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Improving Weed Control in Dry Bean Using Narrow Planting

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Introduction

IDAHO CURRENTLY RANKS SIXTH in the nation for edible dry bean (*Phaseolus vulgaris* L.) production and was valued at $83 million in 2017 (United States Department of Agriculture 2018). Dry bean yield loss due to uncontrolled weeds is about 50% in Idaho (Soltani et al. 2018). Based on grower response to surveys by the Idaho Bean Commission (2014), hairy nightshade (*Solanum physalifolium* Rusby) and season-long weed control were ranked among the biggest challenges in dry bean production. Hairy nightshade was considered the most troublesome weed in dry bean production in southern Idaho and other parts of North America (Blackshaw 1991). Previous studies have shown that as few as two hairy nightshade plants per 3 feet of row competing with the crop for water, nutrients, and light during the growing season can reduce dry bean yield by 13%. Hairy nightshade not only competes with dry bean during the growing season, causing yield losses (Blackshaw 1991) but can also create challenges during harvest by plugging the harvester. Furthermore, the crushed berries of hairy nightshade can stain the beans, which reduces their quality and market value (Rich and Renner 2009). Weed control is, therefore, an important practice in dry beans.

Raptor is the most effective and currently labeled postemergence herbicide for controlling hairy nightshade and other weeds in dry beans. However, its drawback for many growers is the rotation restriction to sensitive crops such as sugar beet (*Beta vulgaris* L.) and potato (*Solanum tuberosum* L.). A need exists for season-long weed control in dry beans that is not solely dependent on herbicides. Use of integrated weed management (IWM) practices combining herbicides with cultural and mechanical control methods could allow choosing herbicide(s) with fewer or no crop rotation restrictions while still obtaining the level of control provided by Raptor.

One of the IWM methods which may help obtain successful season-long control would be enhancing the competitiveness of dry bean. Cultural practices to consider include fertilizer placement, seeding rate, time to canopy closure, row spacing, and plant architecture, i.e., growth habit, branching pattern, and plant canopy. Canadian and midwestern US studies in soybean and various classes of dry beans have shown that planting in narrow rows instead of traditional wide-row spacing improves the competitiveness of the crop against weeds (Blackshaw et al. 1999, 2000; Holmes and Sprague 2013; Rich and Renner 2009; Yelverton and Coble 1991). There also have been studies supporting the practice of higher seeding rates as a means of increasing competitiveness in narrow-row crops (Blackshaw et al. 1999, 2000; Place et al. 2009). However, growing conditions in southern Idaho are quite different from conditions in these study locations. For example, Idaho's low humidity, semiarid climate requiring irrigation creates a much different environment than the relatively higher humidity and rainfed conditions in midwestern dry bean production areas. Therefore, Idaho studies are needed to develop appropriate IWM practices for successful, season-long control of weeds, including hairy nightshade.

Description of the Studies

A row-spacing study was conducted in 2014 and 2015 at the University of Idaho Kimberly Research and Extension Center to determine the effect of row spacing, plant architecture (upright versus viny growth habit), and herbicide combinations on season-long weed control and pinto bean yield. Six weed-control treatments that included four herbicide treatments, a nontreated weedy control, and a hand-weeded control were compared for their effectiveness. Herbicides used were Basagran, Eptam, Outlook, Prowl H2O, and Sonalan in various two-way preemergence (PRE) and sequential postemergence (POST) combinations (Table 1). Two pinto bean cultivars were selected based on their plant architecture. 'Sequoia' has a Type II upright growth habit and 'Othello' has a Type III viny or trailing growth habit. The two varieties were planted in narrow rows with a grain drill in 6-inch and 7.5-inch row spacing in 2014 and 2015, respectively (Figure 1). Both varieties were planted in 22-inch wide-row spacing with a standard row crop planter (Figure 1). The seeding rate for narrow and wide-row spacing was the same at 95,000 seeds/A. Beans planted in wide-rows were cultivated twice, and the narrow-row treatments were not. Visual weed-control evaluations were conducted on four weed species present for both years of the study. Hairy nightshade, common lambsquarters (*Chenopodium album* L.), green foxtail (*Setaria viridis* L.), and redroot pigweed (*Amaranthus retroflexus* L.) control were rated on a 0% (no control)–100% (complete death) scale twice during the growing season: at midseason and one month later. There were no differences in weed control between 2014 and 2015, so the weed-control data were combined for both years.

