Figure 3 shows the relationship between yield of 10 ounce and larger tubers and seed size. Here again, there is the same general shape of the relationship, yield of large tubers increases at first and then declines. Note, however, that there are some changes here. First, the optimum seed size is smaller. For total yield and for U.S. No. 1's, the optimum seed size was approximately 2 ounces. For 10 ounce and larger tubers, the optimum seed size is about 1-1/2 ounces. Substantially smaller seed is apparently required to get larger tubers.

The other thing of interest to note here is that as spacing increases, yield of the large tubers increases so that there is a direct conflict with optimum production of U.S. No. 1's and total yield.

FIGURE 3: **YIELD OF TEN OUNCE and LARGER by SEED SIZE**



Up to this point, most of you are probably well aware of these relationships so that nothing new has been said. The next step then is to figure out what all this really means in terms of returns to the grower. In order to be able to determine the economic effects of these various factors, it is necessary to evaluate each and every observation in the data in terms of returns to the grower.

Table 2 shows the values of the incentives, the base price, etc. All this information was presented last year at the potato conference, so for full details, please refer to last year's proceedings. The base price in the contract was \$60 per ton of useables. The incentive for U.S. No. 1's was \$.40 per percentage point above or below 60 percent with a cutoff of 40 and 80 percent. The incentive for 10 ounces and larger tubers was \$.25 per percentage point above or below 22 percent.

In addition, since yields vary, a harvest cost was included. It was based on the 1980 Cooperative Extension production cost estimates for potatoes. That harvest cost estimate is \$50.96 plus \$4.08 times the number of tons per acre. The adjusted returns include the base price, incentives for large tubers and No. 1's, less the cost of harvest. All other production expenses and seed costs must be deducted from the figures in the following graph (Figure 4) to obtain net returns. Once these economic returns calculations are finished, the same statistical procedure was used to estimate the relationship between seed size and spacing as they relate to returns.

Figure 4 shows that relationship. Note that as seed size increases, returns to the grower increases -- up to about 2 ounce seed piece size -- and then declines. Note also that the returns gained by increasing seed piece size eventually decline. There is some point that brings the best returns, and all other seed piece sizes generate lower returns for the grower. Returns also decrease as spacing increases. Keep in mind that this figure does not include the cost of seed. As seed cost increases, the most appropriate seed piece size and the most appropriate spacing of the seed pieces changes. This is something that many growers have argued over the years and their perception of how the appropriate seed piece size changes as the price of seed increases is correct.

Given that seed does cost money, what is the appropriate seed size? The answer to that question depends on the cost of the seed and the preferred spacing.

TABLE 2: CONTRACT PROVISIONS

BASE PRICE:	$60 per ton usables
INCENTIVES:	
U.S. No.1	40¢ per percentage point above or below 60%
Ten Ounce and Larger	25¢ per percentage point above or below 22%
HARVEST COST:	$50.96 + $4.08 (tons per acre)

