Research Progress Report for 1986

Michael K. Thornton
Research Horticulturist
San Luis Valley Research Center

Research in 1986 was conducted in the following areas:

a) Potato Clone Spacing and Fertility
b) Phosphorus Fertility
c) Nitrogen Fertility
d) Fertilizer Recommendations
e) Conservation Tillage
f) Alar
g) Minituber Size, Depth and Density
h) Microplant Starter Fertilizer
i) Microplant Spacing

Unless otherwise noted, the plots were located at the San Luis Valley Research Center on a sandy loam soil (pH 8.1, 0.9% O. M., 4 ppm residual nitrate). The plots were irrigated with a center pivot or solid set sprinkler.

POTATO CLONE SPACING AND FERTILITY

Three advanced selections from the breeding program (AC77513-1, AC77652-1, and AC79100-1) were compared with Russet Burbank and Centennial Russet for response to nitrogen and spacing rates. Three preplant nitrogen rates (80, 120, and 160 lbs N/acre) and three in-row spacings (9, 12, 15 inches) were used. All plots received 120 lbs P_2O_5/acre. A mixture of cut and single-drop foundation seed was planted on May 16, 1986. The plots were cultivated and hilled on June 2 and 2 pints/acre Dual 8E herbicide applied to control weeds. Vines were killed on September 5 and plots harvested on September 16.

AC79100-1 produced the highest total and marketable yields (Table 1). All advanced selections produced higher marketable yields than Russet Burbank or Centennial.

Marketable yield and % marketable potatoes increased with increasing nitrogen rate in AC79100-1 and Russet Burbank only (Table 1). The highest nitrogen rate (160 lbs N/acre) tended to decrease yields in AC77513-1.

Increasing in-row spacing from 9 to 15 inches decreased total and marketable yields in AC79100-1, AC77652-1 and Centennial (Table 2). However, % marketable yields were generally highest at the largest in-row spacing.

Table 1. Effect of nitrogen rate on total yield, marketable yield, and percentage marketable yield of 5 potato clones.

N Rate (lbs N/acre)	Russet Burbank	Centennial	AC77513-1	AC77652-1	AC79100-1
	Total Yield (cwt/acre)[1]				
80	321.5 A[2]	245.3 A	324.8 AB	254.0 A	380.3 A
120	343.2 A	251.9 A	337.6 A	259.6 A	385.3 A
160	337.8 A	242.4 A	306.0 B	275.5 A	396.5 A
	Marketable Yield (cwt/acre)				
80	151.8 B	175.9 A	222.4 AB	186.2 A	301.0 B
120	189.0 A	190.3 A	241.0 A	198.0 A	321.9 AB
160	189.3 A	178.3 A	209.4 B	207.3 A	333.2 A
	% Marketable				
80	47.1 B	72.2 A	68.3 A	73.8 A	79.1 B
120	55.0 A	75.9 A	71.1 A	77.0 A	83.5 AB
160	56.0 A	73.6 A	68.3 A	74.8 A	84.0 A

[1]Values are means of 4 replications averaged over 3 spacings.
[2]Column means followed by the same letter are not significantly different ($P<.05$) by LSD test.

Table 2. Effect of in-row spacing on total yield, marketable yield and percentage marketable yield of 5 potato clones.

Spacing (inches)	Russet Burbank	Centennial	AC77513-1	AC77652-1	AC79100-1
	Total Yield (cwt/acre)[1]				
9	343.5 A[2]	271.8 A	331.7 A	303.9 A	404.9 A
12	328.8 A	252.4 A	325.3 A	255.8 B	383.4 B
15	330.2 A	215.3 B	311.4 A	229.3 C	373.7 B
	Marketable Yield (cwt/acre)				
9	179.2 A	192.5 A	220.8 A	221.5 A	328.2 A
12	171.2 A	182.7 AB	225.7 A	191.4 B	311.3 A
15	179.7 A	169.3 B	226.2 A	178.5 B	316.7 A
	% Marketable				
9	51.9 A	70.9 B	66.2 B	72.5 A	80.7 A
12	51.5 A	72.3 B	69.0 AB	75.1 A	81.1 A
15	54.3 A	78.5 A	72.3 A	78.0 A	84.8 A

[1]Values are means of 4 replications averaged over 3 nitrogen rates.
[2]Column means followed by the same letter are not significantly different ($P<.05$) by LSD test.

PHOSPHORUS FERTILITY

Three fields in different areas of the San Luis Valley were chosen to study the effect of phosphorus fertility on petiole phosphate levels, tuber composition, yield and grade. Fields at all three farms contained high levels of residual phosphate in the soil (Table 1). Phosphorus fertilizer was applied to the plots with a small plot bander at 4 rates (0, 60, 120, 240 lbs P_2O_5/acre). Other nutrients were applied according to the growers' normal practices. Seed source, planting, weed control, irrigation and cultivation practices were all carried out by the growers. Each plot consisted of 4 rows, 40 feet long, replicated 4 times in a randomized complete block design. Beginning in early July, petiole samples were taken on a weekly basis to determine petiole phosphate content. Tubers were also sampled on a bi-weekly basis and analyzed for total N and P. After vinekill the middle 20 feet of the center 2 rows were harvested and graded by hand.

Phosphorus applications up to 240 lbs P_2O_5/acre did not significantly increase marketable yield or percent marketables at any of the three locations (Table 3). Total yields were increased significantly by applying 240 lbs P_2O_5/acre at Hollands. As noted before, residual phosphorus levels were very high in all 3 fields prior to fertilization. The lack of yield response to phosphorus fertilizer would indicate that residual phosphorus availability was adequate to supply plant needs.

Tuber composition was not significantly affected by fertilizer rate (Table 2). Tuber tissue contained an average of 1.96 to 1.28% total N and 0.25 to 0.16% total P, depending on time of the season. Both N and P content of tuber tissue tended to decrease with time.

Petiole phosphate levels have been used to determine if phosphorus fertility levels are adequate for crop needs. Research in Idaho has shown that petiole phosphate levels should be maintained above 1000 ppm until 20 days before vinekill to optimize yields. Initial petiole phosphate levels were highest at the high preplant fertilizer rates. Petiole phosphate levels in these three fields fell below 1000 ppm by 80 to 90 days after planting (Figures 1 to 3). Petiole levels dropped below the threshhold at this time regardless of fertilization rate. The 80 to 90 day period (approx. July 29) corresponds with the phase of most rapid tuber bulking, and was 2 to 4 weeks prior to the target date of 20 days before vinekill in all fields.

This drop in petiole phosphate levels early in the season occurred in the Kelly field, even though this field was severely affected by rhizoctonia, and had delayed emergence, poor stand, and stunted vine growth. The petiole levels would indicate a deficiency in phosphorus, although phosphorus fertility levels should have been more than adequate. This illustrates how factors other than nutrient availability, such as disease, growing conditions, etc., can affect petiole nutrient levels.

Early season petiole levels can be plotted on semilog paper to predict when petiole phosphate levels will drop below 1000 ppm. Plotting petiole phosphate levels versus time for the Holland and Davis fields did not closely predict when the 1000 ppm threshold would be reached (Figures 4 and 5). This method would predict that P fertility levels were adequate to maintain the petiole phosphate above 1000 ppm at the Davis farm. However, petiole phosphate levels dropped below the threshold at least 2 weeks earlier than predicted.

SUMMARY - Very high P fertilization rates did not increase marketable yield in any of the fields studied. Petiole phosphate levels in plants which have adequate P available can fall below 1000 ppm before the target date of 20 days prior to vinekill. This may indicate that the demand for P is so great at that time that plant uptake cannot furnish it, even if soil P levels are high. Petiole phosphate levels can be affected by factors other than soil P levels. Diseases, growing conditions, or anything that affects plant uptake can make it appear as if soil P is not adequate.

Table 1. Residual soil phosphate levels and recommended P fertilization rates for three San Luis Valley farms.

Farm	Soil P (ppm)	Fertilizer Recommendation (lbs P_2O_5/acre)
K. Holland	77 (High)	60
W. Davis	63 (High)	60
J. Kelly	61 (High)	60

Table 2. Effect of preplant phosphorus fertilizer rate on tuber composition.

lbs P_2O_5/acre	Tuber Composition, Days After Planting: 67-77		81-91		95-105		109-119	
	% N	% P	% N	%P	% N	% P	% N	% P
0	1.96[1]	0.25	1.45	0.17	1.28	0.16	1.47	0.17
60	1.80	0.23	1.40	0.17	1.36	0.17	1.49	0.18
120	1.90	0.23	1.44	0.18	1.29	0.17	1.45	0.16
240	1.82	0.23	1.49	0.19	1.69	0.18	1.28	0.17

[1] Values are means for the 3 farms.

Table 3. Effect of preplant phosphorus fertilizer rate on yield at 3 farms in the San Luis Valley.

Farm	Cultivar	P_2O_5 (lbs/acre)	Marketable Yield	Total Yield	% Marketable
			------- Cwt/Acre	------	
Holland	Russet Burbank	0	157.6[1]	284.1	55.4
		60	173.7	276.4	62.7
		120	191.8	317.1	60.1
		240	192.2	321.7	59.8
	LSD(.05)[2]		36.3	25.8	9.9
Davis	Centennial Russet	0	220.6	265.2	83.1
		60	222.6	297.5	75.0
		120	208.0	266.8	78.0
		240	249.9	310.6	80.6
	LSD(.05)		43.8	59.2	6.9
Kelly	Centennial Russet	0	123.8	168.0	74.0
		60	138.0	177.2	77.0
		120	155.3	195.3	78.7
		240	133.0	168.4	78.2
	LSD(.05)		37.7	43.4	7.2

[1]Values are means of 4 replications.

[2]Means differing by more than LSD value are significantly different (P>.95).

Figure 1. Effect of preplant phosphorus fertilizer rate (lbs P_2O_5/acre) on petiole phosphate level at Holland Farm.

