ECONOMICS OF VARIABLE RATE NEMATICIDE FOR SUGAR BEETS

Larry J. Held[a/], Tina J. Opp[b/],
David W. Koch[c/], Fred A. Gray[d/] and Jeffery W. Flake[e/]

Abstract

The benefit of applying fumigant for control of the sugar beet nematode on a variable versus uniform rate basis is examined. Compared to fumigating an entire field at a constant full-label rate, variable rate application provides a savings ranging from $31/ac (heavily infested field) to $69/ac (lightly infested field).

Professor[a/] and Graduate Research Assistant[b/]
Department of Agricultural & Applied Economics
P.O. Box 3354, University of Wyoming, Laramie, WY 82071
Phone: (307) 766-2325 e-mail: held@uwyo.edu

Professor of Agronomy[c/], Professor of Plant Pathology[d/], and Research Assoc.[e/]
Department of Plant Sciences
P.O. Box 3354, University of Wyoming, Laramie, WY 82071

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Background

The sugar beet cyst nematode, SBN (*Heterodera schachtii*), a microscopic roundworm, is among the most destructive of pests affecting sugar beets, causing severe yield reductions (Gray, 1997). Crop rotations are important for control of SBN. However, rotations long enough to alleviate the need for nematicide (3 to 5 years or longer out of beets) are not always practical in many areas due to the lack of profitable alternative crops. As a result, sugar beet growers have relied heavily on costly nematicides for control of SBN. For example, Telone II® (1,3-dichloropropene) is a soil fumigant commonly used by growers to control SBN. It may cost over $150 per acre, and can generate significant risks to the environment and its applicators. As of 1997, 1,3-dichloropropene was applied to an estimated 45,000 acres of sugar beet across Colorado, Idaho, Nebraska and Wyoming (EPA, 2000).

One of the developing technologies with potential for reducing costs and achieving higher profits is site-specific crop management, also know as precision agriculture. This approach involves the variable application of inputs such as fertilizer, water or pesticides; and is based on sampling to determine variability in fertility, soil type, and pest populations, as opposed to a blanket or uniform rate of input. The site-specific approach has been employed mainly with variable fertility. However, site-specific technology could have greater potential with nematicides than with fertility, since the SBN intensity is more variable than soil fertility, and nematicides are a much costlier input than fertilizer. In a review of previous site-specific studies, Swinton and Lowenberg-DeBoer (1998) indicate that variable rate applications may be more successful with higher valued crops such as sugar beets.

Some input suppliers and crop consultants have GPS-based sampling services to implement variable rate application. Increasingly, farmers have equipment with computers programmable for variable rates on-the-go. Often, the weak link in applying this technology for precision nematicide management, occurs in programming the variable Telone II rates. The interaction of SBN populations, nematicide application rates and yield responses are needed in order to better program the variable rate applicators to deliver optimum rates, to avoid over- or under-application of Telone II.

This paper examines the profitability of applying any one of several uniform input rates versus variable (site-specific) applications of the soil fumigant, Telone II, for sugar beet cyst nematode (SBN) control.

Data and Methods

A 39-acre sugar beet field in southeast Wyoming was grid sampled for commercial production with GPS (3-acre grids) in early spring 2000. Locations for sampling SBN populations were identified at the center of the 3-acre grids with the assistance of GPS. Populations of nematodes were determined, and found to be highly variable, ranging from fewer than 2.0 to over 23 eggs cm^{-3} of soil.

Within this same field, an experimental area was flagged off to identify the relationship between sugar beet yield and different rates of Telone II. The experimental area was comprised of 24 blocks (30 x 60 ft.) arranged in a rectangular manner, with three blocks across and eight blocks deep, representing an 180 foot wide experimental strip from top to bottom of the 39-acre field (Table 1). Each of the 24 blocks contained four strips (or plots) to allow the application of three different rates of Telone II, as well as a no treatment rate (0.0 gal/ac), representing a total of 96 plots (24 blocks x 4 rates). Each of the 24 blocks were re-sampled for SBN infestation.

Table 1 shows populations of SBN in the experimental blocks ranging from 1.1 to 14.5 eggs cm^{-3}. After sampling, Telone II was applied within the experimental strips up and down the field representing the different rates (in addition to the zero untreated rate): a full-label banded rate (14.4 gal/ac), a lower supplemental suppression rate (9.5 gal/ac), and a half-rate (7.2 gal/ac). Sugar beets were planted in late April 2000 and harvested in early October to obtain yield data (ton/ac) to associate with SBN populations (eggs cm^{-3}), within each of the 96 plots (Table 1). Yield data were obtained for root yield (ton/ac) as well as sugar yield (lbs/ac), which accounts for percent of sugar from the beets. In this case, the impact of increased nematode populations on output was very similar, whether expressed in terms of root yield or actual pounds of sugar (Opp, 2001). For brevity, the analysis for this paper is conducted in terms of root yield (tons/ac).

