POTATO VINE KILL: PULLING, CHEMICAL KILLING AND ROLLING EFFECTS ON YIELD AND QUALITY OF RUSSET BURBANK[1]

J.L. Halderson, L.C. Haderlie and D.L. Corsini[2]

Abstract

Pulling of potato vines in Idaho was compared to three chemical vine killing methods for a period of three years. Rolling was examined alone or in combination with chemicals. Effects on yield, grade, specific gravity and stem-end discoloration of the Russet Burbank variety were determined. Rolling increased desiccation overall by 6% but was not a satisfactory vine kill method when used alone. Pulling reduced yields by 14% compared to control plots and 7% compared to sulfuric acid treatments. Specific gravity was reduced overall by 0.002 for all vine killing treatments compared to the control. Pulling and rolling did not affect the amount of stem-end discoloration.

Introduction

Vine killing is practiced for a number of reasons. Tuber skinning at harvest can be greatly reduced through proper vine kill (14). Vine killing also permits growers to more fully complete scheduled harvesting activities on time, control size of seed potatoes, reduce virus spread by aphids and reduce vine quantity to make harvest easier. A period of two or more weeks is recommended after vine killing before potatoes are dug (12). During this period, tubers loosen from stolons, skin matures and vines decrease in bulk. Because of these factors, vine killing is a recommended practice. Some growers roll vines, either as a single operation to kill vines or as a combined operation with chemical applications. Rolling can crush stems and change the vine canopy so more contact is obtained with vine kill chemicals. Rolling is thought to be more beneficial with slow-killing chemicals than with faster ones. Rolling also tends to seal soil cracks and improves tuber quality through reduced greening.

Previous research suggested that rapid killing of vines, especially of less mature vines, could cause stem-end discoloration (SED) of the tuber (9).

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[2]J.L. Halderson, Associate Research Professor; L.C. Haderlie, Associate Research Professor; and D.L. Corsini, Research Plant Pathologist, USDA-ARS; Research and Extension Center, University of Idaho, Aberdeen, Idaho 83210.
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Vine rolling is a commercial practice in Idaho but performance documentation was not available prior to this study.

Yields of potatoes (*Solanum tuberosum* L. cv. Russet Burbank) have been shown to be primarily affected by length of the growing season (13, 18). Therefore vine killing procedures that are applied while the vines are growing will affect yield to varying degrees. Methods which kill vines rapidly, such as pullers, flails or sulfuric acid, appear to minimize the tuber maturation period while maximizing the length of the growing period (1, 2). Certain studies have shown that early season cultivars need approximately 95 days to reach maximum yield while late season cultivars require about 120 days after planting (19). Regrowth of the plant has occurred in some instances when pullers, flails and chemicals have been used (2, 12). Regrowth can cause serious quality reduction, but vine killing, in general, improves quality (13). Split applications of chemicals or mechanical killing followed by chemical application, have been shown to control regrowth (5, 13). European producers use vine killing more often to control spread of diseases than do U.S. producers (1, 2, 5, 16, 17).

Specific gravity is a major factor in tuber quality. Yield and specific gravity are closely tied together in that a given number of days must elapse after planting before yield and specific gravity will tend to plateau (20). Vine killing procedures, which reduce yield, also appear to reduce specific gravity, but not to the same extent (10, 13, 18, 20). Because pullers remove roots, specific gravity is less predictable than for other vine killing methods.

Tuber stem-end discoloration (SED) appears to be less of a problem with vines that were killed by pullers or slow chemicals compared to rapid chemicals (5, 10, 15). Sometimes cut vines have shown more SED than slow chemicals (3) but other tests have shown all forms of mechanical vine killing, applied at various stages of vine maturity, to be unrelated to increased SED (6). Most researchers agree that less mature vines tend to have more SED and that vines which are killed more rapidly tend to have more SED (3, 9, 18). Soil moisture content at vine killing time may or may not influence SED (4, 6).

Because of the sometimes contradictory results obtained in the above noted reports, a comprehensive vine kill study was initiated. This study was conducted to determine: 1) the effects of vine kill speed on tuber yield and quality, and 2) the effects of vine rolling on the desiccation rate. Characteristics measured were: yield, grade, specific gravity, stem-end discoloration, leafroll net necrosis, rate of desiccation and seedpiece vigor. Data for yield, grade, and specific gravity are discussed in this report. Stem-end discoloration effects are discussed in another report (8) while performance of the chemicals used to kill vines is discussed in a third report (7). Seedpiece vigor studies are not complete at this time.

Materials and Methods

In this study, mechanical vine killing was conducted in two ways: a) hand pulling and b) hand cutting at the soil surface. Chemical vine killers included sulfuric acid, dinoseb, diquat and endothall. These chemicals were chosen to provide a range of desiccation speeds from fast to slow, respectively. The research also included several vine rolling treatments where weight per row of the roller was varied. Two ages of vines were provided by plantings which were 30 to 40 days apart.