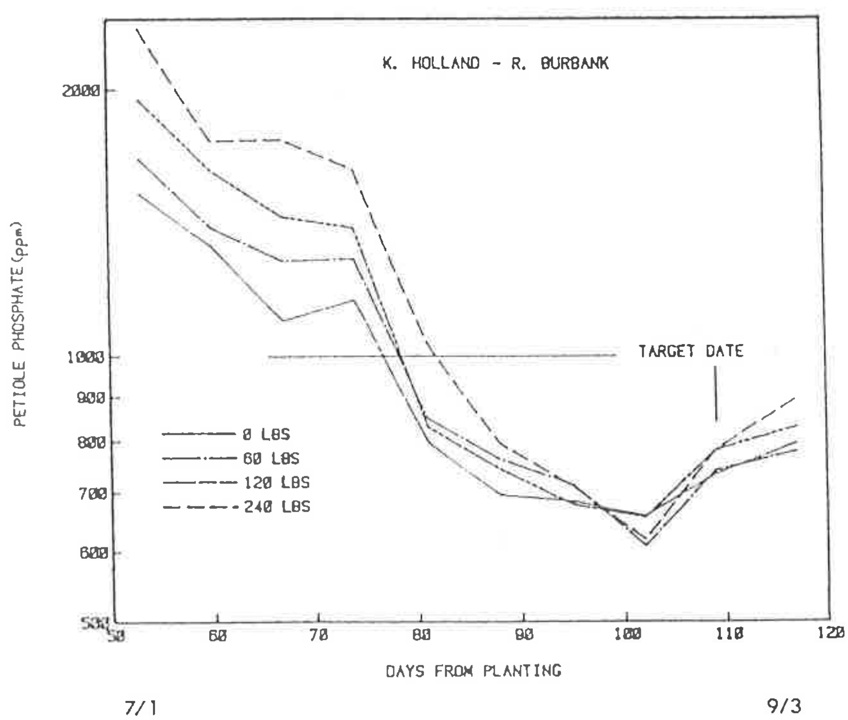


Figure 2. Effect of preplant phosphorus fertilizer rate (lbs P_2O_5/acre) on petiole phosphate level at Davis farm.

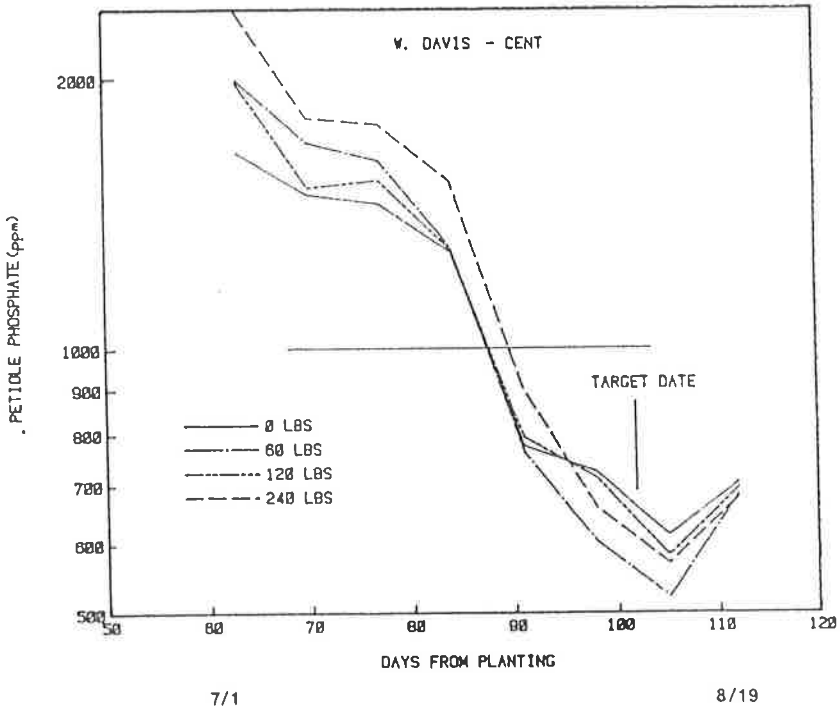


Figure 3. Effect of preplant phosphorus fertilizer rate (lbs P_2O_5/acre) on petiole phosphate level at Kelly farm.

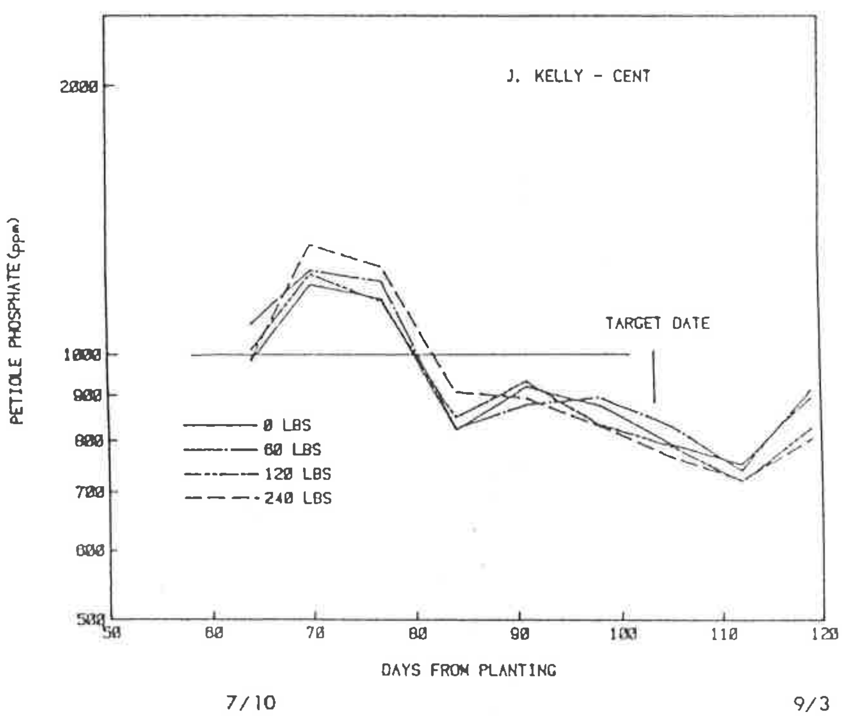


Figure 4. Projected (dashed line) and actual (solid line) petiole phosphate levels at 2 preplant phosphate rates (lbs P_2O_5/acre) in Russet Burbank.

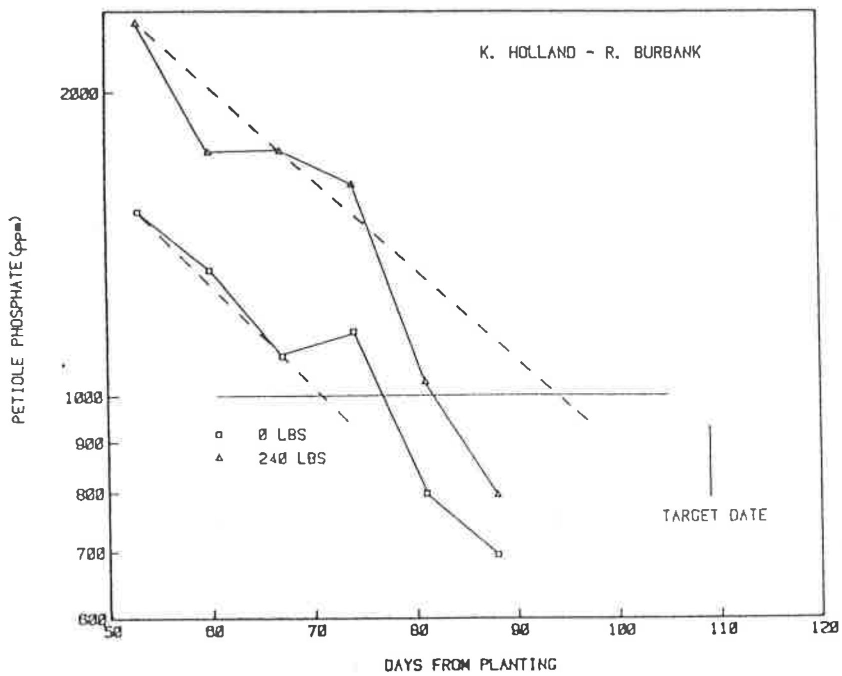
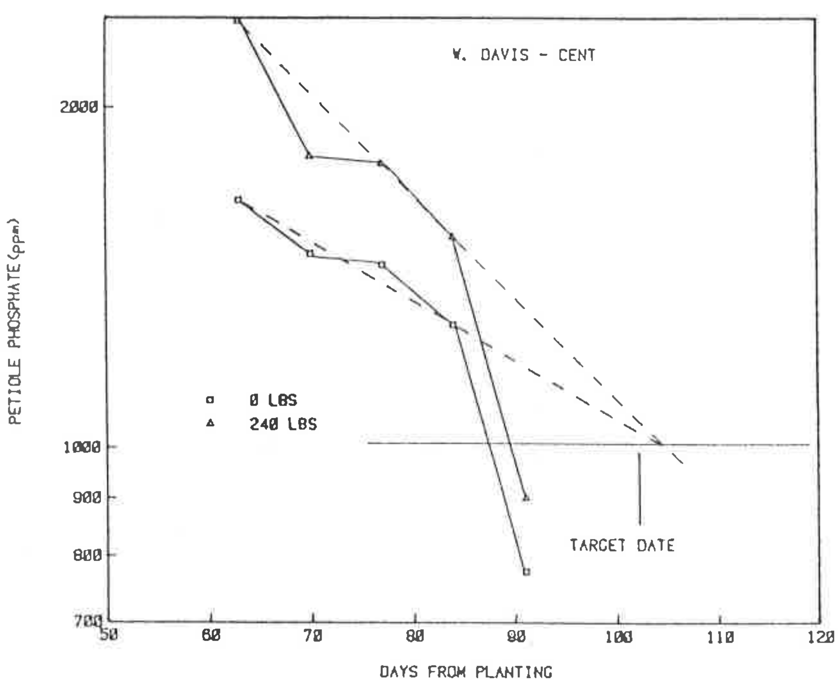


Figure 5. Projected (dashed line) and actual (solid line) petiole phosphate levels at 2 preplant phosphate rates (lbs P_2O_5/acre) in Centennial Russet.



NITROGEN FERTILITY

Although research in the past two years has shown that high preplant nitrogen rates do delay tuber growth in Centennial, it is not known how the timing and rate of seasonal N applications affect tuber growth, yield and quality. This study was begun in 1986 to determine how different preplant N rates, combined with different timing and rates of seasonal N affect petiole nitrate levels, tuber and vine growth, yield and quality.