The effectiveness of Telone II for reducing yield losses from the SBN was examined with linear regression, relating sugar beet yield (ton/ac) as a function of nematode eggs counts, given a particular rate of Telone II (Table 2). The R^2 values for all four treatments were low, ranging from 0.27, (14.4 gal.) to 0.38 (no treatment), indicating substantial influence on yield from factors other than nematodes. Slope coefficients across all treatments were statistically significant from zero (a = 0.05).

The numeric slope of 1.137 tons/acre beet yield reduction with each additional egg cm^{-3} (no control), is within the range of results reported by Robb et. al. (1992) in Western Nebraska, i.e., 2.888 to 0.562 ton/acre yield losses. As expected, numeric slope values relating yield losses are lower when applying 7.2 gal/acre (-0.921) and 9.5 gal/acre (-0.786) than no control (-1.137). Surprisingly, the yield loss associated with 14.4 gallon rate (-0.817) was slightly higher than the lower 9.5 gallon rate (-0.786). If the 14.4 gallon rate had proved to be more effective for controlling nematodes in this case, a slope coefficient closer to zero would be expected.

To facilitate an economic analysis, sugar beet yield data (ton/ac) associated with different Telone II rates (as shown in Table 1), were sorted into two SBN categories, either low (1.1 – 5.7 eggs cm^{-3}) or high (5.7 – 14.5 eggs cm^{-3}). Table 3 shows that given lower SBN counts, mean beet yields across the four Telone II rates are numerically similar, ranging from 27.2 ton/ac (0.0 gal) to 29.2 ton/ac (14.4 gal). These yields were not statistically different (α = 0.10).

Table 4 shows that given higher SBN populations (5.7 – 14.4 eggs cm^{-3}), mean beet yields increased from 18.3 ton/ac with no treatment (0.0 gal) up to 23.1 ton/ac applying a full-label rate of Telone II (14.4gal). Mean yields between rates, given the higher SBN category were statistically different (α = 0.10), with the exception of the 22.7 ton/ac yield (9.5 gal) vs. the 23.1 ton/ac yield (14.4 gal).

As expected, beet yields given lower (Table 3) vs. higher (Table 4) SBN counts are numerically higher and are statistically higher (α = 0.05) as well. In addition, higher SBN counts appear to create more yield variability, e.g. given no control, CV = 0.304 with higher populations (Table 4) vs. CV = 0.134 with lower populations (Table 3). Finally, given higher egg counts, yield variability (CVs) appear to be lowered with higher rates of Telone II (Table 4).

Results

Using yield data from Tables 3 and 4, net returns are estimated (Table 5) for each of the four treatment rates of Telone II, given either low (1.1 – 5.7 eggs cm^{-3}) or high (5.7 – 14.4 eggs cm^{-3}) populations. Net return for this purpose is defined as gross return from an acre of sugar beets (yield x price), minus specified costs for fumigant material and application as well the extra cost of harvesting/hauling higher yielding beets .

Table 5 shows that given a low SBN population (1.1 – 5.7 eggs cm^{-3}), not applying Telone II (0.0 gal) yields by far the highest net return ($954/ac). Added beet yields from using

Telone II at any of the specified rates were insufficient to cover additional treatment costs. Within the higher SBN category (5.7 – 14.4 eggs cm^{-3}), the lower supplemental label rate (9.5 gal) provided the highest net return ($678/ac), exceeding non-use by $38/ac ($678 vs. $640). Although the full-label rate (14.4 gal) supplied a slightly higher yield (23.1 ton/ac) than the lower 9.5 gal/ac supplemental rate (22.7 ton/ac), the added cost of extra Telone II far outweighed the extra revenue. The 7.2 gal half-rate resulted in the poorest net return ($600/ac). In summary, these results suggest (1) not treating those portions of a field having SBN counts below a threshold of 5.7 eggs cm^{-3}, and (2) applying the supplemental rate (9.5 gal/ac) over portions of the field having SBN counts exceeding 5.7 eggs cm^{-3}.