Figure 1. Pinto bean planted in narrow- (top) and wide-row (bottom) spacing. Photos were taken July 9, 2015. Difference in color between photos is due to camera exposure and time of day the photos were taken.

In 2016 and 2017, another study was conducted to determine if increasing seeding rates of dry bean planted in narrow rows could increase weed control and bean yield compared to a standard seeding rate in wide rows. This also was conducted at the U of I Kimberly Research and Extension Center. The variety used was 'La Paz,' which is an upright indeterminate Type II pinto bean. This was chosen with the intent of potentially swathing or direct harvesting the crop. The beans were planted at 100,000, 125,000, 150,000, 175,000, and 200,000 seeds/A in narrow 7.5-inch rows and at 100,000 seeds/A in wide 22-inch rows. Five weed-control treatments consisting of a nontreated weedy control, a hand-weeded control, and three herbicide treatments were included in the trial. The

Table 1. Hairy nightshade control in response to weed-control treatments in narrow- and wide-row spacing averaged across pinto bean varieties and two years in a row-spacing study near Kimberly, Idaho.

Treatment[b]	Rate (pint/A)	Cost[c] ($/A)	Hairy nightshade Control[a]			
			Early evaluation		Late evaluation	
			Narrow[d] (%)	Wide (%)	Narrow (%)	Wide (%)
Weedy control	-	-	-	-	-	-
Eptam + Sonalan	3 + 3	$41.63	31 e	61 d	50 c	72 b
Eptam + Outlook fb	3 + 0.875	$73.02	92 ab	93 a	95 a	94 a
Sonalan + Basagran	3 + 1					
Eptam + Sonalan fb	3 + 3 fb	$73.02	91 abc	92 ab	95 a	92 a
Outlook + Basagran	14 fl oz + 1					
Prowl H2O + Outlook fb	2 + 14 fl oz fb	$44.38	91 abc	92 ab	93 a	94 a
Basagran	1					
Hand weeded	-		87 bc	86 c	95 a	93 a

[a]There was a significant interaction between weed-control treatment and row spacing for hairy nightshade control and the data are averaged across variety and year. Means followed by the same letter within each evaluation time are not statistically different using Least Square Means analysis performed at P = 0.05. Visual control was rated on a 0% (no control)–100% (completely dead) scale.

[b]All of the weed control treatments were compared to the weedy control. Basagran applications included 3.27 pt/A of Bronc Max and 1.5 pt/A of Super Spread MSO. Abbreviations: fb, followed by.

[c]All costs were based on Approximate Retail Price Per Unit of Selected Herbicides for Field Crops-CropWatch and the University of Idaho Agricultural Economics publication 2017 Cost and Returns Estimate Southcentral Idaho: Magic Valley Commercial Dry Beans. EBBB3-DB-17. Cost includes adjuvants added to Basagran treatments. Application cost with a ground sprayer is $7.00/A per application and custom cultivation cost is $13.50/A per cultivation.

[d]Narrow-row spacing in 2014 and 2015 was 6 and 7.5 inches, respectively. Wide-row spacing was 22 inches, both years, with one in-season cultivation.

Table 2. Hairy nightshade and common lambsquarters control in response to weed-control treatments averaged across dry bean seeding rate near Kimberly, Idaho.

Treatment[b]	Rate (pint/A)	Weed Control[a]							
		Hairy nightshade				Common lambsquarters			
		2016		2017		2016		2017	
		Early (%)	Late (%)	Early (%)	Late (%)	Early (%)	Late (%)	Early (%)	Late (%)
Nontreated control	-	-	-	-	-	-	-	-	-
Eptam + Sonalan	3 + 3	12 b	24 b	95 a	81 b	19 a	15 a	80 a	73 c
Eptam + Sonalan fb Outlook	3 + 3 fb 1	15 b	31 b	91 a	80 b	21 a	13 a	76 a	74 c
Eptam + Sonalan fb Varisto	3 + 3 fb 1	26 a	66 a	97 a	95 a	20 a	13 a	76 a	87 b
Hand-weeded control	-	-	-	93 a	93 a	-	-	75 a	91 a

[a]Means followed by the same letter within a year are not significantly different at P = 0.05 using least square means. The early weed-control evaluations were completed three and two weeks after emergence in 2016 and 2017, respectively. The late weed-control evaluations were completed seven and five weeks after emergence in 2016 and 2017, respectively.