Nitrogen was banded in the center of each row prior to planting at three rates (60, 100, 140 lbs N/acre). Phosphorus was banded in all plots at a rate of 120 lbs P_2O_5/acre. Each plot was 4 rows wide and 25 feet long, with the middle two rows used for data collection. The experiment was designed as a randomized complete block with 4 replications, preplant N as main plots and foliar N as subplots. Seedpieces of Centennial Russet were planted in the plots on May 14, 1986. The plots were cultivated and hilled on June 2 and 2 pints/acre Dual 8E herbicide applied to control weeds. Petiole samples were taken weekly beginning on June 26. Tuber and vine fresh weights were taken biweekly beginning on July 10. Foliar N applications began on June 27 (early application), July 9 (mid application) or July 22 (late application). All plots, except those receiving no N after preplant, received at least 150 lbs total N during the season (Table 1). Foliar nitrogen was applied in 100 gallons water/acre using a backpack sprayer. Applications were made immediately prior to irrigation with the center pivot sprinkler to minimize leaf burning and to more closely simulate conventional application methods. Vines were killed on September 5 and plots harvested on September 10. During grading ten 8 to 12 oz tubers from each plot were cut open to determine incidence of brown center and hollow heart.

Timing of foliar nitrogen applications significantly affected petiole nitrate level. When foliar applications were begun at the beginning of tuber set (June 27), petiole nitrate levels stayed above the 15,000 ppm guideline much later in the season than when applications were begun just two weeks later (July 9), especially at the 60 lbs N/acre preplant rate (Figure 1). Applying an extra 20 lbs N/acre late in the season (beginning July 22) did not help maintain petiole nitrate levels above 15,000 ppm any better than applying less nitrogen beginning July 9 (Figure 2).

Vine growth rate was also affected by foliar nitrogen application timing. Applying nitrogen early significantly increased vine growth, and decreased the rate of vine senescence late in the season (Figure 3). Applying extra nitrogen later in the season did not help increase vine growth or delay vine senescence.

Early tuber growth rate was significantly affected by preplant nitrogen rate. Tuber yields were significantly lower in the 100 and 140 lbs N/acre preplant rates than the 60 lb N rate from mid July to early August (Figure 4). Foliar N applications also affected tuber growth, but generally not until after the first week of August (Figure 5). Early season foliar N applications tended to have the highest tuber growth rates after that time. This could be attributed to the greater vine growth and slower vine senescence associated with the earlier foliar applications. Timing of foliar N applications was particularly critical at the 60 lbs N/acre preplant rate. Delaying foliar N applications by just 14 days (from early to mid season) decreased late tuber growth and final yield significantly at this rate (Figure 6, Table 2).

Marketable and total yields tended to be highest when foliar applications were begun early in the season (Table 2). Applying an extra 20 lbs of N late in the season (total 170 lbs N/acre) did not increase total or marketable yields over applying less nitrogen (total 150 lbs N/acre) early in the season. Total and marketable yields were not different whether most of the N was applied preplant (140 lbs preplant + 10 lbs foliar) or foliar (60 lbs preplant + 90 lbs foliar).

Brown center and hollow heart were not found in any of the tubers. It cannot be determined if seasonal nitrogen application would have any effect on this disorder from this study.

SUMMARY - Application of 60 to 140 lbs N/acre at planting, combined with early season foliar applications maintained petiole nitrate levels at adequate levels, provided good vine growth, rapid late season tuber growth and high total and marketable yields. However, timing of foliar nitrogen applications were more critical when low preplant N rates (60 lbs N/acre) were used. Nitrogen applications of 150 lbs N/acre split as a preplant and early foliar applications produced higher petiole nitrate levels, and higher tuber and vine growth rates than applying 170 lbs N/acre split as a preplant and late foliar applications.

Late foliar applications of high rates of nitrogen did not increase brown center and hollow heart in this study. However, this practice cannot be recommended due to reduced efficiency of uptake by vines late in the season and delay in tuber maturity.

* The assistance and support of several individuals and companies in conducting the previous two experiments is gratefully acknowledged. Wayne Davis, Keith Holland and John Kelly provided plot space and performed all cultural practices for the P fertility trial. Agro Engineering coordinated plot set-up with cooperators, provided labor for sampling and assisted in harvesting the P fertility trial. Servi-Tech provided soil, petiole and tuber tissue analysis for the N fertility and P fertility trials.

Table 1. Dates and rates of preplant and foliar nitrogen applications to Centennial.

			Foliar N application dates				
Preplant N	Foliar N	Total N	6/27	7/9	7/22	8/4	8/21
lbs N/acre							
60	90 Early	150	30	30	30	-	-
60	90 Mid	150	-	30	30	30	-
60	110 Late	170	-	30	30	30	20
60	0	60	-	-	-	-	-
100	50 Early	150	20	20	10	-	-
100	50 Mid	150	-	20	20	10	-
100	70 Late	170	-	20	20	20	10
100	0	100	-	-	-	-	-
140	10 Early	150	10	-	-	-	-
140	10 Mid	150	-	10	-	-	-
140	30 Late	170	-	-	10	10	10
140	0	140	-	-	-	-	-

Table 2. Effect of preplant and foliar nitrogen application rates on total and marketable yield of Centennial.

Preplant N	Foliar N	Total N	Marketable Yield	Total Yield	% Marketable
------ lbs/acre ------			------ cwt/acre ------		
60	90 Early	150	296.9[1]	337.5	88.0
60	90 Mid	150	246.2	285.2	86.5
60	110 Late	170	277.9	324.4	85.6
60	0 None	60	233.3	283.5	81.8
100	50 Early	150	283.3	330.2	86.0
100	50 Mid	150	293.3	338.2	86.6
100	70 Late	170	298.3	342.5	87.2
100	0 None	100	258.5	309.2	83.6
140	10 Early	150	299.0	348.0	85.9
140	10 Mid	150	273.7	325.4	84.1
140	30 Late	170	274.8	326.7	84.1
140	0 None	140	272.1	322.9	84.3
LSD (.05)[2]			40.7	39.1	5.2
Means					
Preplant N - 60 lbs			263.6	307.6	85.4
100 lbs			283.3	330.0	85.8
140 lbs			279.9	330.7	84.6
Foliar N - Early			293.1	338.6	86.6
Mid			271.0	316.3	85.7
Late			283.7	331.2	85.6
None			254.6	305.2	83.2

[1] Values are means of 4 replications.
[2] Means differing by more than LSD value are significantly different (P>.95).

Figure 1. Effect of foliar nitrogen application timing at the 60 lbs N/acre preplant rate on petiole nitrate level in Centennial.

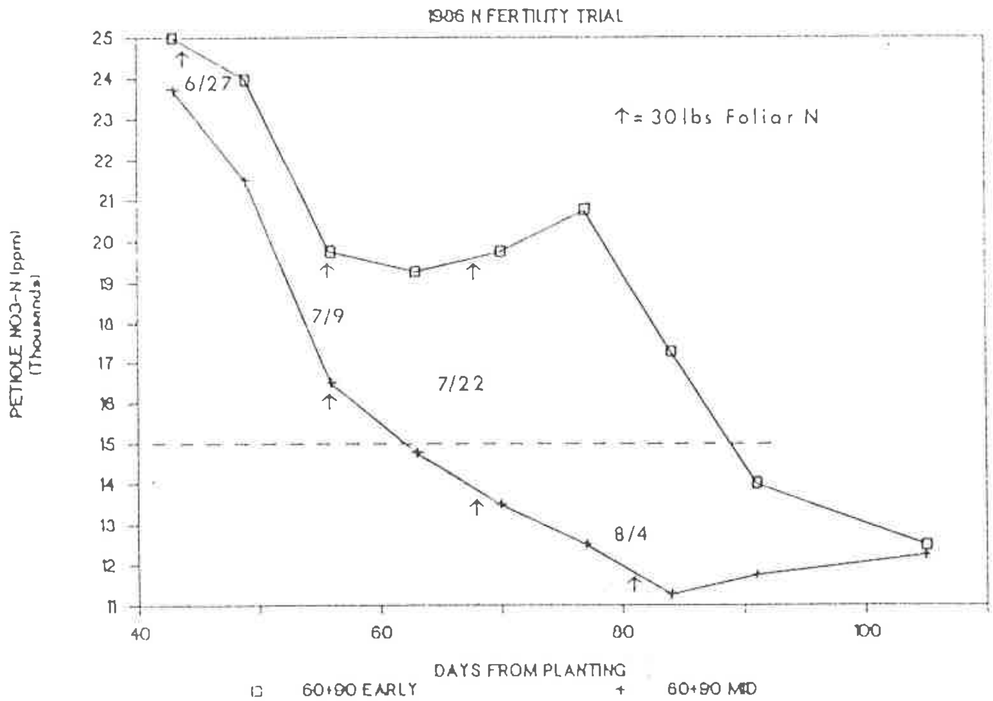


Figure 2. Effect of foliar nitrogen application timing (ave. for 60, 100 and 140 lbs N/acre preplant rates) on petiole nitrate level in Centennial.

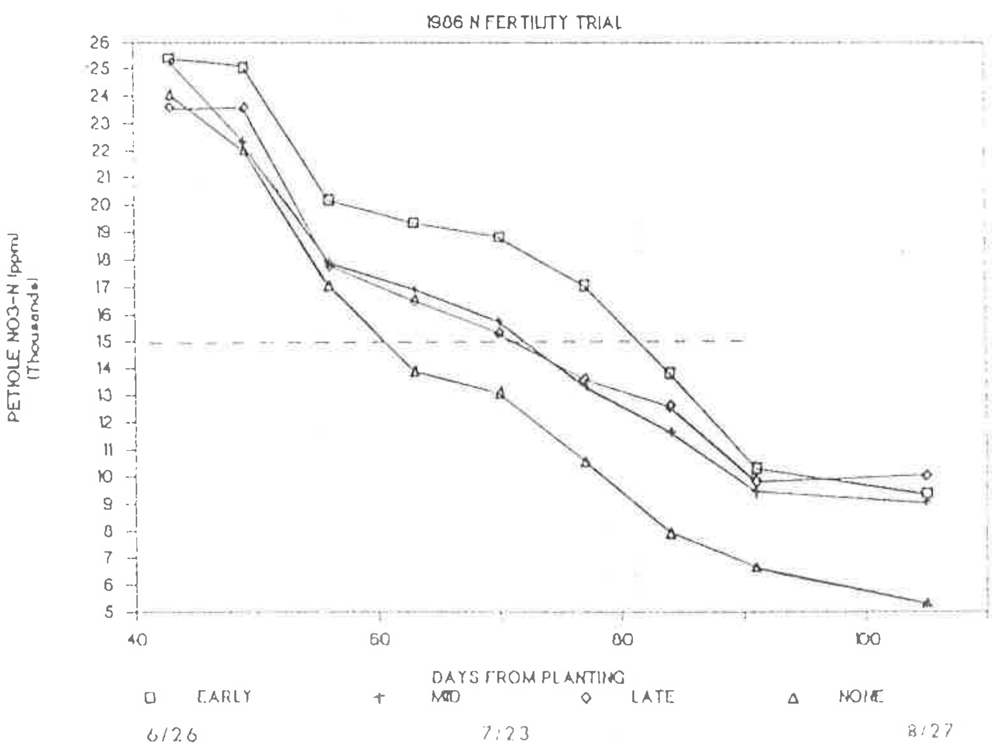


Figure 3. Effect of foliar nitrogen application timing (ave. for 60, 100 and 140 lbs N/acre preplant rates) on vine growth rate in Centennial.