To assess the benefit of variable (vs. uniform) rate application, the added per acre costs associated with a variable rate approach were estimated. These costs are expected to vary considerably from one field situation to the next. Table 6 details the estimated added cost ($17/ac), for implementing a variable rate application on the 39-acre field in Southeastern Wyoming , within which the experimental plots were located. The total $17/ac variable application was comprised of: (1) an added application charge for variable vs. uniform rate ($3.00/ac), (2) soil sampling for nematodes ($2.80/ac), (3) lab analysis ($4.00/ac), (4) mapping and consultation ($2.28/ac) and (5) service provider overhead ($4.92/ac).

Average net return for variable rate application is estimated in Table 7, and compared to the net return associated with any of the uniform rate options (0.0, 7.2, 9.5 or 14.4 gal/ac) as derived above. The net return associated with a variable rate application in Table 7 (col. 1), is based on: (1) selecting the best uniform rate (0.0, 7.2, 9.5 or 14.4 gal/ac) and associated net return for acreage that is lightly infested (1.1 – 5.7 eggs cm^{-3}), and similarly the best rate and net return for heavily infested acreage (5.7 – 14.5 eggs cm^{-3}); and then (2) calculating a weighted average of the two optimum net return values, based on a field's respective proportions of infestation. As noted above in this case, the highest net return (given light infestation) is associated with not applying Telone II ($954/ac); and the best choice (given heavier infestation) is applying the supplementary label rate of 9.5 gal/ac ($658/ac).

Table 7, depicts an average field situation of SBN infestation (50% light and 50% heavy). After accounting for an additional $17/ac charge, a variable rate application (col. 1) offers the highest average net return ($799/ac), but only by a very narrow $2 per acre margin over no treatment ($797/ac). The variable rate also generates a higher net return ($799) than the best uniform rate of 9.5 gal/ac ($763/c), representing a margin of benefit of $36/ac ($799 - $763). The margins of benefit for variable rate over the remaining uniform rates (7.2 and 14.4 gal) are even larger ($69 and $50/acre respectively).

To assess the impact of infestation intensity on variable rate feasibility, two different field situations are featured in Table 8. The first is a more lightly infested field with most of the acreage (80%) having low SBN counts (1.1– 5.7 egg cm^{-3}), and remainder (20%) having high SBN counts (5.7–14.5 egg cm^{-3}). With a lightly infested field, no control over the entire field (col. 2) offered the best average net return ($891). The next closest is a variable rate application. Specifically, after accounting for the additional $17/ac charge, variable rate is $9/ac worse than no control ($882 vs. $891/ac) However, if no control for "an entire" field is not acceptable, and it is judged necessary to apply Telone II, a variable rate is shown to be a better choice than any of the uniform rates. Specifically, the variable rate generates a higher net return ($882) than the best (9.5 gal/ac) uniform rate ($815), thus yielding an $67/ac margin of benefit ($882 - $815). In similar manner, the margin of benefit from variable rate over the remaining uniform rates (7.2 and 14.4 gal) are even larger ($73 and $69/acre respectively).

The second field, a mirror opposite, is more heavily infested, with most of its acreage (80%) having high egg counts. Table 8 shows that given a heavily infested field, variable rate is better than not treating, by a margin of $13/ac ($716 vs. $703). However, the margin of benefit from using variable rate technology relative to uniform application decreases with a more heavily infested field. For example, using a uniform 9.5 gal/ac rate as a base (col. 4), the margin of benefit from variable application declines from $67/ac (lighter infestation), to only $4/ac (heavier infestation). Likewise, given a full-label rate of 14.4 gal/ac, the margin of benefit decreases from $69/ac to only $31/ac. The potential for wasted input from blanket applications is greatest when nematodes affect a only smaller part of a field, however, when most of the field is heavily infested, the additional cost of variable application may not be worthwhile.

Conclusion

The main purposes of this study was to examine the feasibility of adjusting Telone II application rates to a wide variety of nematode populations. The identification of optimum Telone II rates in this study was limited to only two categories of infestation, either low or high, as opposed to perhaps three or four, as originally anticipated. The data in this case produced a large degree of unexplained yield variation, beyond that which could be accounted for by the effects of the Telone treatments per se. It is possible that the tendency for higher egg counts to be located in the upper portions of the 39-acre experimental field (having perhaps less productive soil), may have confounded the effect of nematodes reducing the yield of sugar beets. In addition, more data points containing heavier concentrations of nematodes may have revealed more potential yield damage, and hence greater yield benefits from Telone II, than what was evident in this case.