Experimental Design—The effects of five vine kill treatments were studied in a randomized complete block design with four replications over a three-year period. The effects of field differences between blocks was separated from the treatment effects by a two-way analysis of variance. Rolling of vines as the main treatment was tested for two years in a split-plot design with vine killing as subtreatments.

Experimental Procedure—Russet Burbank cut seed was planted in rows 91 cm apart at several Idaho sites—Tetonia, Shelley, Aberdeen and Kimberly in 1981; Shelley, Aberdeen and Kimberly in 1982; and Aberdeen and Kimberly in 1983. Two planting dates were used at Aberdeen in 1981 and at all locations in 1982 and 1983. Normal (early) planting dates varied depending upon the sites. The early planting date at Aberdeen and Shelley was the last week of April or the first week of May, Kimberly was about one week earlier, and Tetonia about four weeks later. Single planting dates in 1981 were comparable to the early planted dates in subsequent years. All plots were four rows wide (91 cm) by 18 m in length. Cultural practices were standard for producing high yield and quality. Seed was stored at 4 C between early and late plantings.

Vine rolling and killing treatments were applied when one of the following two conditions developed: 1) when vine death from disease became evident, treatments were applied before 10% of the vines died (desiccated), or 2) green vines were killed in early-September to allow two to three weeks of tuber maturation before harvest.

Vines were rolled with a three-point hitch-mounted, two-row roller at zero and 160 kg/row weight in 1982 and zero, 204 and 300 kg/row in 1983. No rolling treatment was used in 1981.

Chemicals were applied with a four-row, tractor-mounted boom sprayer at 164 l/ha and 207 KPa except in 1981 when the volume was 328 l/ha. Sulfuric acid was applied as 93% concentrate at a rate of 88 kg (sulfur equivalent)/ha, dinoseb at 2.5 kg/ha, diquat at 0.28 kg/ha, and endothall at 1.1 kg/ha. Herbimax[1] oil was used with dinoseb and X-77[2] with diquat at approximately 1% by volume. Vines were visually rated for percent desiccation at several time intervals after rolling and chemical application.

[1]Crop oil concentrate, Loveland Industries, Inc., Loveland, CO.
[2]Non-ionic surfactant from Ortho, Chevron Chemical Co., San Francisco, CA.

Tubers were lifted with a two-row level bed digger and dropped on the soil surface directly behind the digger. The two center rows of each four-row plot were harvested. Potatoes were picked by hand and placed into burlap bags until approximately 35 kg were obtained from each plot. Harvested row length was measured for yield determination purposes. Tubers were stored at approximately 6 C until early December when grading was done. At grading time, potatoes were sorted to determine undersized, malformed and U.S. No. 1's by weight. Measurements were made for specific gravity (water immersion method), and fifty tubers from the No. 1 lot were cut on the stem end to determine discoloration.

Bulking rates were determined by computing the three-year average yield increase for the control compared to the pulled treatment from the time from vine killing treatment to harvest.

Results and Discussion

Total Yield and Grade—There were no significant differences in total yield due to any vine killing treatments in 1981 (Table 1). Results for 1981 are shown for data pooled for each treatment at Kimberly, Aberdeen, Shelley and Tetonia (Table 1). Total yield was affected by the vine killing treatments for both the early and late planted potatoes in 1982 and 1983 (Table 1). Rolling had no effect on yield and grade in 1983. Vine killing treatments were applied over a wide range of temperatures during the three years while soil moisture at vine killing time was never deficient.

A trend existed for lower yields, except for diquat, as vine kill speed increased for all combinations of vine age, years and locations. The control averaged 14% more total yield than the pulled treatment, 8% more than diquat, 7% more than sulfuric acid and 4% more than dinoseb when combined over years and locations (Table 2). No evident explanation exists for yield results from the diquat treatment. Higher yields were expected with less rapid desiccants, such as diquat, than for more rapid methods.

Typical bulking rates (daily increase in total yield) for this area have been shown to be approximately 580 kg/ha/day at the first of September and zero by mid-September (11). Vines were killed in these experiments as early as 24 August and as late as 16 September. The calculated average for three years for bulking rate, between the pulled treatment at vine kill and the control treatment at harvest, was 425 kg/ha/day, which is somewhat higher than expected. Total yield differences due to treatments are, therefore, somewhat higher than normal.

The number of growing days, from planting to treatment application, ranged from 76 days to 142 days for the three years. As would be expected, the percentage of No. 1 potatoes, as a portion of total yield, decreased markedly as the length of the growing season decreased (Table 1). The highest overall percentage of No. 1's (64.5%, Table 2) was obtained with

TABLE 1. — *Total yield and percent No. 1's following vine killing treatments of early-planted and late planted Russet Burbank potatoes.*[1,2]

Treatment	1981 Not Rolled Early Planted Total Yield mt/ha	1981 Not Rolled Early Planted % 1's	1982 Rolled Early Planted Total Yield mt/ha	1982 Rolled Early Planted % 1's	1982 Rolled Late Planted Total Yield mt/ha	1982 Rolled Late Planted % 1's
Control	28.2	66	41.0	61	29.8	56
Dinoseb	27.2	68	41.0	58	29.0	54
Diquat	28.0†	64†	38.0	56	26.8	51
Sulfuric acid	26.3	63	39.2	58	27.7	51
Pulled	25.9	65	36.1	54	25.8	50
Cut	25.5	65	*	*	*	*
LSD (P=0.05)	n.s.	n.s.	3.8	3	2.1	3