[b]Abbreviations: fb, followed by. Varisto application included 3.27 pt/A of Bronc Max and 1.5 pt/A of Super Spread MSO.

three herbicide treatments were Eptam + Sonalan applied PRE alone and Eptam + Sonalan applied PRE followed by sequential POST applications of Outlook or Varisto (Table 2). Like the row-spacing study, the beans planted in wide rows were cultivated twice and the beans planted in narrow rows were not cultivated. Visual weed-control evaluations of hairy nightshade, common lambsquarters, redroot pigweed, and green foxtail were conducted twice during the growing season: early (1st trifoliate growth stage) and late (two weeks after the first evaluation). The results from 2016 and 2017 are presented separately due to statistical differences in the data between years (Table 3).

Comparing Weed Control in the Row-Spacing Study

Hairy nightshade control was influenced by row-spacing and weed-control treatment (Table 1). Averaged across the two varieties, hairy nightshade control with Eptam + Sonalan applied PRE alone to beans grown in narrow rows had the poorest control at early and late evaluations with 31% and 50% control, respectively, followed by the second-poorest control of 61% and 72%, respectively, with the same PRE-alone herbicide treatment in the wide-row spacing. The difference in control between the same herbicide treatments, but different row spacing, was most likely due to being able to cultivate in the wide but not the narrow rows. In contrast, herbicide treatments that included a POST-sequential application, in both narrow and wide rows, controlled hairy nightshade better than the PRE-only treatment. There were no differences in control among these herbicide combinations between row spacings. This suggests that, even without in-season cultivation, planting dry beans in narrow rows increases competitiveness with hairy nightshade compared with that in wide rows and can provide effective hairy nightshade control when combined with POST-sequential herbicides. This is consistent with a study in soybean, where narrow row spacing reduced weed interference and increased subsequent yield compared to wide rows (Norris et al. 2009).

Hairy nightshade control was also influenced by differences in plant architecture between the two

Table 3. Dry bean yield in response to herbicide treatments in narrow- and wide-row spacing averaged over pinto bean varieties and analyzed separately for 2014 and 2015 in the row-spacing study near Kimberly, Idaho.

Treatment[b]	Rate (pint/A)	Bean yield[a]			
		2014		2015	
		Narrow[c] (lb/A)	Wide (lb/A)	Narrow (lb/A)	Wide (lb/A)
Weedy control	-	894 f	1315 f	2293 g	2334 fg
Eptam + Sonalan	3 + 3	2590 de	1975 e	3071 abc	2786 cde
Eptam + Outlook fb	3 pr + 0.875 fb	3775 ab	3135 bcd	3173 a	2642 e
Sonalan + Basagran	3 + 1				
Eptam + Sonalan fb	3 + 3 fb	3636 abc	3085 cd	3009 a-d	2598 ef
Outlook + Basagran	0.875 + 1				
Prowl H2O + Outlook fb	2 + 0.875 fb	3034 cd	3144 bcd	3093 ab	2736 de
Basagran	1				
Hand weeded	-	3928 a	2977 d	2813 b-e	2813 b-e

[a]*Bean yield was averaged across variety. An interaction occurred among weed-control treatments, row spacing, and year. The data were analyzed by year. Means followed by the same letter within a year are not statistically different using a Least Square Means analysis performed at P = 0.05.*

[b]*Basagran applications included 3.27 pt/A of Bronc Max and 1.5 pt/A of Super Spread MSO. Abbreviations: fb, followed by.*

[c]*Narrow-row spacing in 2014 and 2015 was 6 and 7.5 inches, respectively. Wide-row spacing was 22 inches, both years.*

dry bean varieties (data not shown). Averaged across herbicides and row spacing, early and late hairy nightshade control was 90% or greater in Othello compared to 86% control in Sequoia. This suggests that Othello, which has a viny, trailing growth habit, is more competitive with hairy nightshade than Sequoia, which has an upright, erect growth habit and a more open canopy.

