CULTIVAR AND SEEDPIECE SPACING EFFECTS ON POTATO COMPETITIVENESS WITH WEEDS[1]

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Abstract

Field studies were conducted in 1991 and 1992 to evaluate the effects of cultivar, row spacing, and within-row spacing on potato yield and quality under weedy and weed-free conditions. Cultivars tested were Russet Burbank, an indeterminate, large-vined cultivar, and Frontier Russet, a determinate, small-vined cultivar. The two cultivars were grown under weedy and weed-free conditions with either 76 or 91 cm row spacings in factorial combination with either 15, 25, or 35 cm within-row spacings. The major competitive weeds were redroot pigweed, common lambsquarter and hairy nightshade. The weedy plots consistently produced less vine and tuber biomass and less total and U.S. No. 1 tuber yield than the weed-free plots. The time of weed emergence strongly affected potato competitiveness with weeds. In 1991, weeds emerged after potatoes, giving the crop some competitive advantage. In 1992, weeds emerged before the potatoes, resulting in heavy competition and large decreases in vine and tuber production for both cultivars. Reductions in U.S. No. 1 tuber yield were proportionally greater than the reductions in total yield. Weedy plots in 1991 and 1992 produced 25% and 68% less total yield and 43% and 92% less U.S. No. 1 yield, respectively, than weed-free plots. Russet Burbank was more competitive with weeds than Frontier Russet. Frontier Russet suffered substantial losses in productivity due to the presence of weeds, even under moderate weed pressure in 1991. Decreasing the row width from 91 to 76 cm did not provide a competitive advantage for potatoes as measured by vine or tuber biomass, or tuber yield. Decreasing within-row spacing under weedy conditions provided some competitive advantage and resulted in higher vine and tuber biomass and greater total tuber yield. The closer within-row spacing resulted in a substantial decrease in U.S. No. 1 yield with Russet Burbank but a slight increase with Frontier Russet. There were several significant interactions involving cultivar, weed level, and within-row spacing. These were due, in part, to each cultivar's unique response to inter-and intra-species competition. Cultivar had a greater influence on competitiveness than any plant spatial arrangement.

[1]Paper No. 93766 of the Idaho Agricultural Experiment Station.

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Accepted for publication December 9, 1994.

ADDITIONAL KEY WORDS: *Solanum tuberosum*, plant population, redroot pigweed, common lambsquarter, hairy nightshade.

Compendio

En 1991 y 1992, se condujeron estudios de campo para evaluar los efectos del cultivar, y del espaciamiento entre surcos y entre semillas sobre el rendimiento y la calidad de la papa en presencia y ausencia de malezas. Los cultivares probados fueron Russet Burbank, un cultivar indeterminado de gran follaje, y Frontier Russet, un cultivar determinado de pequeño follaje. Los dos cultivares fueron mantenidos en presencia y en ausencia de malezas, con 76 o 91 cm entre surcos, en una combinación factorial con 15, 25 o 35 cm entre semillas. Las principales malezas competidoras fueron el amaranto verde (*Amaranthus retroflexus*), el quenopodio común (*Chenopodium album*) y la hierba mora velluda (*Solanum sp.*). Las parcelas con malezas produjeron consistentemente un menor follaje y biomasa de tubérculos y un menor rendimiento total y de tubérculos U.S. No. 1 que las parcelas sin malezas. El momento de emergencia de las malezas afectó fuertemente la competencia de la papa con las mismas. En 1991, las malezas emergieron después de las papas, dando al cultivo cierta ventaja de competencia. En 1992, las malezas emergieron antes que las papas, dando lugar a una fuerte competencia y gran reducción en el follaje y en la producción de tubérculos de ambos cultivares. Las reducciones en los rendimientos de tubérculos U.S. No. 1 fueron proporcionalmente mayores que las reducciones en los rendimiento totales. En 1991 y 1992, las parcelas con malezas produjeron rendimientos totales 25% y 68% menores, y 43% y 92% menos en tubérculos U.S. No. 1 que las parcelas libres de malezas, respectivamente. Al competir con las malezas. Russet Burbank fue mejor que Frontier Burbank. Frontier Burbank sufrió pérdidas considerables en productividad debido a la presencia de las malezas, incluso bajo una presión moderada de éstas en 1991. Disminuyendo el ancho del surco de 91 a 76 cm no se logró para las papas ventaja alguna de competencia, usando como medida el desarrollo del follaje o la biomasa de tubérculos, o el rendimiento total. La disminución del espacio entre semillas dentro del surco, bajo la presencia de malezas, proveyó cierta ventaja de competencia dando por resultado un mayor follaje y una mayor biomasa de tubérculos, así como también un mayor rendimiento total. Cuanto menor fue el espacio entre semillas dentro del surco, sustancialmente menor fue el rendimiento de Russet Burbank en tubérculos U.S. No. 1, pero para Frontier Burbank hubo un pequeño incremento. Hubo varias interacciones significativas incluyendo al cultivar, nivel de malezas y espacio entre semillas dentro del surco. Estas se debieron, en parte, a la respuesta particular de cada cultivar a la competencia entre y dentro de las especies. El cultivar tuvo una mayor influencia sobre la competencia que cualquier arreglo de espacio de las plantas.