The lower supplemental label rate (9.5 gal/ac) clearly emerged as the best uniform rate yielding the highest net return when nematode populations were above 5.7 eggs cm^{-3}. Conversely, the 7.2 gal/ac half-rate was the poorest with heavier SBN populations, producing yields that were not much better than no control. Similarly, the extra yield and revenue benefit of full label 14.4 gal/ac rate versus the supplemental 9.5 gal/ac rate was small, and not worth the extra cost. It is interesting to note that in actual practice, the 9.5 gallon rate is used extensively by sugar beet growers in this region.

The benefits of using variable rate technology for applying nematicide for sugar beets are unclear from this analysis. An important issue concerns the consequences of not applying Telone II. If a grower prefers to apply Telone II, (for biological or other personal reasons) the margin of benefit from variable rate application appears to be substantial with fields having a relatively low percentage of infestation. However, the margin of benefit becomes more modest if a larger portion of the field contains heavier SBN populations. In this case a blanket application without the extra cost of precision application, may be more economical. If a grower views non-use of Telone II as a viable option, it may be difficult to justify the extra cost of variable rate technology from the standpoint of achieving maximum net return. The limited yield response from treatments in this experiment did not always match the high input cost of Telone II.

This analysis considers profit-maximization as the sole basis for decision-making. Yet variable rate may be more attractive than portrayed here if production risk is a consideration, or if higher threshold yields are desirable for meeting needed production targets for processors. Also, it is extremely important to note that the benefits of reducing the pesticide load in the environment is an important factor, which is not easily measured or considered in this analysis.

Table 1. Configuration of experimental plots (#1 - #24) with respect to nematode populations (eggs cm^{-3}); 4 rates of Telone II (0.0, 7.2, 9.5 and 14.4 gal/ac) and resulting sugar beet yields (t/A).

0.0 gal/ac	7.2 gal/ac	9.5 gal/ac	14.4 gal/ac	0.0 gal/ac	7.2 gal/ac	9.5 gal/ac	14.4 gal/ac	0.0 gal/ac	7.2 gal/ac	9.5 gal/ac	14.4 gal/ac
Block 1 (13.1 eggs cm^{-3})				**Block 2 (8.0 eggs cm^{-3})**				**Block 3 (4.8 eggs cm^{-3})**			
11.1 t/A	14.3 t/A	23.3 t/A	13.7 t/A	22.7 t/A	22.7 t/A	27.1 t/A	23.3 t/A	19.3 t/A	17.3 t/A	24.3 t/A	27.2 t/A
Block 4 (7.8 eggs cm^{-3})				**Block 5(14.5 eggs cm^{-3})**				**Block 6 (6.9 eggs cm^{-3})**			
16.6 t/A	18.6 t/A	25.9 t/A	21.3 t/A	22.9 t/A	28.8 t/A	17.4 t/A	21.1 t/A	22.7 t/A	19.6 t/A	23.0 t/A	24.4 t/A
Block 7 (12.4 eggs cm^{-3})				**Block 8 (6.2 eggs cm^{-3})**				**Block 9 (6.2 eggs cm^{-3})**			
12.7 t/A	10.5 t/A	15.3 t/A	20.6 t/A	16.2 t/A	17.3 t/A	28.8 t/A	17.3 t/A	14.2 t/A	15.9 t/A	21.9 t/A	24.9 t/A
Block 10 (7.5 eggs cm^{-3})				**Block 11 (10.1 eggs cm^{-3})**				**Block 12 (4.6 eggs cm^{-3})**			
9.7 t/A	14.9 t/A	9.0 t/A	19.3t/A	18.3 t/A	18.3 t/A	23.3 t/A	28.7 t/A	29.1 t/A	27.4 t/A	22.4 t/A	36.4 t/A
Block 13 (4.0 eggs cm^{-3})				**Block 14 (5.4 eggs cm^{-3})**				**Block 15 (5.7 eggs cm^{-3})**			
22.0 t/A	31.7 t/A	29.7 t/A	31.1 t/A	30.1 t/A	27.5 t/A	25.7 t/A	34.2 t/A	28.8 t/A	24.9 t/A	33.9 t/A	26.5 t/A
Block 16(9.1 eggs cm^{-3})				**Block 17 (2.5 eggs cm^{-3})**				**Block 18 (2.4 eggs cm^{-3})**			
26.7 t/A	28.5 t/A	29.8 t/A	32.3 t/A	29.4 t/A	26.5 t/A	24.7 t/A	23.4 t/A	27.7 t/A	27.4 t/A	30.1 t/A	26.2 t/A
Block 19 (4.7 eggs cm^{-3})				**Block 20 (2.1 eggs cm^{-3})**				**Block 21 (1.1 eggs cm^{-3})**			
27.0 t/A	25.1 t/A	26.0 t/A	25.0 t/A	27.1 t/A	26.8 t/A	27.5 t/A	35.5 t/A	30.7 t/A	29.5 t/A	30.5 t/A	26.0 t/A
Block 22(3.0 eggs cm^{-3})				**Block 23 (2.1 eggs cm^{-3})**				**Block 24 (5.7 eggs cm^{-3})**			
23.4 t/A	36.1 t/A	28.1 t/A	30.1 t/A	32.3 t/A	26.2 t/A	27.6 t/A	28.3 t/A	26.0 t/A	27.4 t/A	27.0 t/A	30.4 t/A