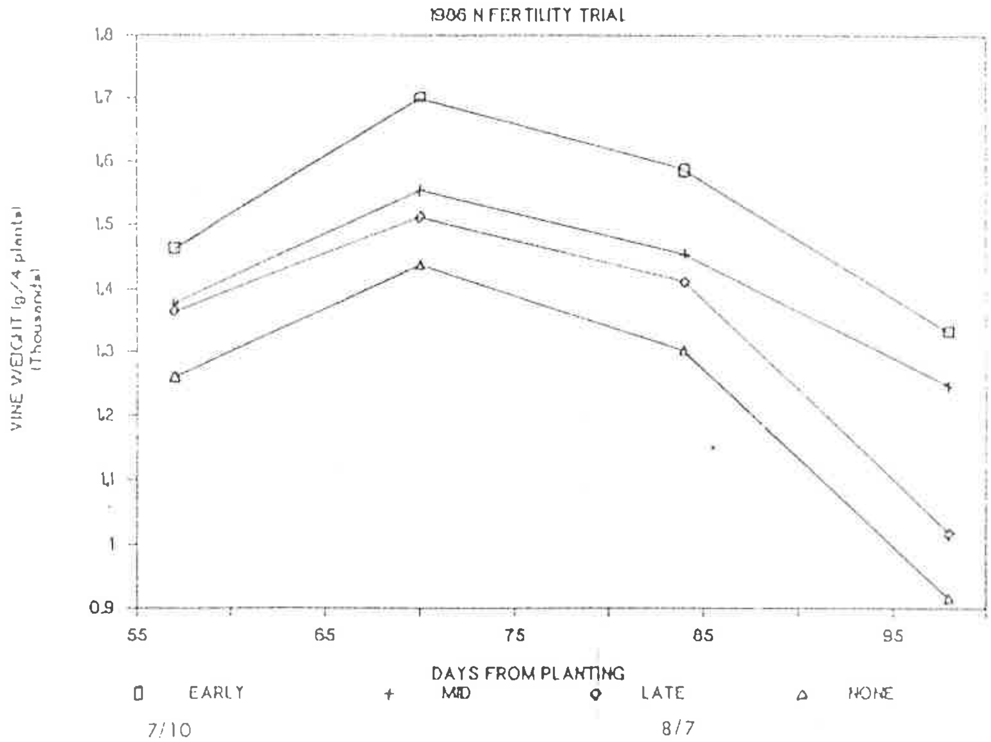


Figure 4. Effect of preplant nitrogen rate (lbs N/acre) on tuber growth rate in Centennial.

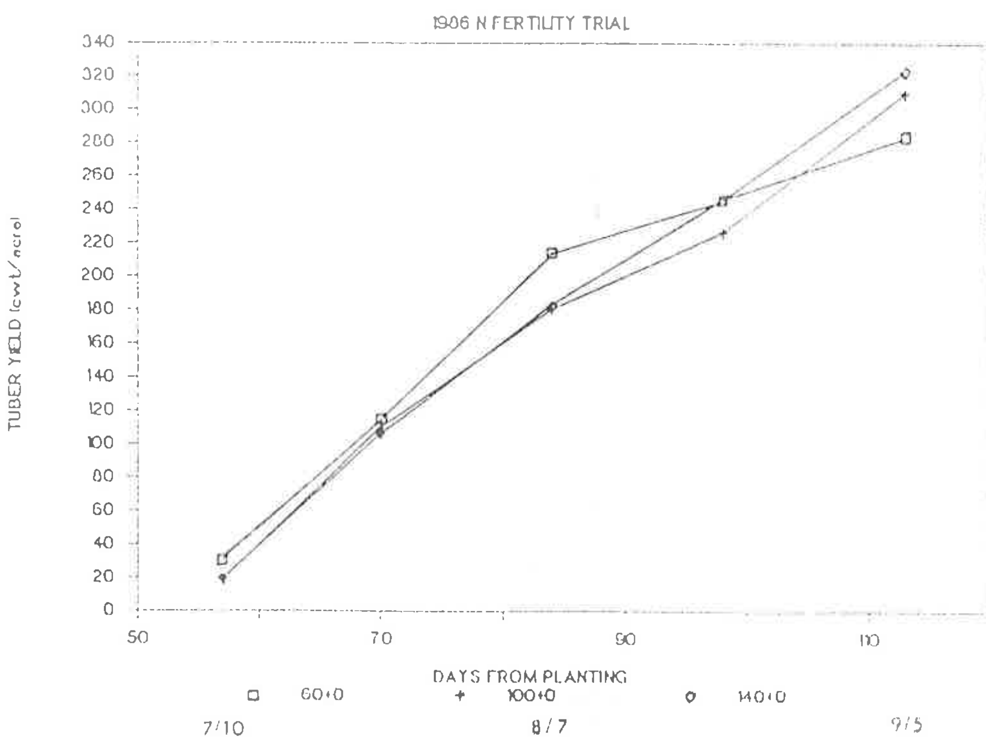


Figure 5. Effect of foliar nitrogen application timing (ave. for 60, 100 and 140 lbs N/acre preplant rates) on tuber growth rate in Centennial.

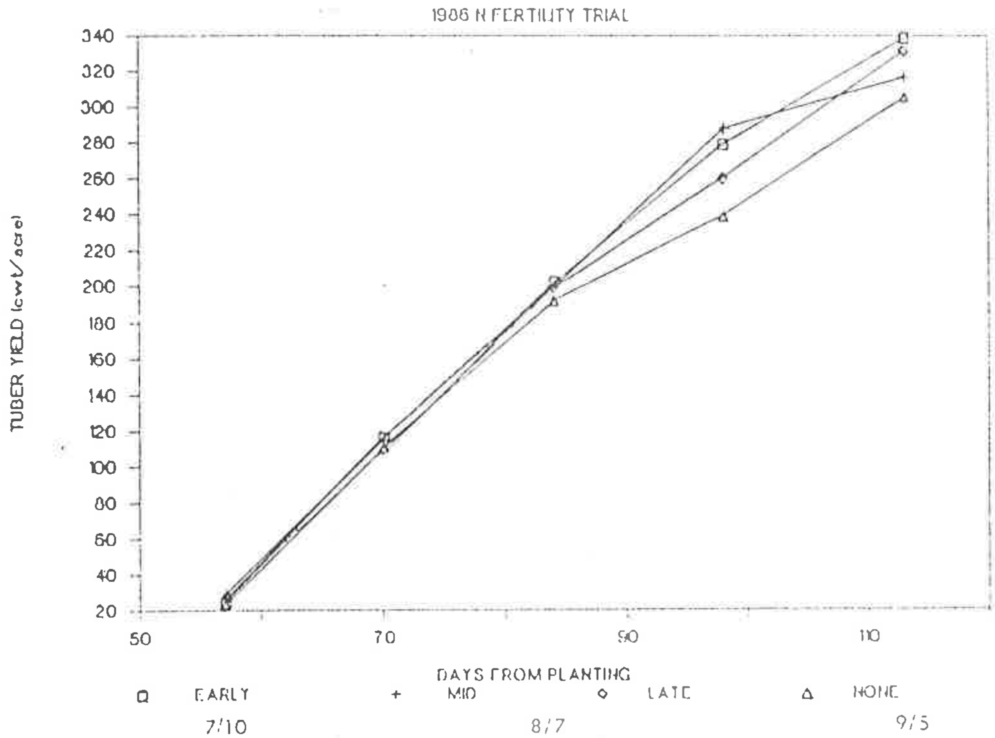
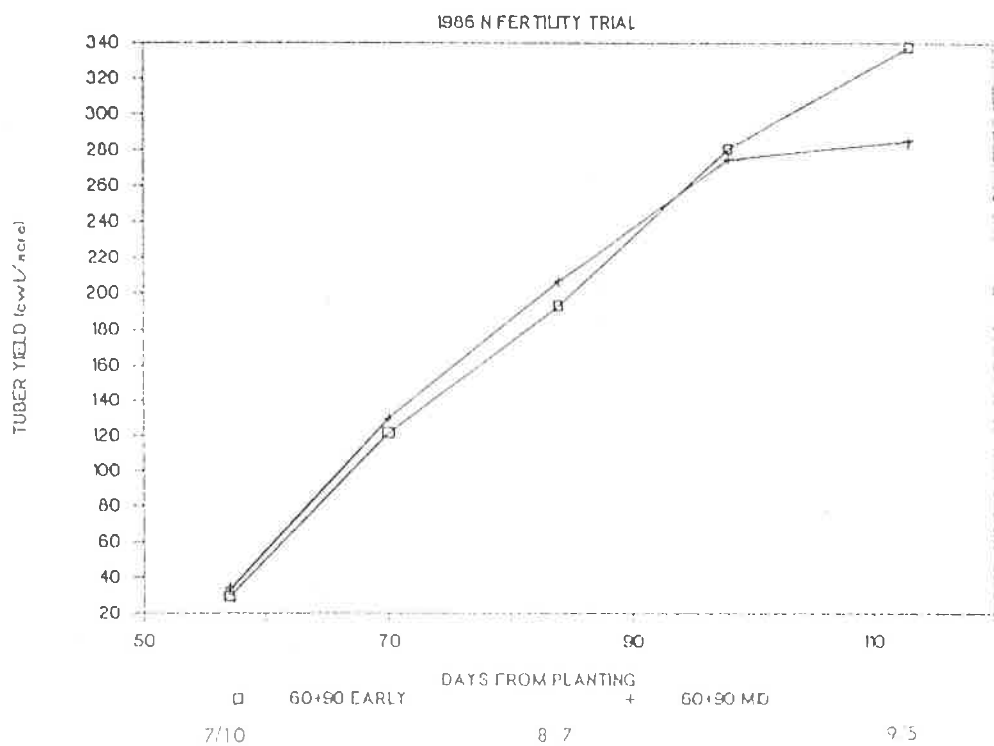


Figure 6. Effect of foliar nitrogen application timing at the 60 lbs N/acre preplant rate on tuber growth rate in Centennial.