Introduction

Weeds infesting potato fields are most commonly controlled with a combination of herbicides and cultivation. Recently, agriculture has experienced an increased emphasis on sustainable practices and a decreased emphasis on pesticide usage. Herbicide use may be reduced if a more competitive potato cropping system can be developed. Manipulation of plant density may contribute to potato competitiveness with weeds. Planting density influences yield and many quality characteristics such as tuber size and grade (1, 5, 13, 17).

Previous research has shown that cultivars of several crops including peanut (2), white bean (8), small grains, (3, 14), and sugar beets (6) can differ greatly in their ability to compete with weeds. Varietal differences in competitiveness were attributed to plant height, leaf area, growth habit, and duration of vegetation. Richards (14) reported that wheat cultivars that produced rapid, early ground cover were more competitive with weeds than slower growing cultivars. Similarly, Lotz *et al.* (6) found that rapid ground cover was an important factor in sugar beet competitiveness with late emerging weeds. Low growing sugar beet cultivars with prostrate leaves were more competitive than tall, upright cultivars.

Malik *et al.* (8) compared weed competitiveness of three dry bean cultivars planted at different row widths and seeding rates. Any combination of cultivar and planting density that increased the leaf area index improved the ability of the crop to compete with weeds. Increasing plant density under weed-free conditions did not increase seed yield, whereas under weedy conditions, higher crop density resulted in a 16 percent increase in yield.

Only limited research has been conducted on potato competitiveness with weeds (11, 16, 18, 19). On muck soils in Michigan, Russet Burbank was more competitive with weeds than Atlantic (18). However, on mineral soils, when the seed-piece spacing of Atlantic was reduced to 21 cm, it was more competitive than Russet Burbank grown at 31 cm. The major difference between the growth characteristics of the cultivars was higher vine biomass for Russet Burbank. In North Dakota, the early small-vined cultivar Red Norland was less competitive with weeds than the late large-vined cultivar Red Pontiac (11). With Red Pontiac, a single cultivation with one application of herbicide provided good weed control, while with Red Norland it did not. In studies in New York, cultivars that emerged early, had rapid early growth, and maintained a dense canopy throughout the growing season were more competitive with weeds than later emerging, slower growing cultivars (19).

Manipulation of plant density has not been investigated in potatoes with the goal of improving potato competitiveness with weeds. The objective of this study was to compare the yield, quality, and competitive ability of two potato cultivars when grown using different combinations of row widths and within-row spacings under weedy and weed-free conditions.

Materials and Methods

Field studies were conducted in 1991 and 1992 at the University of Idaho Research and Extension Center at Aberdeen. Plots were established on a

TABLE 1.—*Agronomic and environmental information for the studies conducted at Aberdeen, Idaho, in 1991 and 1992.*

Item	1991	1992
Soil Type	Silt Loam (pH 8.2)	Silt loam (pH 8.3)
Fertilizer (kg/ha)[1]		
Nitrogen	200	245
Phosphorus	95	115
Potassium	40	40
Irrigation Type[2]	Sprinkler	Sprinkler
Dates		
Planting	29 May	14 May
Weed biomass samples		
Early	15-16 July	10-11 July
Late	15-16 Aug	20-21 Aug
Potato Biomass Sample[3]	29 Aug	3 Aug
Final Harvest	7 Oct	5 Oct
Average Air Temperature (C)[4]		
High	22	26
Low	5	6
Rainfall in May (cm)	7.0	0.0

[1]Fertilized according to University of Idaho recommendations (8).
[2]Available soil moisture in the upper 45 cm was maintained above 65% throughout the growing season.
[3]Dates corresponded with the approximate time of maximum vine mass for the potato plants.
[4]Averaged for the first two weeks after planting.

Declo silt loam soil (coarse-loamy, mixed, mesic Xerollic Calciorthid) in fields that had previously been cropped to wheat. Cultivars tested were Russet Burbank, the standard cultivar grown in the Pacific Northwest, and Frontier Russet, a new early russet cultivar. Russet Burbank produces vigorous vine growth, is indeterminate, and late maturing. Frontier Russet produces considerably less vine growth than Russet Burbank, is determinate, and early to medium maturing. Russet Burbank typically outyields Frontier Russet in total tuber production but produces less U.S. No. 1 tuber yield. Frontier Russet has many characteristics desirable for sustainable production such as lower fertilizer demand and less sensitivity to fluctuations in soil moisture.

The experiment was arranged in a split-split plot design with weed treatments (weedy or weed-free) as main plots, row spacings (76 or 91 cm) as subplots, and a factorial arrangement of cultivar by within-row spacings (15, 25, or 35 cm) as sub-subplots, with five replications. Individual sub-subplots were four rows wide (3.0 or 3.6 m) and 18.3 m long. Plot management and environmental information for the two years is shown in Table 1.

Certified seed potatoes of the two cultivars were used for the study. To facilitate planting, furrows were opened with tractor-mounted shovels spaced at 76 or 91 cm intervals. Seed pieces of the two cultivars were then hand planted at 15, 25, or 35 cm within-row spacings. The furrows were subsequently closed by offsetting the shovels and repeating the operation.