Regardless of herbicide combinations and timings or row spacing, hairy nightshade control in the dry bean variety Othello was better than Sequoia—the variety with the more upright and open canopy. Also, when pinto bean was planted in narrow rows, competition against hairy nightshade was seemingly increased enough for control of the weed by PRE fb (followed by) POST-herbicide applications to be comparable to that in wide rows, which included cultivation.

Common lambsquarters, green foxtail, and redroot pigweed control in the row-spacing study was affected only by the weed-control treatments (Table 4). Similar to hairy nightshade control, PRE application of Eptam + Sonalan PRE alone had the poorest control of these three weed species at both evaluation dates. Otherwise, control of these three species with herbicide treatments that included a POST-sequential herbicide application was better and ranged from 83% to 94%. Common lambsquarters and redroot pigweed control with Eptam + Outlook PRE fb Sonalan + Basagran POST and redroot pigweed control with Prowl H2O + Outlook PRE fb Basagran POST was better than Eptam + Sonalan PRE fb Outlook + Basagran POST at the early and late evaluations (Table 4). Overall, the addition of a POST-sequential herbicide application to the PRE-applied herbicides was needed to provide effective season-long control of any of the four weeds in this study.

Comparing Weed Control in the Seeding-Rate Study

There was no difference in weed control in response to dry bean seeding rates at any of the evaluation dates. Thus, weed control was compared between weed-control treatments for each year averaged across all seeding rates (Table 2). In 2016, the overall weed control in the seeding-rate experiment was poor to fair due to ineffective weed control before planting. Even though the broadleaf weed control was unacceptable (<70%) in 2016, there were still

Table 4. Common lambsquarters, redroot pigweed, and green foxtail control in response to weed-control treatments averaged across pinto bean varieties, row spacing, and years in the row-spacing study near Kimberly, Idaho.

Treatment[b]	Rate (pint/A)	Weed Control[a]					
		Common lambsquarters		Redroot pigweed		Green foxtail	
		Early (%)	Late (%)	Early (%)	Late (%)	Early (%)	Late (%)
Weedy control	-	-	-	-	-	-	-
Eptam + Sonalan	3 + 3	62 c	34 c	70 c	70 c	70 b	64 b
Eptam + Outlook fb	3 + 0.875 fb	90 a	89 a	93 a	93 a	91 a	93 a
Sonalan + Basagran	3 + 1						
Eptam + Sonalan fb	3 + 3 fb	84 b	83 b	87 b	86 b	89 a	92 a
Outlook + Basagran	0.875 + 1						
Prowl H2O + Outlook fb	2 + 0.875 fb	88 ab	88 ab	92 a	93 a	91 a	94 a
Basagran	1						
Hand weeded	-	86 ab	90 a	90 ab	93 a	87 a	90 ab

[a]Weed control was averaged across variety, row spacing, and year. Means followed by the same letter within a column are not statistically different using a Least Square Means analysis performed at P = 0.05. Visual control was rated on a 0 (no control) to 100% (completely dead) scale.

[b]All of the herbicide treatments were compared to the weedy control. The weedy control value (0%) was not included in the data analysis.

Abbreviations: fb, followed by; pt, pint. All treatments with Basagran included 3.27 pt/A of Bronc Max and 1.5 pt/A of Super Spread MSO.

some differences between weed-control treatments. At the early and late evaluations in 2016, hairy nightshade control was better with Eptam + Sonalan applied PRE fb Varisto applied POST than Eptam + Sonalan PRE or Eptam + Sonalan PRE fb Outlook POST. At the early evaluation in 2017, there were no differences in hairy nightshade control between weed-control treatments. However, at the late evaluation, the hand-weeded control and Eptam + Sonalan PRE fb Varisto POST had better control at 93% and 95%, respectively, than Eptam + Sonalan PRE alone or Eptam + Sonalan PRE fb Outlook POST at 81% and 80% control, respectively.