FERTILIZER RECOMMENDATIONS

A farm near Center, Colorado, was chosen as the location for this trial to compare fertilizer recommendations from soil testing laboratories commonly used in the San Luis Valley, and to determine the effects of these recommendations on yield and fertilizer cost per acre.

A soil sample was taken from the plow layer in the plot area on March 30, 1986. The sample was mixed, dried and divided into five subsamples. Each subsample was sent to a soil testing laboratory which currently makes recommendations in the San Luis Valley. The laboratories were asked to make fertilizer recommendations for a 400 cwt/acre yield of Centennial Russet potatoes. The soil samples were not identified as coming from a CSU research plot.

The fertilizer recommended by each laboratory was banded at a depth of 6 inches in the middle of each row on April 29. All fertilizer, except supplemental N applied by the grower as a liquid top dress, and through the sprinkler, was applied preplant. Each plot was 4 rows and 25 feet long. The 5 treatments were replicated 4 times in a randomized complete block design. The grower's own certified seed was planted throughout the plot on April 29. All cultural practices were carried out by the grower, Mr. Wayne Davis. The vines were killed on August 29 and the middle two rows of each plot harvested and weighed on September 8.

Fertilizer costs were calculated based on current prices from a local distributor.

Fertilizer recommendations varied widely between laboratories (Table 1). Two laboratories recommended nitrogen and phosphorus fertilizer rates twice as high as CSU. Potassium, sulfur and micronutrients were also recommended by several laboratories. Research has not shown sulfur or micronutrients, other than zinc and iron, to limit yields of potatoes in Colorado.

Recommendations for high levels of nitrogen and phosphorus, plus micronutrients increased fertilizer costs substantially. Total fertilizer cost per acre ranged from $44 to $144/acre (Table 2). Fertilizer recommendations from two laboratories resulted in total yields 35 cwt/acre higher than CSU (Table 2). Total yields of plots fertilized according to the other two laboratories were not significantly different. Fertilizer costs for the two laboratories with the highest yields (C and D) were substantially higher than CSU. This resulted in an expense of $2.19 to $2.49 for each cwt. of yield increase (Table 2). To be economically feasible, the higher fertilizer recommendations would have to consistently account for a higher yield which could be sold at a price high enough to make up for the added cost.

Table 1. Fertilizer recommendations given by each laboratory for a 400 cwt/acre Centennial Russet yield goal.

	Laboratory				
	CSU	B	C	D	E
	lbs/acre				
Nitrogen	140	140	216	285	140
Phosphorus (P_2O_5)	120	60	220	215	30
Potassium (K_2O)	0	0	100	80	40
Sulfur (SO_4)	0	0	30	35	0
Zinc	0	0	3	8	0
Manganese	0	0	6	4	0
Copper	0	0	3	0	0
Boron	0	0	1	1.5	0

Table 2. Cost of fertilizer recommended by each laboratory and total yield, increased yield and relative cost per cwt yield increase.

	Laboratory				
	CSU	B	C	D	E
	$/acre				
Nitrogen	25.90	29.28	39.64	57.95	30.99
Phosphorus (P_2O_5)	29.42	14.71	53.94	52.72	7.36
Potassium (K_2O)	0	0	9.33	7.47	5.60
Sulfur (SO_4)	0	0	1.17	1.70	0
Zinc	0	0	4.17	11.11	0
Manganese	0	0	12.00	8.00	0
Copper	0	0	9.00	0	0
Boron	0	0	3.41	5.12	0
Total fert cost, $/acre	55.32	43.99	132.66	144.07	43.95
Total yield, cwt/acre	319.8	331.5	355.1	355.4	321.3
Yield increase, cwt/acre[1]	–	NS[2]	35.3	35.6	NS
$ fert input/ cwt yield increase[3]	–	–	$2.19	$2.49	–

[1] Average total yield increase compared to CSU.
[2] Total yield not significantly different than CSU.
[3] Additional dollars spent on fertilizer compared to CSU per cwt yield increase.

CONSERVATION TILLAGE

This is the third year of this trial conducted in conjunction with the Soil Conservation Service.

The conservation tillage regime for potatoes consisted of primary tillage with a Howard Rotavator (chisel plow w/mulching attachment) on October 14, 1985. The plot was tilled twice in the spring with a cultipacker prior to marking out rows on March 27, 1986.

The conventional tillage regime consisted of primary tillage with a moldboard plow on November 11, 1985. The plot was then tilled with a straight chisel and left until rows were marked out on March 27, 1986.

Both tillage plots received 140 lbs/ac N and 60 lbs/ac P_2O_5 as a liquid band in each row on May 2, 1986. Foundation Centennial Russet seed was planted at 12 inch in-row spacing on May 2, 1986. All plots were cultivated and hilled on June 4, 1986. Dual 8E herbicide was applied at a rate of 2 pints product per acre by ground-rig sprayer on June 5, 1986. Vines were killed on September 5 and plots harvested by hand on September 18.

Grass and Broadleaf herbicide trials were conducted in conjunction with Dr. Phil Westra and will be reported in his annual research summary.

The seedbed for both conservation and conventional tillage wheat plots was prepared by chiseling twice on October 2, 1985. Aroostook winter rye and common rye were seeded as cover crops in the conservation tillage area on October 4, 1985. On March 27, 1986, the cover crops were sprayed with Roundup using a ground-rig sprayer at either 1 pint in 5 gallons water per acre or 2 pints in 10 gallons water per acre. Frigate surfactant was added to the spray at 4 pints per 100 gallons. The rye was resprayed with Roundup on April 9, 1986, due to poor kill-down. Five days after the rye was resprayed (April 14), wheat was seeded into the conservation and conventional tillage plots.

Potato plants emerged in both plots on June 9, 1986. Stands were not different in the conservation or conventional tillage plots (Table 2). Conventional tillage potatoes contained higher nitrate levels and lower phosphate levels than conservation tillage potatoes on several sample dates (Table 1). These differences in petiole nutrient levels do not fully account for the yield differences obtained. The conservation tillage plot produced much higher total and marketable yields than the conventional tillage plot (Table 2). The plants in the conservation tillage area were larger and more vigorous throughout the season. The reasons for these dramatic yield differences are not known.

Aroostook and common rye emerged at the same time and produced good ground cover. The reasons for lack of a good kill-down of the cover crop with the first Roundup application is unknown as spray and weather conditions were good. Wheat seeded directly into the cover crop produced stands which appeared equal to those in conventional tillage.

Three-Year Summary

This three-year study has shown that although either Aroostook or common rye can produce an effective ground cover which reduces wind erosion, the lack of consistent spring kill-down with Roundup continues to be a serious drawback. Potatoes planted in ground under some kind of conservation tillage outyielded the conventional tillage in 2 out of 3 years and averaged 36 cwt/acre higher over this study (Table 3). Tillage deep enough to break up compaction layers, volunteer grain control, and adequate weed control appear to be critical factors in obtaining good yields under conservation tillage.

Although detailed studies were not conducted, soil samples taken in the conservation and conventional tillage plots indicates a possible buildup of organic matter and stratification of potassium in the top 10 inches of the conservation tillage treatment (Table 4). Further studies need to be conducted to confirm this.

*Special thanks to Steve Tonso and Bob Myers for applying conservation tillage treatments; and Ron Miller, Richard Sparks and Merlin Dillon for technical advice.

Table 1. Petiole levels of nitrate and phosphorus in conservation and conventional tillage Centennial Russet potatoes in 1986.

Date	Tillage	NO_3-N (ppm)	PO_4-P (ppm)
7/2	Conservation	20200[a]	1800*
	Conventional	21200	1180
7/17	Conservation	18300	1340*
	Conventional	20300*[b]	1050
7/31	Conservation	15000	790
	Conventional	17500*	750
8/13	Conservation	10000	560
	Conventional	12300*	580

[a] Values are means of 6 samples.
[b] Means are significantly different (P>.95).

Table 2. Stand and yield of conservation and conventional tillage Centennial Russet potatoes in 1986.

Tillage	Stand (Plants/50')	Yield (cwt/acre)[a] Total	Yield (cwt/acre)[a] Marketable
Conservation	49	363.4*[b]	311.8*
Conventional	47	198.6	156.2

[a] Values are means of 6 samples.
[b] Means are significantly different (P>.95).

Table 3. Average yield over three-year period of conservation and conventional Tillage Centennial Russet Potatoes.

Tillage	Yield (cwt/acre) Total	Marketable
Conservation	272.9	211.7
Conventional	236.2	173.1

Table 4. Effect of conservation and conventional tillage on soil nutrient levels and organic matter.

Soil Sample Results		1983	1984	1985
Conservation Tillage (Field 4N)	N(ppm)	8.0	7.0	15.0
	P(ppm)	20.0	16.6	15.8
	K(ppm)	291.0	261.0	240.0
	OM %	1.0	1.2	1.1
Conventional Tillage (Field 4S)	N(ppm)	8.0	6.0	17.0
	P(ppm)	20.0	14.2	16.5
	K(ppm)	291.0	206.0	223.0
	OM %	1.0	0.9	0.9
Conservation Tillage (Field 8N)	N(ppm)	4.0	4.0	7.0
	P(ppm)	12.0	11.6	12.5
	K(ppm)	244.0	320.0	191.0
	OM %	1.0	1.4	0.9
Conventional Tillage (Field 8S)	N(ppm)	4.0	4.0	5.0
	P(ppm)	12.0	14.2	13.5
	K(ppm)	244.0	255.0	173.0
	OM %	1.0	0.9	0.8

ALAR

Russet Burbank and Centennial minitubers were planted at 12 inch spacing on April 30, 1986. On this same date, seedpieces of Russet Burbank obtained from plants sprayed with Alar the previous season were also planted in a separate experiment. The treatments were arranged in a randomized complete block design with 4 replications. The plots were cultivated and hilled on June 2. Prior to planting 60 lbs N/acre and 60 lbs P_2O_5/acre were applied to each row as a band. On June 3, Dual 8E herbicide was applied at a rate of 2 pints/acre to control weeds.