Weed-free plots received a preemergence herbicide application (metribuzin at 0.35 kg a.i./ha and metolachlor at 2.2 kg a.i./ha) to assist with weed control. Occasional hand weeding was still required to keep the plots completely weed-free. No injury symptoms or growth differences were observed in the herbicide treated plots in comparison with the weedy plots. The major competitive weeds in the weedy plots were redroot pigweed (*Amaranthus retroflexus* L.), common lambsquarter (*Chenopodium album* L.), and hairy nightshade (*Solanum sarrachoides* L.). Weed densities in 1991, by species, were hairy nightshade 10.4/m^2, common lambsquarter 3.2/m^2, and redroot pigweed 140.0/m^2 with a total density of 153.6/m^2. In 1992, the total weed density was similar to 1991 with 154.4/m^2. The ratio of the three major weeds was different with densities of 83.2/m^2 for hairy nightshade, 16.8/m^2 for common lambsquarter, and 54.4/m^2 for redroot pigweed.

Above ground weed biomass was measured from two 0.25 m^2 quadrats/plot before row closure and again during late tuber bulking. Total dry weed biomass was determined after drying the samples at 65 C for two days. Potato tubers and vines were harvested from a 1.5 m section of one of the middle two rows in each plot. Total vine and tuber dry weights were determined by either drying the entire fresh sample at 65 C for two days, or by multiplying the total sample fresh weight by the percent dry matter of a 300 to 600 g subsample. Biomass was expressed as dry matter produced per m^2. Final tuber yield and grade were determined following machine harvesting of 9.0 m sections from each of the middle two rows in each plot. Specific gravities were determined for a 3 kg sample of U.S. No. 1 tubers using the weight-in-air/weight-in-water method (4).

Data analyses were completed using the PROC ANOVA program of SAS (15). The initial analysis incorporated a data set combined over years. The presence of significant interactions involving year made it more appropriate to analyze each year separately. Both main and interaction effects were computed and the main effect means separated using the least significant difference (LSD) method.

Results and Discussion

The 1991 and 1992 growing seasons were distinctly different, providing unique treatment responses for each year of the study. Total weed biomass was much less in 1991 than in 1992 (Table 2), even though total weed numbers at row closure were similar each year. In 1991, the major competitive weeds (redroot pigweed, common lambsquarter, and hairy nightshade)

TABLE 2.—*Weed biomass on August 15-16, 1991 and August 20-21, 1992 as affected by cultivar, row spacing and within-row spacing.*

	Weed biomass[1]	
Treatment	1991	1992
	g dry wt./m²	
Cultivar		
Russet Burbank	141 A	1180 A
Frontier Russet	726 B	1412 B
Row spacing		
76 cm	386 A	1304 A
91 cm	480 A	1288 A
Within-row spacing		
15 cm	384 A	1176 A
25 cm	398 A	1271 A
35 cm	518 A	1442 A

[1] Within a given treatment variable, means in a column followed by the same letter are not significantly different at p=0.05.

emerged after the potatoes, giving the crop some competitive advantage. In 1992, weeds emerged before the potatoes, giving a competitive advantage to the weeds. The spring of 1992 was unusually warm and dry. Potatoes had to be irrigated immediately after planting, which provided ideal conditions for weed growth.

With respect to the weed growth, Russet Burbank was more competitive than Frontier Russet in both years of the study. Weed biomass was 81% less (141 vs 726 g/m^2) in Russet Burbank than in Frontier Russet plots in 1991 and 16% less (1180 vs 1412 g/m^2) in 1992 (Table 2). Similar results were reported by Nelson and Giles (11) who found that Red Norland, an early maturing, determinate potato cultivar, was less competitive with weeds than Red Pontiac, an indeterminate cultivar. Changes in plant population did not have a statistically significant (p=.05) impact on weed biomass in either year of the study (Table 2). Decreasing the row spacing from 91 to 76 cm did not affect weed biomass. Decreasing the within-row spacing of potatoes tended to decrease weed biomass in both years, although the treatment means were not significantly different (p=.05) (Table 2).

A summary of analysis of variance for vine biomass, tuber biomass, total tuber yield, and U.S. No. 1 tuber yield is presented in Table 3. Weed

TABLE 3.—*Mean squares from the analysis of variance for vine biomass, tuber biomass, total tuber yield, and U.S. No. 1 tuber yield as influenced by weed level, row spacing, and cultivar.*