Treatment	1983 Not Rolled Early Planted Total Yield mt/ha	1983 Not Rolled Early Planted % 1's	1983 Not Rolled Late Planted Total Yield mt/ha	1983 Not Rolled Late Planted % 1's	1983 Rolled Early Planted Total Yield mt/ha	1983 Rolled Early Planted % 1's	1983 Rolled Late Planted Total Yield mt/ha	1983 Rolled Late Planted % 1's
Control	38.6	66	23.4	35	43.1	65	20.3	32
Dinoseb	39.3	65	18.8	22	41.9	67	17.6	22
Diquat	35.7	61	19.3	23	41.4†	66†	18.1†	25†
Sulfuric acid	38.1	66	18.0	19	41.9	66	17.7	23
Pulled	34.2	64	16.5	21	*	*	*	*
LSD (P=0.05)	4.8	n.s.	1.9	6	n.s.	n.s.	1.8	6

[1]Summarized over location
[2]For vine age see reference (8)
†Endothall
*No reading

TABLE 2. — *Total yield and % No. 1's following vine killing treatments of early-planted and late-planted Russet Burbank potatoes when combined over three years and several sites.*

Treatment	Early Planted Total Yield mt/ha	Early Planted % 1's	Late Planted Total Yield mt/ha	Late Planted % 1's
Control	37.8	64	24.5	41
Dinoseb	37.8	64	21.8	33
Diquat	35.8	62	21.4	33
Sulfuric acid	36.4	63	21.1	31
Pulled	32.1	61	21.1	35

dinoseb and the control treatments on the early planted plots. The pulled treatment had the lowest average percentage of No. 1's for early planted potatoes (61%) but had the highest average, excluding the control, for late planted potatoes (35.5%, Table 2). Pullers are not recommended at this time for a commercial crop.

Specific Gravity—The control tended to have the highest overall specific gravity (highly significant at some locations) for both early and late planted potatoes (Table 3). Of the other treatments used, pulling tended to have higher specific gravity when means were combined. This response was highly significant at some locations. The removal of roots in the pulling operation might be responsible because additional tuber moisture uptake is precluded. Tubers from vines killed with sulfuric acid and dinoseb tended, overall, to have the lowest specific gravity. Location affected specific gravity but not in a pattern that was consistent from year to year.

TABLE 3. — *Specific gravity of Russet Burbank tubers following various vine killing treatments. Data are averages of several locations.*

	1981		1982	
Treatment	Early Planted	Late Planted	Early Planted	Late Planted
Control	1.086	1.079	1.085	1.082
Dinoseb	1.082	1.078	1.082	1.078
Diquat	1.083†	1.080†	1.083	1.079
Sulfuric acid	1.081	1.080	1.082	1.077
Pulled	1.084	1.086	1.082	1.078
Cut	1.081	1.077	*	*
LSD (P = 0.05)	0.002	0.006	0.002	0.003

†Endothall
*No reading

Rolling—There were trends toward increased vine desiccation when rolling was used with subsequent chemical treatments but results were often not significant (Table 4) when locational variations were considered. Over all treatments, rolling increased desiccation by 6% at four days after treatment (7). The largest desiccation increase from rolling (16%) occurred with immature vines which were subsequently killed with chemicals. This result might suggest that rolling improves the uniformity of chemical coverage when the vine canopy is disturbed. When used as a sole vine killing procedure, rolling was more effective on mature vines. Rolling is only recommended as an aid to chemical treatments because it provides inadequate desiccation when used alone.

Total yield was not significantly affected by rolling alone but several rolling interactions (location by rolling, treatment by rolling) did reduce total yield. Consistent trends were observed toward less yield when vines were rolled but this response is most probably due indirectly to increased

TABLE 4. — *Vine desiccation rates of stems and leaves four days after vine rolling and chemical treatments.*

Location	Planting Date	Percent desiccation 1982 Rolled[1]	1982 Not Rolled	1983 Rolled	1983 Not Rolled
Aberdeen	Early	87	76	94	94
	Late	76	76	67	53
Kimberly	Early	54	52	76	72
	Late	56	54	64	60
Shelley	Early	70	69	*	*
	Late	55	54	*	*
LSD (P = 0.05)	Early	9		5	
	Late	4		7	
Combined means	Early	70	66	85	83
	Late	62	61	66	57

[1]Roller weight of 160 kg/row in 1982, 300 kg/row in 1983
*No reading

desiccation from rolling. Rolling did not affect specific gravity for any treatment combinations within these experiments.

Since the vine desiccation rate is increased with more effective vine killing methods, the tuber maturation period following vine kill could likely be reduced. Yields and specific gravity might also be increased by killing vines later with more rapid methods.

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