Alar 85 was applied to the plants from minitubers at a rate of 1.8 lbs in 40 gallons of water/acre on 1 of 3 dates. The treatments included were:

1. Alar at tuber initiation (7/9/86);
2. Alar 7 days after tuber initiation (7/16/86);
3. Alar 14 days after tuber initiation (7/23/86);
4. Untreated check.

Alar was applied with an R&D backpack sprayer, two-row boom, LF-3 flat fan nozzles, 40 psi and 2.1 mph walking speed. Dinitro 5B was applied on August 15 to desiccate vines. Plots were harvested by hand on August 25.

The plots were observed for emergence, plant height and stem production. After harvest, data was taken on yield, tuber production, eye number per tuber and length to width ratio.

Alar Replant

Seedpieces from plants sprayed with Alar the previous season emerged slower, but produced stands equal to the check (Figure 1). Seedpieces from plants sprayed 7 or 14 days after tuber initiation had the slowest emergence. These same treatments also tended to increase stem production in plants the following year (Table 1). Seedpieces from plants sprayed with Alar 14 days after tuber initiation produced the highest yields of <4 oz tubers, although total yields were not significantly different among any of the treatments (Table 1). This same treatment increased production of <4 oz tubers. Total tuber production was similar in all treatments. Alar treatment the previous season had no effect on length to width ratio or eye number (Table 1).

Alar on Minitubers

Alar sprayed directly on foliage of plants from minitubers caused no phytotoxicity. Alar did affect plant height and flower production. Plants sprayed with Alar at tuber initiation, or 7 days after tuber initiation, were significantly shorter and produced fewer flowers than the check (Table 2).

Plants sprayed with Alar tended to have the highest yields in all size categories, although yields were not significantly different (Table 2). Plants sprayed with Alar also tended to produce more total tubers per plant (Table 3).

Alar application at tuber initiation or 7 days after tuber initiation significantly affected both tuber shape and eye number. Alar application at these dates increased tuber length and the number of eyes on each tuber (Table 3). Changes in tuber shape and eye number were more pronounced in Russet Burbank than Centennial.

Summary

Alar is a growth regulator which has been registered for increasing production of "seed sized" tubers in Europe. Because minitubers produce mostly single stemmed plants with few tubers, it would be desirable to increase tuber set.

This two-year study has shown that although Alar does tend to increase tuber set of plants from minitubers when applied as a foliar spray near tuber initiation, the increase averages less than 1 tuber per plant. This may not be enough of an increase

to make Alar application a practical method for increasing tuber set of generation seed stocks. Alar application also affects tuber shape and eye number. Emergence and stem production were also altered when seedpieces from plants sprayed with Alar the previous season were planted. Yield and tuber production of subsequent crops was not altered by Alar.

Table 1. Effect of Alar application the previous season on stem production, tuber production, yield, tuber shape and eye number of the subsequent crop.

1985 Alar Application Timing	Stems/ Plant		Yield (cwt/acre) <4 oz	4-10 oz	>10 oz	Total
Tuber initiation (TI)	3.3[1]		79.3	236.2	23.4	338.8
TI + 7 days	3.7		81.2	247.2	32.6	361.0
TI+ 14 days	3.6		95.3	239.2	25.2	359.1
Untreated check	3.3		72.0	251.5	24.0	347.5
LSD(.05)	0.5[3]		18.3	48.0	20.9	50.8
	Length to width	**Eye No. per tuber**	**Tuber No./Plant <4 oz**	**4-10 oz**	**>10 oz**	**Total**
Tuber initiation (TI)	1.86[2]	16.0[2]	3.4[1]	4.5	0.2	8.0
TI + 7 days	1.84	15.6	3.7	4.6	0.3	8.6
TI + 14 days	1.89	16.8	4.2	4.5	0.2	8.9
Untreated check	1.78	15.6	3.1	4.7	0.2	8.0
LSD(.05)	0.16[3]	1.6	0.7	1.0	0.2	1.1

[1] Values are means of 4 replications.
[2] Values are means of 40 tubers.
[3] Means differing by more than LSD value are significantly different (P>.95).

Figure 1. Emergence of Russet Burbank seedpieces as affected by previous season treatment with Alar.

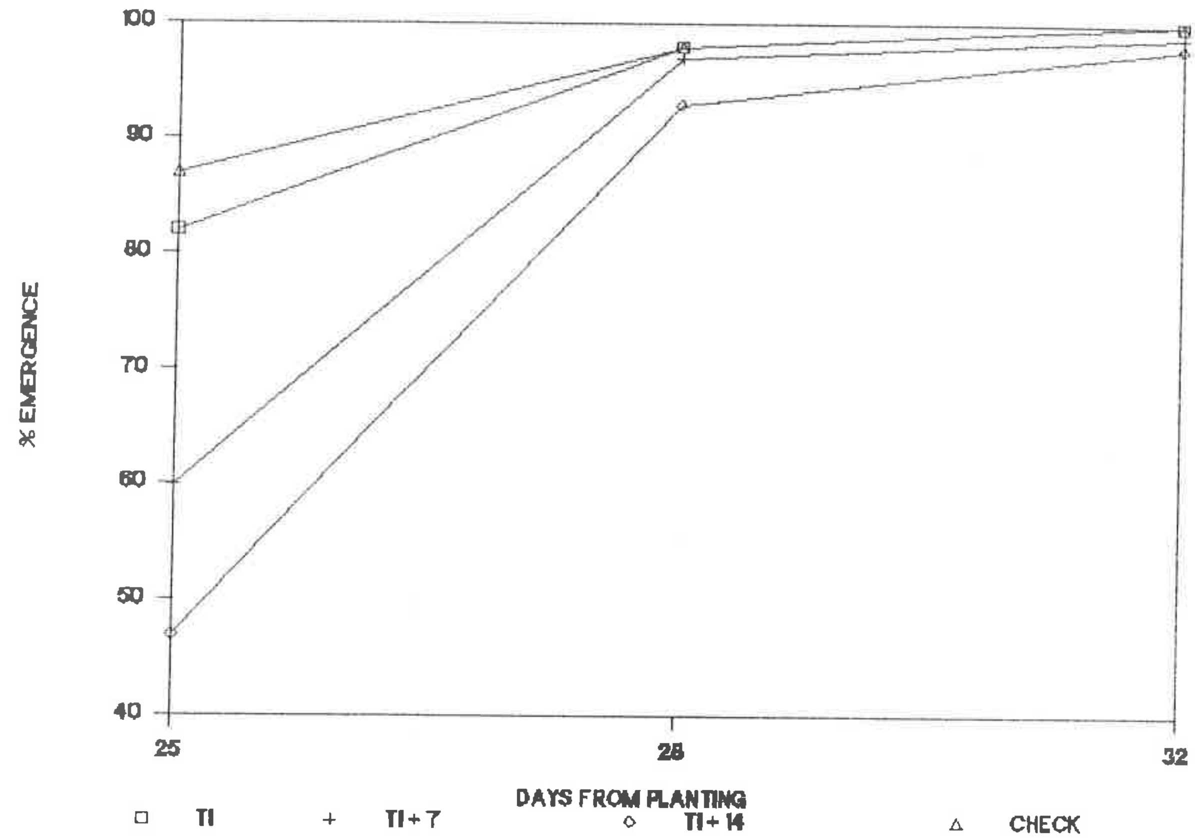


Table 2. Effect of Alar on plant height, flower production and yield of Russet Burbank and Centennial plants from minitubers.

Cultivar	Application Timing	Plant Height(in)	Flowers per plant	----------Yield (cwt/acre)-------- <4 oz	4-10 oz	>10 oz	Total
Russet Burbank	Tuber init.(TI)	15.3[1]	7.8[1]	65.8[2]	75.7	16.0	156.8
	TI + 7 days	15.3	8.0	52.3	98.4	23.4	173.4
	TI + 14 days	16.0	11.0	56.0	94.0	23.4	172.8
	Untreated check	17.3	26.5	49.8	86.1	15.4	150.7
Centennial	Tuber init.(TI)	8.7	0.8	57.8	52.3	0.0	110.1
	TI + 7 days	10.6	0.0	51.7	35.1	0.0	86.0
	TI + 14 days	11.2	0.5	52.3	41.8	4.3	97.8
	Untreated check	11.0	0.0	41.2	44.3	3.7	89.2
Means							
Alar-Tuber initiation (TI)		12.0	4.3	61.5	63.3	8.0	133.4
TI + 7 days		13.0	4.0	52.3	66.4	11.7	129.8
TI + 14 days		13.6	5.8	54.1	67.7	13.5	135.3
Check		14.1	13.3	45.5	64.6	9.8	119.9
LSD(.05)		1.1[3]	6.0	22.9	30.9	9.4	33.7

[1]Values are means of 40 plants.
[2]Values are means of 4 replications.
[3]Treatment means differing by more than LSD value are significantly different (P>.95).

Table 3. Effect of Alar on tuber shape, eye number and tuber production of Russet Burbank and Centennial plants from minitubers.

Cultivar	Application Timing	Length to width	Eye No. per tuber	Tuber No./Plant <4 oz	4-10 oz	>10 oz	Total
Russet	Tuber Initiation (TI)	2.12[1]	19.9[1]	4.4[2]	1.8	0.2	6.3
Burbank	TI + 7 days	2.02	18.7	3.6	2.3	0.3	6.1
	TI + 14 days	1.95	18.7	3.3	1.9	0.2	5.4
	Untreated check	1.93	17.1	3.3	2.1	0.2	5.6
Centennial	Tuber Init (TI)	1.54	7.5	2.9	1.1	0.0	4.0
	TI + 7 days	1.57	6.9	3.2	0.9	0.0	4.1
	TI + 14 days	1.54	7.1	2.7	1.0	0.0	3.6
	Untreated check	1.50	6.9	2.1	1.0	0.0	3.0
Means							
Alar - Tuber Initiation (TI)		1.83	13.7	3.6	1.4	0.1	5.1
	TI + 7 days	1.80	12.8	3.4	1.6	0.1	5.1
	TI + 14 days	1.75	12.9	3.0	1.4	0.1	4.5
	Check	1.71	12.0	2.7	1.5	0.1	4.3
LSD(.05)		0.09[3]	0.7	1.4	0.6	0.1	1.4

[1]Values are means of 40 tubers.
[2]Values are means of 4 replications.
[3]Treatment means differing by more than LSD value are significantly different (P>.95).