Source	Vine Biomass (gm/m²)		Tuber Biomass (gm/m²)		Total Tuber Yield (t/ha)		U.S. No. 1 Tuber Yield (t/ha)	
	1991	1992	1991	1992	1991	1992	1991	1992
Weed Level (W)	51101 **	819210 **	732488 **	3084550 **	197394 **	2004292 **	188887 **	1262328 **
Row Spacing(R)	450 NS	354 NS	355470 **	111 NS	7743 NS	90 NS	3001 NS	3943 NS
Within-Row Spacing (WI)	22331 **	71561 **	337734 **	288215 **	57240 **	66848 **	1473 NS	1931 *
Cultivar (C)	61653 **	336056 **	1224730 **	8609 NS	428940 **	196819 **	9908 **	15622 **
W x R	14 NS	503 NS	39938 NS	6075 NS	894 NS	511 NS	1399 NS	4587 NS
WI x C	6317 *	2025 NS	109358 **	11915 NS	3200 *	925 NS	15572 **	1137 NS
W x WI	8097 *	22643 **	74271 *	12534 NS	278 NS	2287 NS	414 NS	1347 NS
W x C	38396 **	1485 NS	692993 **	264333 **	56010 **	17936 **	68757 **	56463 **
R x WI	3659 NS	2241 NS	5865 NS	5711 NS	807 NS	1071 NS	451 NS	193 NS
R x C	81 NS	9 NS	554 NS	6602 NS	2465 NS	224 NS	10409 **	534 NS
W x R x WI	7406 *	707 NS	8563 NS	3238 NS	2079 NS	1245 NS	780 NS	1113 NS
W x R x C	9513 *	1190 NS	8781 NS	7028 NS	79 NS	463 NS	922 NS	617 NS
W x WI x C	2745 NS	19491 **	4474 NS	8624 NS	1 NS	8429 **	784 NS	4833 **
R x WI x C	211 NS	108 NS	22446 NS	6769 NS	1245 NS	71 NS	291 NS	258 NS
W x R x WI x C	611 NS	2140 NS	36433 NS	29179 NS	43 NS	3076 *	275 NS	366 NS

[1] NS, *, ** = Not significant, or significant at the .05 or .01 levels, respectively.

TABLE 4.—*Main effect means for vine biomass, tuber biomass, total tuber yield, and U.S. No. 1 tuber yield in 1991 and 1992.*

Main Effect	Vine Biomass 1991	Vine Biomass 1992	Tuber Biomass 1991	Tuber Biomass 1992	Total Yield 1991	Total Yield 1992	U.S. No. 1 Yield 1991	U.S. No. 1 Yield 1992
	----- gm/m² DW -----				-------- t/ha --------			
Weed Level								
Weedy	144	134	588	236	27.3	13.7	11.8	2.4
Weed-Free	186	300	745	556	36.4	42.7	20.6	25.3
LSD (.05)	21	54	45	46	1.9	0.9	1.7	1.6
Cultivar								
Frontier Russet	142	164	566	387	25.1	23.7	15.2	15.1
Russet Burbank	188	270	768	404	38.5	32.7	17.2	12.6
LSD (.05)	16	20	48	NS	1.1	1.1	1.0	1.0
Row Width								
76 cm	167	215	721	395	32.7	28.1	15.7	13.2
91 cm	163	219	612	397	30.9	28.3	16.8	14.5
LSD (.05)	NS	NS	23	NS	NS	NS	NS	NS
Within-Row Spacing								
15 cm	191	265	771	485	36.1	33.1	15.5	14.5
25 cm	158	203	630	386	31.7	27.5	16.9	14.1
35 cm	146	184	599	317	27.7	24.0	16.3	13.0
LSD (.05)	19	25	59	46	1.4	1.4	NS	1.2

level, within-row spacing, and cultivar effects generally were significant. Row-spacing effects generally were not significant. The within-row spacing by cultivar interactions were significant for all four variables in 1991 but not in 1992. The weed level by within-row spacing interactions were significant for vine biomass and for tuber biomass (in 1991), but not for tuber yield variables. The weed level by cultivar interactions were generally significant. The weed level by within-row spacing by cultivar interactions were generally significant in 1992. All other interactions were largely not significant.

Table 4 summarizes the main effect means for vine and tuber biomass and for total and U.S. No. 1 yield. The presence of weeds caused reductions in all four measures of productivity. Reductions resulting from weed competition were greater in 1992 than in 1991. Averaged across both cultivars, the presence of weeds caused a 23% reduction (from 186 to 144 g/m^2) in vine biomass in 1991 and a 55% reduction (from 300 to 134 g/m^2)