There were no differences in common lambsquarters control between weed-control treatments in 2016 or at the early evaluation in 2017 (Table 2). At the late evaluation in 2017, common lambsquarters control with Eptam + Sonalan PRE fb Varisto POST was the best herbicide treatment, providing 87% control.

Redroot pigweed control at the early and late evaluation in 2016 was generally poor with all herbicide treatments, but Eptam + Sonalan PRE fb Varisto POST provided the best control (Table 5). In 2017, redroot pigweed control at the early evaluation was equal among the herbicide treatments, but at the late evaluation, redroot pigweed control was best with Eptam + Sonalan PRE fb Varisto POST at 97%.

Green foxtail control at the early evaluation in 2016 was 70% in Eptam + Sonalan PRE fb Varisto POST treatment, which was greater than the 54% recorded in the nontreated control (Table 5). At the late evaluation in 2016, green foxtail control was better with Eptam + Sonalan PRE fb Outlook POST and Eptam + Sonalan PRE fb Varisto POST at 87% and 90%, respectively, compared to Eptam + Sonalan PRE only, which averaged 58% control. At both evaluation dates in 2017, green foxtail control averaged 91% or better with the three herbicide treatments. Redroot pigweed responded similarly to the herbicide treatments as green foxtail, with the most effective herbicide sequence being Eptam + Sonalan PRE fb Varisto POST.

Averaged over all of the weed-control treatments in 2016 and 2017, weed control in dry bean planted in narrow rows was as good as the wide row spacing that was cultivated. Overall, a sequential application of Eptam + Sonalan PRE fb Varisto POST was the most effective weed-control treatment for all of the weeds in this experiment.

Table 5. Redroot pigweed and green foxtail control in response to weed-control treatments averaged across dry bean seeding rate near Kimberly, Idaho.

Treatment[b]	Rate (pint/A)	Weed Control[a]							
		Redroot pigweed				Green foxtail			
		2016		2017		2016		2017	
		Early (%)	Late (%)	Early (%)	Late (%)	Early (%)	Late (%)	Early (%)	Late (%)
Nontreated control	-	-	-	-	-	-	-	-	-
Eptam + Sonalan	3 + 3	23 b	39 b	88 a	79 c	54 b	58 b	92 a	92 b
Eptam + Sonalan fb Outlook	3 + 3 fb 1	25 b	50 b	87 a	88 b	61 ab	87 a	91 a	97 a
Eptam + Sonalan fb Varisto	3 + 3 fb 1	42 a	75 a	89 a	97 a	70 a	90 a	93 a	96 a
Hand-weeded control	-	-	-	64 b	88 b	-	-	81 b	85 c

[a]Means followed by the same letter within a year are not significantly different at P = 0.05 using least square means. The early weed-control evaluations were completed 3 and 2 weeks after emergence in 2016 and 2017, respectively. The late weed-control evaluations were completed 7 and 5 weeks after emergence in 2016 and 2017, respectively.

[b]Abbreviations: fb, followed by. Varisto application included 3.27 pt/A of Bronc Max and 1.5 pt/A of Super Spread MSO.

Dry Bean Yield in Row-Spacing and Seeding-Rate Studies

Due to differences in results between the two years, bean yields were analyzed separately and are presented by year. In 2014, Eptam + Sonalan PRE alone had the lowest yield among the herbicide treatments, regardless of row spacing, compared with yields that included POST- sequential treatments which provided season-long weed control (Table 5). Eptam + Outlook PRE fb Sonalan + Basagran POST and Eptam + Sonalan PRE fb Outlook + Basagran POST in narrow rows had yields greater than Eptam + Sonalan PRE only in narrow rows. In the wide rows, all treatments with a sequential POST application had yields greater than Eptam + Sonalan PRE only. Dry bean yields in the narrow rows were statistically equal to the yield in wide row beans. The only exception was the yield in the hand-weeded control of the narrow row beans were more than 30% higher than the hand-weeded control bean in wide rows (Table 3).