MINITUBER SIZE, DEPTH AND DENSITY

Kennebec tubers produced by tissue-culture plantlets grown in the greenhouse (minitubers) were planted at two depths (2 and 4 in) and two in-row spacings (8 and 12 in). The three sizes of minitubers (4-7, 7-21, 21-42g) were planted by hand on May 9, 1986. The 12 treatments were arranged in a randomized complete block design with 4 replications. Each plot consisted of one row, 25 feet long. Either 25 or 37 minitubers were planted in each plot, depending on in-row spacing. Prior to planting 60 lbs/acre each of nitrogen and phosphate were applied as a liquid band to each row. The plots were cultivated and hilled on June 2. Dual 8E herbicide was applied at a rate of 2 pints/acre on June 3 to control weeds.

Plots were observed for rate of emergence, stand and stem production during the season. The plots were sprayed with Dinitro 5B on August 15 to desiccate vines. The plots were harvested by hand on August 25.

Rate of emergence increased with increasing minituber size (Figures 1-3). Almost 100 percent of the large minitubers (21-42g) had emerged within 28 days after planting (Figure 3). The medium sized minitubers (7-21g) reached the same emergence level by 32 days after planting (Figure 2), while the small minitubers (4-7g) did not attain more than 80 percent emergence (Figure 1). Minitubers planted at 4 inch depth tended to emerge sooner than those at 2 inches, although there was no difference in final stand. The slower emergence of minitubers planted at 2 inch depth may be due to larger variation of soil temperature, and soil cooling associated with low night-time temperatures.

Stem production increased with increasing minituber size. Large minitubers produced two more stems per plant than small minitubers (Table 1). Planting depth and in-row spacing had no effect on stem production.

Large minitubers produced the highest yields in all size categories, except >10 oz (Table 1). Large minitubers produced an average of 143 cwt/acre more total yield than small minitubers. Yield of >10 oz tubers was decreased at the 2 inch planting depth, although total yield was not affected (Table 1). Yield of all size classes except >10 oz was highest at the 8 inch in-row spacing. At the 8 inch in-row spacing, there are almost 50 percent more plants per unit area, but yield was only increased by an average of 30 cwt/acre (Table 1).

Tuber production also increased with increasing minituber size (Table 2). Large minitubers produced an average of 1.3 more tubers per plant than small minitubers. Planting depth had no effect on total tuber production, although the number of >10 oz tubers produced was highest at the 4 inch depth (Table 2). The 8 inch in-row spacing produced the fewest tubers on a per plant basis in all size categories (Table 2).

As in 1984 and 1985, minituber size greatly influenced emergence, stem production, tuber production and yield. Large minitubers produce a faster emerging plant, with more stems and higher tuber production and yield. Minitubers planted at 4 inch depth had slightly quicker emergence. However, planting depth had no effect on yield or tuber production. The 8 inch in-row spacing produced the highest yields on an area basis. Tuber production per plant was decreased at this spacing.

Table 1. Effect of minituber size, planting depth and spacing on yield.

Minituber Size (g)	Planting Depth(in)	In-row Spacing(in)	Stems/ Plant	Yield (cwt/acre)			
				<4 oz	4-10 oz.	>10 oz.	Total
4-7	2	8	1.2[1]	40.0	117.5	11.1	167.9
	2	12	1.3	33.8	102.7	33.2	169.7
	4	8	1.3	28.9	109.5	17.2	155.0
	4	12	1.3	31.4	107.6	32.0	170.3
7-21	2	8	2.4	44.9	197.4	42.4	285.3
	2	12	2.1	35.1	173.4	49.2	257.7
	4	8	1.9	39.4	155.0	37.5	231.8
	4	12	2.2	40.0	186.9	36.3	263.2
21-42	2	8	3.4	61.5	262.0	27.1	350.5
	2	12	3.6	52.9	252.7	23.4	329.0
	4	8	3.3	44.9	190.6	26.4	262.0
	4	12	3.7	36.9	211.5	49.2	297.6
LSD (.05)			0.4[2]	12.4	45.3	20.7	50.3
Means							
Size - 4-7g			1.3c[3]	33.2c	108.8c	23.4b	166.0c
7-21g			2.2b	40.0b	178.3b	41.2a	259.5b
21-42g			3.5a	49.2a	229.4a	31.4ab	309.3a
Depth - 2 in			2.2NS[4]	43.0NS	171.6NS	27.1*	241.7NS
4 in			2.4	38.1	172.2	36.9	247.8
Spacing - 8 in			2.3NS	44.9**	184.5*	30.7NS	260.1**
12 in			2.3	36.9	159.9	33.2	230.0

[1]Means of 4 replications.

[2]Means differing by more than LSD value are significantly different (P<.95).

[3]Means followed by different letters are significantly different (P>.95) by LSD test.

[4]Differences are significant at .01, .05, or not significant (**, *, NS) by single degree of freedom f-test.

Table 2. Effect of minituber size, planting depth and spacing on tuber production.

Minituber Size (g)	Planting Depth(in)	In-row Spacing(in)	Tuber No./Plant <4 oz	4-10 oz.	>10 oz.	Total
4-7	2	8	1.9[1]	1.9	0.1	4.0
	2	12	1.8	1.8	0.3	3.9
	4	8	1.8	2.5	0.2	4.6
	4	12	2.2	2.6	0.4	5.1
7-21	2	8	1.6	2.6	0.3	4.4
	2	12	1.2	2.0	0.3	3.5
	4	8	2.3	2.9	0.3	5.5
	4	12	2.3	3.5	0.3	6.0
21-42	2	8	2.0	3.4	0.2	5.6
	2	12	1.8	2.7	0.1	4.6
	4	8	2.4	3.6	0.2	6.1
	4	12	2.0	4.0	0.4	6.3
LSD (.05)			0.6[2]	0.7	0.2	1.0
Means						
Size - 4-7g			1.9a[3]	2.2c	0.2a	4.4b
7-21g			1.9a	2.7b	0.3a	4.8b
21-42g			2.0a	3.4a	0.2a	5.7a
Depth - 2 in			2.0NS[4]	2.8NS	0.2*	5.0NS
4 in			1.9	2.7	0.3	4.9
Spacing - 8 in			1.7**	2.4**	0.2**	4.3**
12 in			2.2	3.2	0.3	5.6

[1]Means of 4 replications.
[2]Means differing by more than LSD value are significantly different (P<.95).
[3]Means followed by different letters are significantly different (P>.95) by LSD test.
[4]Differences are significant at .01, .05, or not significant (**, *, NS) by single degree of freedom f-test.

Figure 1. Emergence rate of 4-7g Kennebec minitubers at two planting depths.

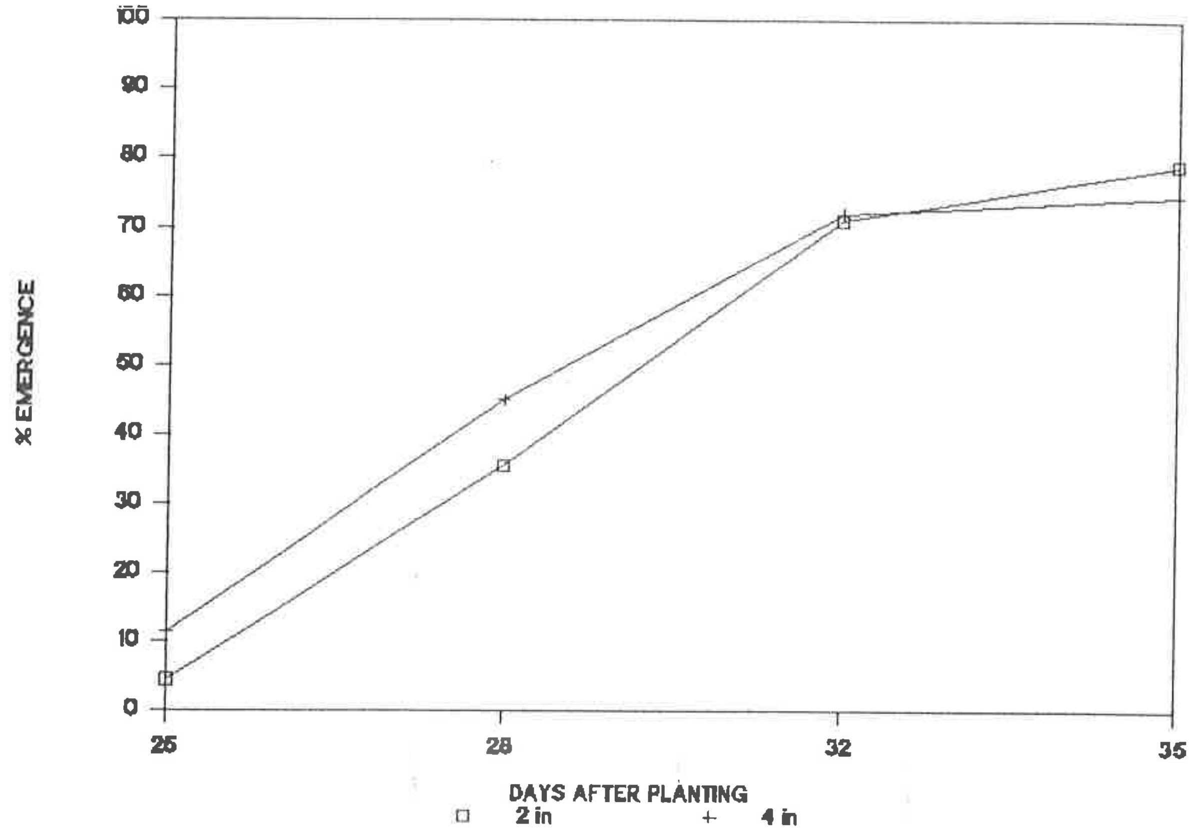


Figure 2. Emergence rate of 7-21g Kennebec minitubers at two planting depths.