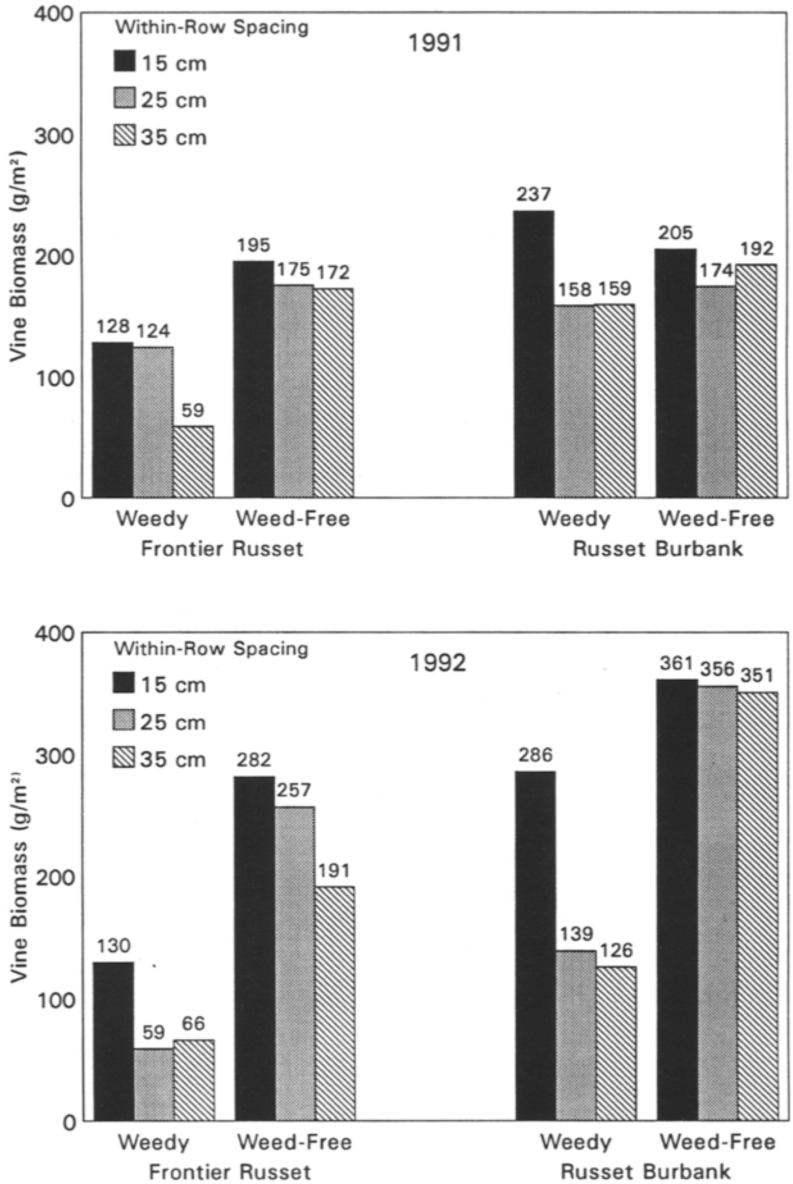

FIG. 1. Vine biomass in 1991 and 1992 of Frontier Russet and Russet Burbank potatoes under weedy and weed-free conditions and a within-row seed-piece spacing of 15, 25, or 35 cm. In 1991 weed pressure was light to moderate, while in 1992 it was severe.

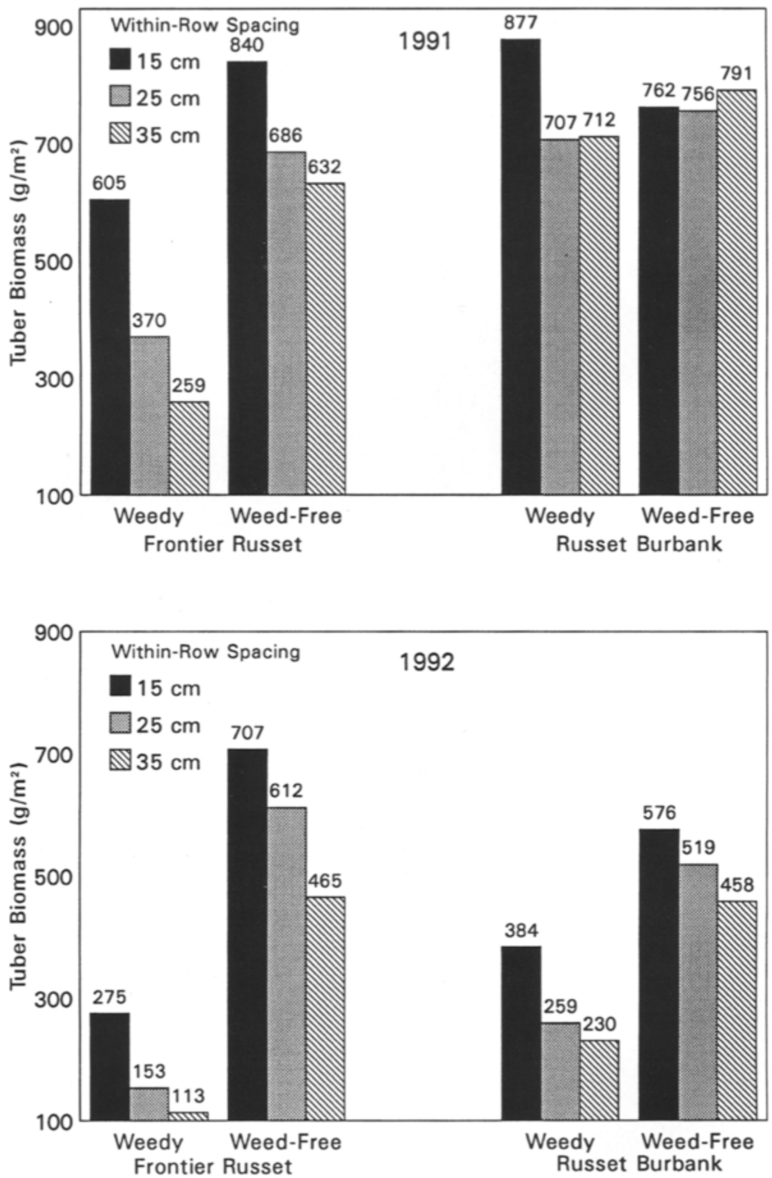

FIG. 2. Tuber biomass in 1991 and 1992 of Frontier Russet and Russet Burbank potatoes under weedy and weed-free conditions and a within-row seed-piece spacing of 15, 25, or 35 cm. In 1991 weed pressure was light to moderate, while in 1992 it was severe.

in 1992. Similar reductions occurred for tuber biomass and total tuber yield. Comparatively greater reductions occurred for U.S. No. 1 yield due to the predominance of small sized tubers produced under weedy conditions.