In 2015, there were no yield differences between Eptam + Sonalan PRE alone and any POST-sequential treatments regardless of spacing, even with differences in weed control between these treatments. In contrast to 2014, bean yields in 2015 were higher in the narrow rows with herbicide treatments that included a POST-sequential herbicide compared to the same treatments in the wide rows. It should be noted that the weed pressure in 2015 was lower than in 2014, which meant less season-long weed competition. As a result, there were no crop yield differences between Eptam + Sonalan PRE alone and the POST-sequential treatments in 2015. This implies that when weed pressure is high, a POST-sequential application will improve weed control and subsequent yield compared with using only PRE herbicides.

In both years, the POST-sequential treatments had comparable yields and those yields were not less than that of the hand-weeded control, where weeds were controlled throughout the season. In 2015, the bean yield in the hand-weeded control was the same in both narrow and wide rows, but there were statistical yield differences between narrow and wide-row spacing with all POST-sequential treatments. The dry bean yield results from the two years of this study strongly suggest that narrow rows yield higher than wide rows. One insight gained from this study is that although the seeding rate for the narrow rows was the same as in the wide rows (95,000 seeds/A), this resulted in some gaps in the plant stand early in the growing season in the narrow rows because the grain drill randomly dropped seed, unlike a row planter which dropped seed precisely (Figures 1 and 2).

Figure 2. Pinto bean planted in narrow- (top) and wide-row (bottom) spacing. Photos were taken August 14, 2015. Difference in color between photos is due to camera exposure and time of day the photos were taken.

Reducing row spacing from 30 inches to anywhere between 7.5 and 15 inches has been shown to increase yields in other studies conducted across North America with several different bean classes (Blackshaw et al. 2000; Cox and Cherney 2011; Holmes and Sprague 2013). When dry beans are grown in narrow rows, using the standard harvesting practices of undercutting and windrowing beans may be eliminated if the seed pods are high enough above the ground. Narrow rows can provide the opportunity to cut beans with a swather or to direct harvest. This can reduce fuel and equipment costs, save time, and reduce or eliminate picking up dirt clods that come from undercutting the beans and that wears down harvesting equipment. However, yield loss is sometimes greater in direct harvest compared to conventional methods depending on variety, especially with varieties that produce pods close to the soil surface (Osorno et al. 2019). Beans with Type III viny growth habit would be especially prone to seed loss because of the difficulty getting the sickle bar on the header under the lowest hanging pods. Environmental conditions, equipment setup, and operator can also make a difference. Direct-harvest or swathing yield loss can be avoided or reduced with a more upright variety (Type I or II growth habit) that produces pods higher off the ground. Additionally, the use of equipment such as flexible cutterbars and pickup reels that operate closer to the soil can reduce seed loss (Orsono et al. 2013). However, there is a risk of increased weed pressure and decreased yield in upright varieties (Blackshaw et al. 1999).

As stated earlier, in the row-spacing study where two pinto bean varieties were compared, Othello with the viny or trailing growth habit yielded higher in both narrow and wide rows compared to Sequoia with the upright and open canopy (Table 6). This is in contrast to a Canadian study that demonstrated navy bean with an upright growth habit yielded higher than the viny or trailing navy bean variety in the presence of hairy nightshade (Blackshaw et al. 1999). In other words, unlike navy beans, a viny or trailing pinto bean variety was more competitive with hairy nightshade than an upright pinto bean variety. However, dry bean plant architecture has not been studied to a large extent and it is unknown how other dry bean classes or other pinto bean varieties would perform in this scenario. A viny or trailing variety may not allow direct harvest or swathing if the pods hang too close to the ground.

Table 6. Dry bean yield in response to variety by row-spacing interaction averaged across herbicide treatments and years in the row-spacing study near Kimberly, Idaho.

Variety	Bean yield[a]	
	Narrow[b] (lb/A)	Wide (lb/A)
Othello	3192 a	3058 a
Sequoia	2692 b	2199 c

[a]*There were no herbicide treatment or year interactions so row-spacing data were pooled across treatment and years. Means followed by the same letter are not statistically different using a Least Square Means analysis performed at P = 0.05.*

[b]*Narrow-row spacing in 2014 and 2015 was 6 and 7.5 inches, respectively. Wide-row spacing was 22 inches, both years.*

Effect of Seeding Rate

In the seeding-rate study, dry bean yield in 2016 was reduced 52% when the weeds were not controlled compared to the hand-weeded control averaged across the seeding rates (Table 7). The hand-weeded control yield in 2016 was highest at 5,650 lb/A. Dry bean yield also was not different between the weedy control and the herbicide treatments in 2017.