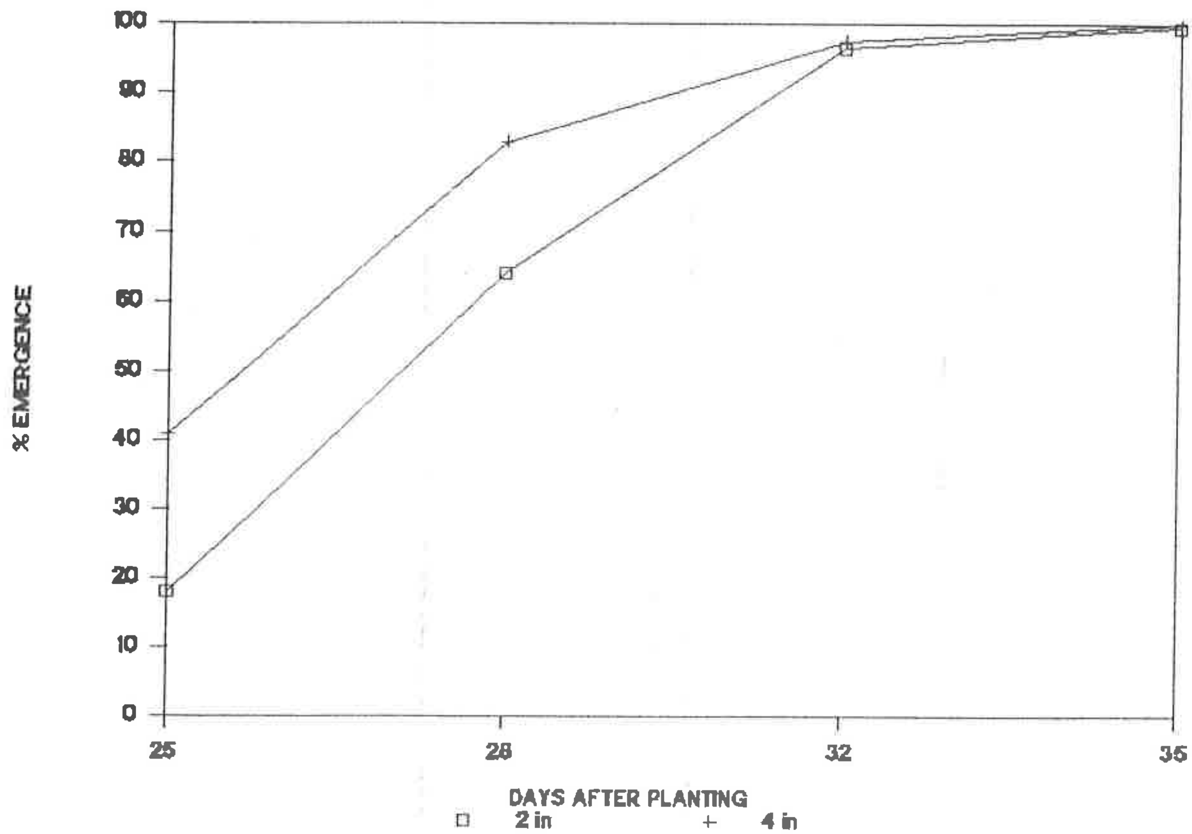
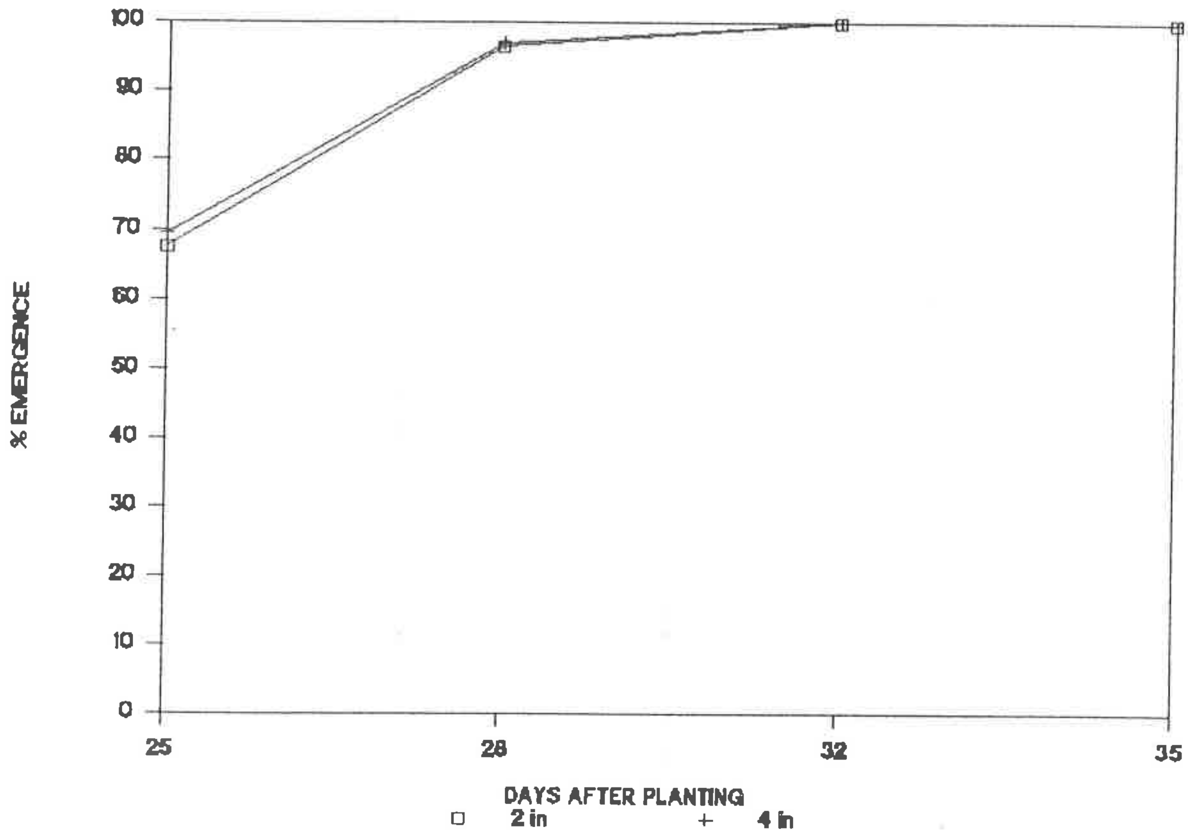


Figure 3. Emergence rate of 21-42g Kennebec minitubers at two planting depths.



MICROPLANT STARTER FERTILIZER

Virus-free Russet Burbank plantlets were rooted in Speedling transplant trays under a water mist system in the greenhouse. After four weeks in the greenhouse, the plantlets were hardened outdoors for one week prior to planting. The plots were planted by hand on June 23, 1986. One cup of starter fertilizer was applied around the base of each plant at planting. Three soluble fertilizers were used to make up starter fertilizers with various P concentrations and N:P ratios. The six treatments were arranged in a randomized complete block design with four replications. Each plot consisted of 25 plantlets, spaced 12 inches apart in the row.

Prior to planting, 140 lbs/acre N and 60 lbs/acre P_2O_5 were applied as a liquid band in each row. Dual 8E herbicide was applied at a rate of 2 pints/acre prior to planting to control weeds. The plots were sprayed with Dinitro 5B to desiccate vines on August 26 and harvested on September 10.

Plantlet survival ranged from 84 to 96% in all plots. Plantlet survival was as high in the check as in the starter fertilizer treatments. Total yield of starter fertilizer treatments tended to be higher than the check (Table 1). The exception was the 20:20:20 fertilizer, which produced the lowest yields. Starter fertilizers with 1000 ppm P_2O_5 or more also tended to produce the highest tuber numbers, although the differences were not significant.

This two-year study has shown a slight but consistent increase in yield and tuber production of plantlets when high phosphorus starter fertilizers are used at transplanting.

Table 1. Effect of fertilizer P concentration on yield, and tuber production of Russet Burbank microplants.

Fertilizer	Phosphate Conc. (ppm)	N:P Ratio	Total Yield(cwt/acre)	Total Tuber No./Plant
Check	0	–	19.1[1]	3.8
20:20:20	500	1:1	13.5	3.9
15:30:15	1000	1:2	27.7	4.5
15:45:5	1500	1:3	32.6	4.4
15:30:15	2000	1:2	28.3	3.8
15:45:5	3000	1:3	27.1	4.4
LSD (.05)[2]			12.3	1.7

[1] Values are means of 4 replications.
[2] Values differing by more than LSD value are significantly different (P>.95).

MICROPLANT SPACING

Virus-free Centennial, Russet Burbank and Sangre plantlets were transplanted from culture jars into Speedling transplant trays and rooted in the greenhouse under a water mist system. After three weeks in the greenhouse, the plantlets were hardened outdoors for one week prior to planting. The plantlets were planted by hand on June 23, 1986, at 3 in-row spacings (4, 8 and 12 inches). Each treatment was replicated four times in plots consisting of one row, 18 feet long. One cup of 15:30:15 soluble fertilizer was applied around each plantlet immediately after planting.

Prior to planting, 140 lbs/acre N and 60 lbs/acre P_2O_5 were applied as a liquid band in each row. Dual 8E herbicide was applied at a rate of 2 pints/acre prior to planting to control weeds. The plots were sprayed with Dinitro 5B to desiccate vines on August 26 and harvested on September 10.

Plantlet survival ranged from 74 to 100%, with Centennial having the lowest survival. Plantlet survival was not influenced by in-row spacing. Total yield tended to increase with decreasing in-row spacing (Table 1). However, both yield and tuber production per plant increased with increasing in-row spacing (Table 1). To optimize tuber production and yield on a per plant basis, large in-row spacings should be used.

Table 1. Yield and tuber production of Centennial, Russet Burbank and Sangre plantlets at 3 in-row spacings.

Cultivar	Spacing (in)	Total Yield (cwt/acre)	Total Yield (lbs/plant)	Tuber No. /Plant
Centennial	4	10.0[1]	0.03	0.9
	8	5.1	0.03	0.8
	12	9.4	0.07	1.4
Russet Burbank	4	42.7	0.10	2.5
	8	41.0	0.18	3.6
	12	37.6	0.24	4.8
Sangre	4	12.8	0.03	2.5
	8	18.8	0.08	3.7
	12	7.7	0.05	2.9
Means				
Cultivars				
Centennial		8.5	0.04	1.0
Russet Burbank		40.1	0.17	3.6
Sangre		12.8	0.05	3.0
Spacings				
4		22.2	0.05	2.0
8		21.4	0.10	2.7
12		17.9	0.12	3.0

[1]Values are means of 4 replications.