When averaged over weed level, in both years, Russet Burbank had significantly more vine biomass, tuber biomass, and total yield than Frontier Russet. Russet Burbank had higher U.S. No. 1 yield in 1991, but lower in 1992.

Of the plant population variables, within-row spacing had the greater effect on potato crop productivity (Table 4). Row width had no influence on vine biomass or tuber yield. The narrower row width did produce significantly greater tuber biomass in 1991, but the difference was not reflected in the total tuber yield. Interactions involving row width were generally insignificant. Narrower row width provided no competitive advantage to the potato crop in the presence of weeds. This somewhat surprising result may be explained by unmeasured observations of canopy development throughout the growing season. Regardless of row width, considerable time was needed before the canopy covered the soil surface between the rows, allowing for early weed establishment and growth. The difference in time of row closure between the two row width treatments was only a few days. Within-row spacing had a greater influence on the time required for row closure. Closer spacing resulted in early within-crop competition and rapid elongation of vines. The longer vines covered the area between the rows more rapidly. Generally, as within-row spacing decreased, crop productivity increased. However, significant interactions of within-row spacing with cultivar and weed level require additional interpretation.

The most prominent interactions for all productivity variables, as indicated by significance level and the magnitude of mean squares, were weed level by cultivar, within-row spacing by cultivar in 1991, and weed level by within-row spacing by cultivar in 1992 (Table 3). These interactions were caused by the unique response of the two cultivars to inter- and intra-species competition. Figures 1 through 4 help illustrate the interaction effects on vine biomass (Fig. 1), tuber biomass (Fig. 2), total tuber yield (Fig. 3) and U.S. No. 1 tuber yield (Fig. 4).

Frontier Russet and Russet Burbank differed in their response to weeds resulting in significant ($p=.05$) weed level by cultivar interactions for all production variables except vine biomass in 1992 (Table 3). In 1991, total yield of Frontier Russet was reduced by an average of 43% (from 32.1 to 18.2 t/ha) under weedy conditions, while Russet Burbank yield was reduced by only 10% (from 40.6 to 36.4 t/ha) (Fig. 3). Similar responses were observed for vine and tuber biomass (Figs. 1, 2). Severe weed competition caused much greater reduction in total yield in 1992 than in 1991 (Fig. 3). Frontier Russet total yield was reduced by an average of 80% (from 39.5 to 7.8 t/ha) while Russet Burbank total yield was reduced by an average of 57% (from 45.9 to 19.6 t/ha).

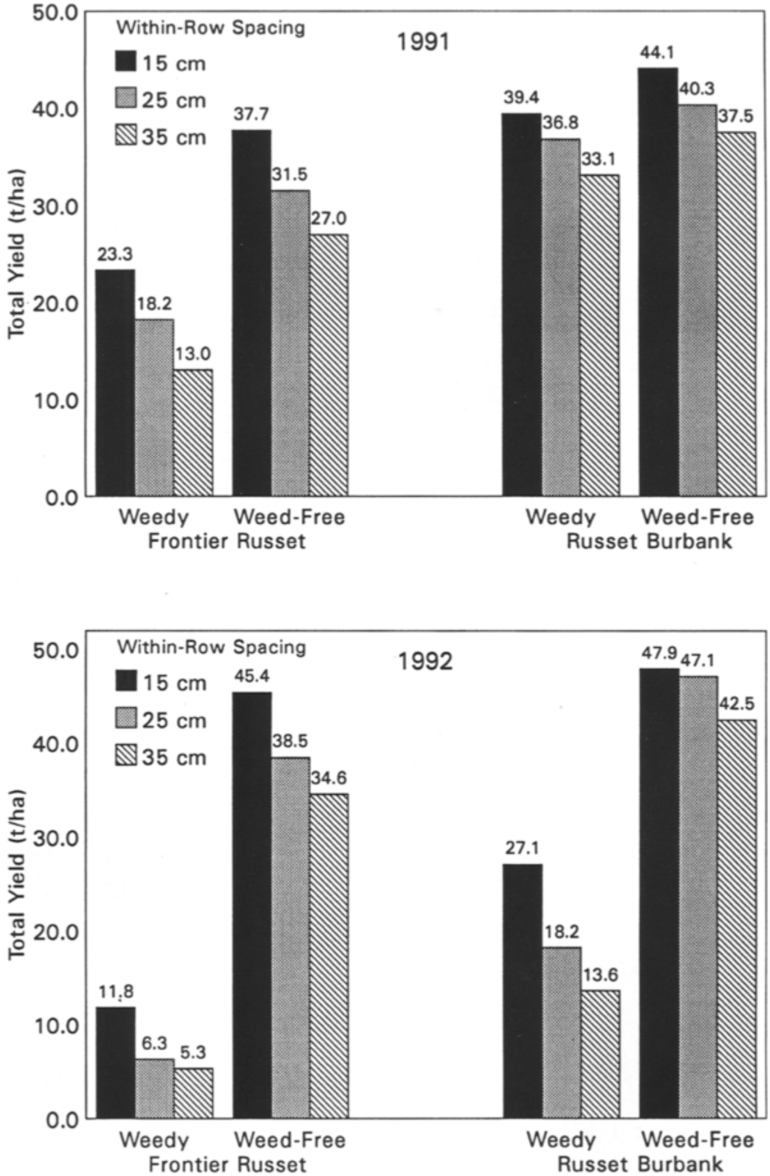

FIG. 3. Total tuber yield in 1991 and 1992 of Frontier Russet and Russet Burbank potatoes under weedy and weed-free conditions and a within-row seed-piece spacing of 15, 25, or 35 cm. In 1991 weed pressure was light to moderate, while in 1992 it was severe.