Table 7. Dry bean yield in response to weed-control treatments averaged across seeding rates in the seeding-rate study near Kimberly, Idaho.

Treatment[b]	Rate (pint/A)	Yield[a]	
		2016 (lb/A)	2017 (lb/A)
Weedy control	-	2,925 b	2,262 a
Eptam + Sonalan	3 + 3	3,380 b	2,682 a
Eptam + Sonalan fb	3 + 3 pt fb	3,407 b	2,984 a
Outlook	1		
Eptam + Sonalan fb	3 + 3 fb	3,495 b	2,950 a
Varisto	1.3		
Hand weeded	-	5,650 a	2,890 a

[a]*The yield data are averaged across dry bean seeding rates and are presented by year since there was a weed-control treatment by year interaction. Means followed by the same letter within a column are not statistically different using a Least Square Means analysis performed at P = 0.05.*

[b]*Varisto application included 3.27 pt/A of Bronc Max and 1.5 pt/A of Super Spread MSO. Abbreviations: fb, followed by.*

Averaged across both years and weed-control treatments of the seeding-rate study, the yield of the dry beans grown in wide rows at 100,000 seeds/A was lower than the beans grown in narrow rows at 100,000 seeds/A (Table 8).

Averaged across both years in the seeding-rate study, there were no statistically significant yield differences among seeding rates in the narrow-row plots, but all had higher yields than the wide-row treatment (Table 8). Other seeding-rate studies on various classes of dry beans have shown similar results in Canada. In one study, with Ember small red bean, Blackshaw et al. (2000) found that increased seeding rates in narrow rows allowed the canopy to close earlier in the growing season, allowing the beans to intercept more light. Yields were higher when increased seeding rates were used in conjunction with narrow rows (Blackshaw et al. 2000; Malik et al. 1993).

Table 8. Dry bean yield in response to seeding rate averaged across weed-control treatments and year in the seeding-rate study near Kimberly, Idaho.

Seeding rate[b] (seeds per acre)	Yield[a] (pounds per acre)
100,000 (wide rows)	2321 b
100,000	3268 a
125,000	3582 a
150,000	3121 a
175,000	3491 a
200,000	3777 a

[a]*The yield data are averaged across weed-control treatments and presented by year since there was a seeding rate by year interaction. Means followed by the same letter within a column are not statistically different using a Least Square Means analysis performed at P = 0.05.*

[b]*Wide-row spacing was 22 inches. All other row spacing was 7.5 inches.*

Conclusion

Season-long weed control can be achieved in edible dry bean production in Idaho with the addition of a POST-sequential application, especially in fields with high weed pressure. Furthermore, due to the increased competitiveness with weeds in narrow- versus wide-row spacing, POST-sequential applications in narrow-row beans without cultivation can control weeds as well or better than in wide-row spacing even when the POST-sequential applications are combined with cultivation. Even though POST-sequential applications increase the production cost, their subsequent increase in yield can offset the added cost, particularly in narrow-row spacing. More research on the economic feasibility of planting beans in narrow rows is needed. Dry beans grown in narrow-row spacing generally had higher yields than wide-row spacing and can become a viable option, especially with upright varieties that produce pods high enough above the soil surface to facilitate direct harvest or swathing. Increased seeding rates, from 125,000 to 150,000 seeds/A in narrow rows, can help beans compete more effectively against weeds, including common lambsquarters and redroot pigweed.

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ALWAYS read and follow the instructions printed on the pesticide label. The pesticide recommendations in this UI publication do not substitute for instructions on the label. Pesticide laws and labels change frequently and may have changed since this publication was written. Some pesticides may have been withdrawn or had certain uses prohibited. Use pesticides with care. Do not use a pesticide unless the specific plant, animal, or other application site is specifically listed on the label. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

Trade Names—To simplify information, trade names may have been used. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

Groundwater—To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.

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