FIGURE 4: **RETURNS by SEED SIZE**

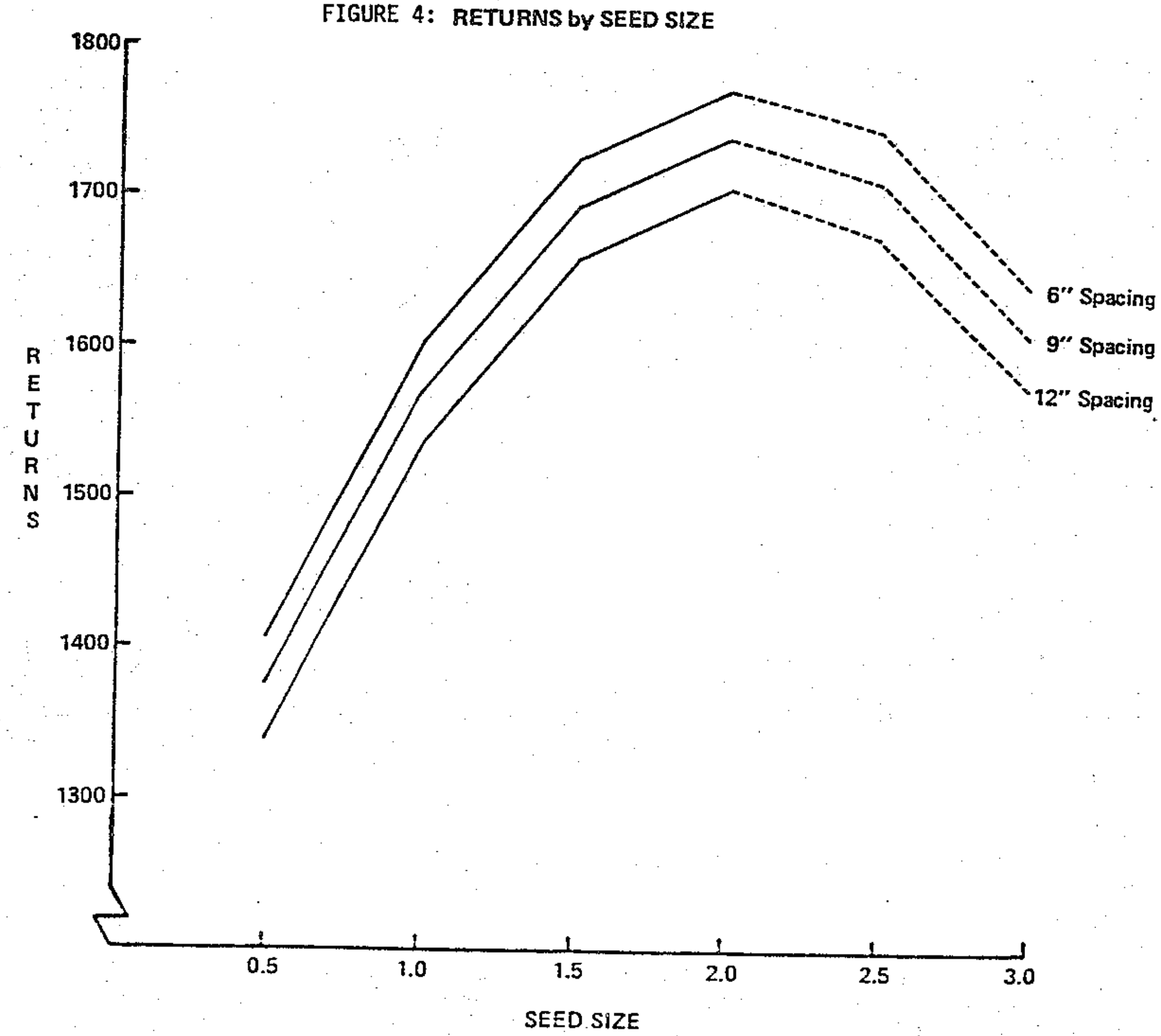


Table 3 contains estimates of the optimum seed size for different spacings and different costs of seed. Assume that the seed cost also includes the amount paid to have that seed cut, treated, and delivered to the field. In each set of numbers for a given seed cost and spacing the top number represents the optimal seed size and the number in parentheses represents the estimated grower returns after adjusting for seed costs and harvest cost. In each column spacing between the seed pieces remains the same and seed cost increases. In each row seed cost remains the same and spacing increases.

TABLE 3: OPTIMAL SEED SIZE and Returns

Seed Cost	Units	Spacing 6"	9"	12"	15"
$ 6	oz.	1.68	1.81	1.87	1.91
	$	(1555)	(1589)	(1592)	(1581)
$ 9	oz.	1.48	1.67	1.77	1.83
	$	(1464)	(1522)	(1539)	(1538)
$12	oz.	1.29	1.55	1.68	1.75
	$	(1389)	(1460)	(1490)	(1497)
$15	oz.	1.10	1.42	1.56	1.68
	$	(1315)	(1403)	(1443)	(1457)

If you look down any one of the columns (hold spacing constant) you can see that as seed cost increases, the optimum seed size declines and the returns decline. Note the difference in the amount of change in seed size. For example, in the 6 inch seed spacing column and $6 seed, the optimum seed size is approximately 1.7 ounces. If seed cost increases to $15 per cwt., optimum seed size is about 1.1 ounces, a decline of over 1.2 ounce.

However, look at 12 inch spacing. Seed costs of $6 implies an optimum seed piece size of approximately 1.9 ounces compared to 1.6 ounces at $15 -- only .3 of an ounce difference. What this says is that as your spacing between seed pieces increases, the optimum seed size is less sensitive to the cost of seed. In other words, if you are striving for 12 inch spacing, then you should be less concerned about seed piece size.

The other thing to note is that when the price of seed is relatively low, it really doesn't make much difference whether you are shooting for a 9 inch spacing of a 12 inch spacing, or even a 15 inch spacing, given this data. However, as seed cost increases, you are better off to strive for a wider spacing.

For all practical purposes, there is no difference in returns between 9 inch and 12 inch spacing when seed costs $6. In some years, obviously, the 9 inch spacing would generate more returns than the 12 inch spacing because these are statistical estimates and merely represent a midpoint of a range of possible returns and not the return that you will actually get. Moving to $9 seed, the difference is $17. At $12 seed, the difference between 9 inch and 12 inch spacing is $30 per acre. For the high cost seed, we are looking at $40 per acre. So when seed is relatively more expensive, the grower is better off shooting for a 12 inch spacing than a 9 inch, which means leaving seed size alone and changing the spacing.

On the average, these data indicate that the grower ought to shoot for about 11-12 inch spacing and a seed piece size of roughly 1-3/4 ounces. One final point should be noted there. While we have talked about average sizes and spacings, having a wide distribution of sizes or spacings doesn't do a bit of good even though the average may be 11 inch spacing and 1-3/4 ounces seed size. A wide-range of seed sizes will reduce returns even though you have a good average figure. The same can be said about seed piece spacing. Having two seed pieces, having two spacings -- one of which is 2 inches and the other is 20 inches for a total of 22 inches, or an average of 11 inches will not generate the same returns that two seed pieces spaced at 11 inches would generate.