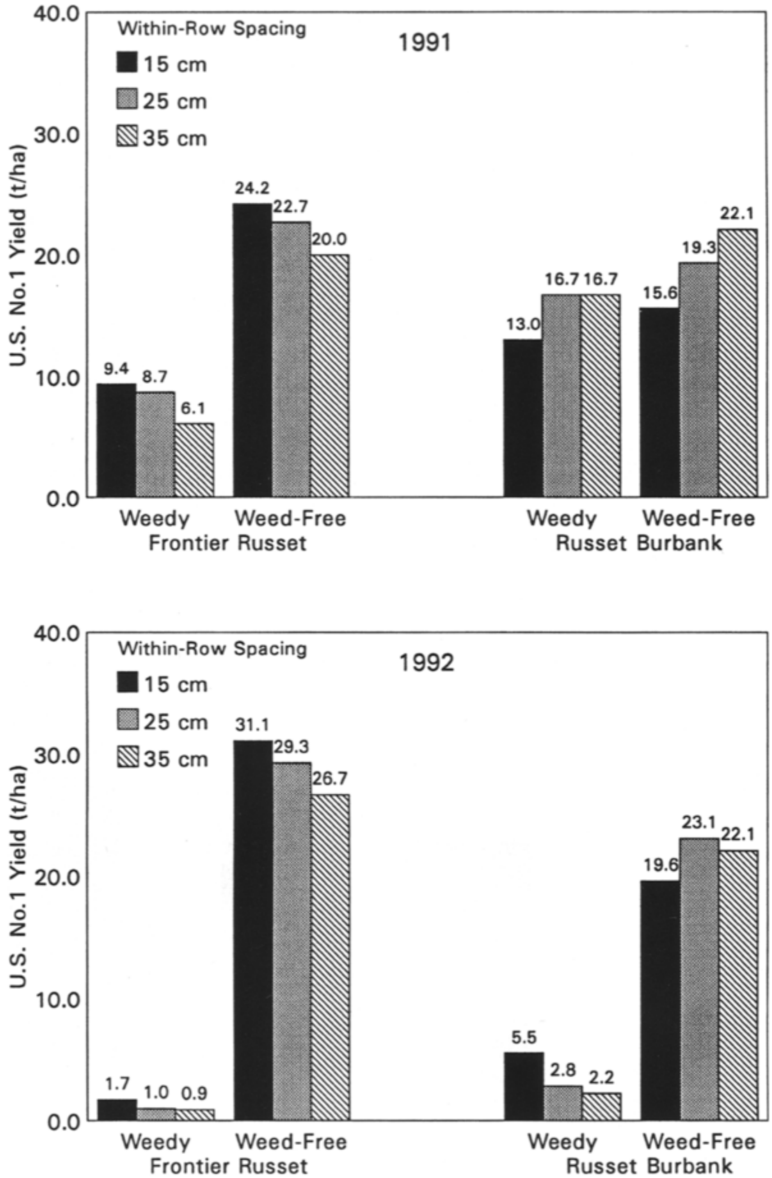

FIG. 4. U.S. No. 1 tuber yield in 1991 and 1992 of Frontier Russet and Russet Burbank potatoes under weedy and weed-free conditions and a within-row seed-piece spacing of 15, 25, or 35 cm. In 1991 weed pressure was light to moderate, while in 1992 it was severe.

Reductions in U.S. No. 1 yields for each cultivar in the presence of weeds was greater than reductions in total yield (Figs. 3, 4). Additionally, reductions in U.S. No. 1 yield due to weeds was greater for Frontier Russet than for Russet Burbank (Fig. 4). In 1991, the presence of weeds reduced Russet Burbank U.S. No. 1 yield by an average of 18% (from 19.0 to 15.5 t/ha) but reduced Frontier Russet U.S. No. 1 yield by 64% (from 22.3 to 8.1 t/ha). Under the heavy weed pressure of 1992, reductions in U.S. No. 1 yield was more severe for both cultivars, but Frontier Russet was reduced the most (Fig. 4). Russet Burbank yield was reduced by 84% (from 21.6 to 3.5 t/ha) while Frontier Russet yield was reduced by 96% (from 29.0 to 1.2 t/ha).