Table 2. Regression results relating loss of beet yield as a function of nematode populations

Items	0.0 gal/ac	7.2 gal/ac	9.5 gal/ac	14.4 gal/ac
Intercept (ton/ac)	29.9	29.2	30	31.2
Slope (eggs / ton)	-1.137	-0.923	-0.789	-0.812
R^2	0.38	0.27	0.28	0.27

Table 3.. Sugarbeet yields (ton/ac) associated with lower category of (SBN) populations (1.1 –5.7 eggs/cm^3), given four selected rates of Telone II (gal/ac).

(Obs. /Block No.)	Spring SBN count (eggs/cm^3)	(1) Beet yield 0.0 gal.ac (ton/ac)	(2) Beet yield 7.2 gal/ac (ton/ac)	(3) Beet yield 9.5 gal/ac (ton/ac)	(4) Beet yield 14.4 gal/ac (ton/ac)
(1) Block 21	1.1	30.7	29.5	30.5	26.0
(2) Block 20	2.1	27.1	26.8	27.5	35.5
(3) Block 23	2.1	32.3	26.2	27.6	28.3
(4) Block 18	2.4	27.7	27.4	30.1	26.2
(5) Block 17	2.5	29.4	26.5	24.7	23.4
(6) Block 22	3.0	23.4	36.1	28.1	30.1
(7) Block 13	4.0	22.0	31.7	29.7	31.1
(8) Block 12	4.6	29.1	27.4	22.4	36.4
(9) Block 19	4.7	27.0	25.1	26.0	35.0
(10) Block 03	4.8	19.3	17.3	24.3	27.2
(11) Block 14	5.4	30.1	27.5	25.7	34.2
(12) Block 15	5.7	28.8	24.9	33.9	26.5
	Mean	27.2	27.2	27.5	29.2
	Std. Dev.	3.7	4.2	3.1	4.1
	C.V.	0.134	0.155	0.111	0.141

Table 4.. Sugarbeet yields (ton/ac) associated with higher category of (SBN) populations (5.7 –14.4 eggs/cm^3), given four selected rates of Telone II (gal/ac).

(Obs. /Block No.)	Spring SBN count (eggs/cm^3)	(1) Beet yield 0.0 gal.ac (ton/ac)	(2) Beet yield 7.2 gal/ac (ton/ac)	(3) Beet yield 9.5 gal/ac (ton/ac)	(4) Beet yield 14.4 gal/ac (ton/ac)
(13) Block 24	5.7	26.0	27.4	27.0	30.4
(14) Block 08	6.2	16.2	17.3	28.8	17.3
(15) Block 09	6.2	14.2	15.9	21.9	24.9
(16) Block 06	6.9	22.7	19.6	23.0	24.4
(17) Block 10	7.5	9.7	14.9	9.0	19.3
(18) Block 04	7.8	16.6	18.6	25.9	21.3
(19) Block 02	8.0	22.7	22.7	27.1	23.3
(20) Block 16	9.1	26.7	28.5	29.8	32.3
(21) Block 11	10.1	18.3	18.3	23.3	28.7
(22) Block 07	12.4	12.7	10.5	15.3	20.6
(23) Block 01	13.1	11.1	14.3	23.3	13.7
(24) Block 05	14.5	22.9	28.8	17.4	21.1
	Mean	18.3	19.7	22.7	23.1
	Std. Dev.	5.6	5.7	5.8	5.2
	C.V.	0.304	0.288	0.257	0.225

Table 5. Net return response to four rates of nematicide (gal/ac), based on experimental beet yields (ton/ac) and two categories of nematode populations, low (1.1 - 5.7 cm^{-1}) and high (5.7 – 14.5 cm^{-1}).