In 1991, the two cultivars responded differently to within-row spacing, resulting in a significant (p=.05) within-row spacing by cultivar interaction for all four production variables (Table 3). For that year, as the spacing changed (regardless of weed level) Russet Burbank showed less response than Frontier Russet for vine biomass, tuber biomass, and total yield (Figs. 1-3). The two cultivars reacted in an opposing manner to within-row spacing for U.S. No. 1 yield (Fig. 4). As spacing increased, Frontier Russet U.S. No. 1 yield decreased, while those of Russet Burbank increased. Russet Burbank failed to maintain adequate tuber size at the closer spacings. Previous research has defined some of the relationships between tuber size, total yield, and U.S. No. 1 yield under weed-free conditions (7, 10, 12). Lynch and Rowberry (7) showed that total yield of Russet Burbank grown in Guelph, Ontario, increased as population increased but at high populations tubers frequently were too small to meet marketable grade requirements. Painter *et al.* (12) varied within-row plant spacing from 15 to 30 cm and reported an increase for both total and U.S. No. 1 yields as spacing decreased. The increase in total yield was proportionally greater than the increase in U.S. No. 1 yield. The study of Painter *et al.* (12) was conducted in an area typified by long seasons and high tuber yields, resulting in larger tuber size and less impact of competition on U.S. No. 1 yield. The result was a closer within-row spacing for optimum U.S. No. 1 tuber production than was observed in the current study, but the tuber size influence on the relationship between total and U.S. No. 1 yield was consistent. Moderate weed pressure appeared to have the same influence on tuber size as would closer spacing, without the benefit of increased tuber numbers. Under severe weed pressure, like that found in 1992, closer within-row spacing seemed to provide the potatoes with enough competitive advantage that the closest spacing resulted in the highest U.S. No. 1 yield, regardless of the size, yield-grade relationship.

In 1992, there was a significant weed level by within-row spacing by cultivar interaction for total yield (Table 3). In 1991, under less severe weed pressure, no such interaction occurred. Under weed-free conditions, increasing the within-row spacing from 15 to 35 cm reduced Frontier Russet total yield 28% (from 37.7 to 27.0 t/ha) in 1991 and 24% (from 45.4 to 34.6 t/ha) in 1992. Russet Burbank yield under the same conditions was reduced by 15% (from 44.1 to 37.5) t/ha) in 1991 and 11% (from 47.9 to 42.5 t/ha) in 1992 (Fig. 3). Under weedy conditions, increasing the within-row spacing from 15 to 35 cm reduced Frontier Russet yield by 44% (from 23.3 to 13.0 t/ha) in 1991 and by 55% (from 11.8 to 5.3 t/ha) in 1992 (Fig. 3). When Russet Burbank within-row spacing was increased from 15 to 35 cm under weedy conditions, yield reduction was 16% (from 39.4 to 33.1 t/ha) in 1991 and 50% (from 27.1 to 13.6 t/ha) in 1992. Total yield of Russet Burbank, therefore, appeared to be less sensitive to within-row spacing under weed-free conditions or when weeds emerged after the potatoes. Frontier Russet was highly sensitive to within-row spacing regardless of when weeds emerged. The unique response of the two cultivars to combinations of weed levels and within-row spacing is the apparent cause of the interaction in 1992.

A weed level by within-row spacing by cultivar interaction also occurred in 1992 for U.S. No. 1 yield. Frontier Russet produced the highest U.S. No. 1 yields at 15 or 25 cm within-row spacings, regardless of weed level. In contrast, Russet Burbank under weed-free conditions for both years, and weedy conditions in 1991, had the highest U.S. No. 1 yield at the 35 cm spacing but highest yield at the 15 cm spacing in 1992 under heavy weed pressure.

Tuber biomass was measured during the late part of the tuber bulking phase to determine if yield trends were established prior to the last few weeks of the season. A second reason for measuring biomass was to determine if dry weight accumulations matched those for fresh weight. For the most part, similar trends occurred for tuber biomass and total yield, indicating that weed competition began to influence tuber productivity relatively early in the bulking period (Table 3, Figs. 2, 3). Also, it appeared that dry weight accumulation and fresh weight yield of the tubers were influenced similarly.

The various treatment combinations had little effect on specific gravity of the tubers. One exception is that Frontier Russet had a higher average specific gravity (1.084) under weed-free conditions than Russet Burbank (1.079), which is typical for these two cultivars. However, under weedy conditions, the average specific gravity of both cultivars was 1.081. The reduction in specific gravity of Frontier Russet occurred primarily in 1992 when heavy weed competition caused specific gravity to decrease from 1.086 to 1.082.

Some trends were constant in spite of the differences in weed pressure between the two growing seasons. The presence of weeds always reduced productivity. Frontier Russet was less competitive than Russet Burbank. Reducing row width did not increase potato competitiveness with weeds, but reducing within-row spacing did. Time of weed emergence relative to potato emergence strongly affected weed competitiveness with potatoes. When weeds emerged before potatoes, they were highly competitive with the crop and severely reduced yield regardless of cultivar grown or planting pattern used. However, when weeds emerged after the crop, Russet Burbank yield in weedy plots was much higher than Frontier Russet yield in weedy plots. Within-row spacing was important for influencing competitiveness of Frontier Russet under moderate weed pressure, while it had little influence on Russet Burbank competitiveness.

Crop competitiveness with weeds has been shown to be cultivar dependent in many crops including barley (14), wheat (14), rice (3), peanut (2), white beans (8), and sugar beet (6). The same principle holds for potatoes, and the cultivar chosen may be more important than planting pattern for improving competitiveness with weeds. Although Frontier Russet may have several desirable characteristics for sustainable potato production, it is not as competitive with weeds as Russet Burbank, and in fact, may require higher cultural and chemical inputs to achieve an acceptable level of weed control.

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