SBN egg cm^{-3}	**Telone Rate** gal/ac	**Beet Yield**[a/] ton/ac	**Crop Value**[b/] $/ac	**Telone Cost**[c/] $/ac	**Apply Telone**[d/] $/ac	**Harvest & Haul Beets**[e/] $/ac	**Total Specified Costs** $/ac	**Net Return** $/ac
1.1 - 5.7	0	27.2	1,090	0	0	136	136	**954**
	7.2	27.2	1,088	75	16	136	227	861
	9.5	27.5	1,102	99	16	138	253	849
	14.4	29.2	1,167	150	16	146	312	855
5.7 – 14.5	0	18.3	732	0	0	92	92	640
	7.2	19.7	790	75	16	99	190	600
	9.5	22.7	906	99	16	113	228	**678**
	14.4	23.1	925	150	16	116	282	643

[a/] Average beet yields associated with four alternative Telone rates (0 to 14.4 gal/ac); and two categories of nematode populations were derived in Tables 3 and 4.
[b/] Crop value based on sugar beet yield times a 10-year (1990-99)average price of $40/ton (Wyoming Agric. Stat).
[c/] Cost of material for Telone II is designated rate times price ($10.43/gal)..
[d/] Application cost is based on a $16/ac rate (using bedder).
[e/] Harvesting & hauling cost is based on beet yield times custom rate of $5/ton (Hewlett, Crews, and Olson, 2000).

Table 6. Cost of Variable Rate Application: 39 ac Field and Per Acre.[a]

		$ / 39 ac field	**$ / acre**
Added Application charge			$3.00
Data Collection			
(1 sample / 3 ac)		109	2.80
Lab Analysis	$12/sample		
x	13 samples	156	4.00
Mapping and Consultation			
Labor		50	1.28
GIS		39	1.00
Overhead		192	4.92
	TOTAL COST PER ACRE		**$17.00**

[a] Cost estimates provided by Simplot are unique to this particular 39-acre field situation, and can vary considerably from field to field.

Table 7. Average net return and margin of benefit ($/ac) from variable vs. uniform rate applications, given: (1) 50% of field is lightly infested (1.1– 5.7 egg cm^{-3}) and (2) 50% is heavily infested (5.7–14.5 egg cm^{-3})

Items	Pct. of acres by category of infestation	Net return by type of application ($/ac)[a/] (1) Variable	(2) None	(3) 7.2 gal	(4) 9.5 gal	(5) 14.4 gal
Light SBN (1.1-5.7 eggs cm^{-3})	50%	954	**954**	861	849	855
Heavy SBN (5.7-14.5 eggs cm^{-3})	50%	678	640	600	**678**	643
Wt. avg. net return, without added cost of variable application	--	816	797	730	763	749
Cost of var. rate applic.	--	-17	--	--	--	--
Average net return	--	799	797	730	763	749
Margin of benefit: variable rate over uniform rate application	--	--	2	69	36	50

[a/] Uniform rate net returns (2 – 5) are from Table 5. Variable rate net return (1) is the highest of the uniform rates (2-5)

Table 8. Average net return and margin of benefit ($/ac) from variable vs. uniform rate applications, given: (1) lightly infested field (20% low SBN & 80 % high SBN) or (2) heavily infested field (80% high SBN & 20% low SBN).

Items	Pct. of acres by category of infestation	Net return by type of application ($/ac)[a/] (1) Variable	(2) None	(3) 7.2 gal	(4) 9.5 gal	(5) 14.4 gal
(1) LIGHTLY INFESTED FIELD						
Low SBN (1.1-5.7 eggs cm^{-3})	80%	954	**954**	861	849	855
High SBN (5.7-14.5 eggs cm^{-3})	20%	678	640	600	**678**	643
Average net return	--	882	891	809	815	813
Margin of benefit: variable rate over uniform rate application	--	--	-9	73	67	69
(2) HEAVILY INFESTED FIELD						
Low SBN (1.1-5.7 eggs cm^{-3})	20%	954	**954**	861	849	855
High SBN (5.7-14.5 eggs cm^{-3})	80%	678	641	600	**678**	643
Average net return	--	716	703	652	712	685
Margin of benefit: variable rate over uniform rate application	--	--	13	64	4	31

[a/] Uniform rate net returns (2 – 5) are from Table 5. Variable rate net return (1) is the highest of the uniform rates (2-5)

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