Trap Cropping for Sugar Beet Nematode Control

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The sugar beet nematode (SBN) (*Heterodera schachtii*) is widespread and one of the most damaging pests of sugar beet (*Beta vulgaris*) (4). Recently, a survey in northwestern Wyoming showed that 57% of fields were infested (3).

Crop rotations are important for the control of the SBN; however, rotations long enough to alleviate the need for nematicides are not practical in many areas due to the lack of adapted and profitable alternative crops. As a result, current U.S. sugar beet (*Beta vulgaris* L.) production relies heavily on nematicides for control of the SBN.

Nematode-resistant cultivars of radish (*Raphanus sativus*) and mustard (*Sinapis alba*), developed in Germany, provide biological control of the SBN (11). These cultivars have been increasingly used in Europe (1) and recently have been evaluated in the U.S. (2,5). Work in Wyoming showed that trap-crop radish is most effective if planted as a second crop after malt barley (*Hordeum vulgare* L.), rather than after dry bean (*Phaseolus vulgaris* L.) or corn (*Zea mays* L.) (7,8). To be effective, trap crops need enough time with adequate temperature and soil moisture to produce an extensive root system (12).

Although trap crops offer a safer alternative to nematicides they must be cost-effective in order to be utilized. Economics of trap crops are improved if (1) they can be grown as a second crop, rather than as a full-season crop; and (2) if they can be fall-grazed, providing low-cost gain for animals. Planting a trap crop following a main crop is more likely to be cost-effective than growing the trap crop for a full season.

One objective of the study was to determine effectiveness of SBN-resistant radish for controlling SBN and maintaining sugar beet yield, compared with control of SBN with nematicide. The other objective was to determine economic feasibility of growing SBN-resistant radish following malt barley or as a full-season crop in a sugar beet rotation.

MATERIALS AND METHODS

Nematode-resistant (trap crop) radish was planted following malt barley harvest on four SBN-infested producer fields: Hefenieder, Worland, WY (HF92), Hefenieder (HF93), Mosegard, Manderson, WY (MS94), and Snyder, Worland, WY (SN94). 'Pegletta' radish was planted on the former and 'Adagio' radish planted on the other fields.

A split-plot design with six replications was used. Main plots (12 x 12 m) were radish-seeded or unseeded. Sub-plots (4 x 12 m) were aldicarb at 0, 2.4, and 4.8 kg ha^{-1}, applied beside the row at sugar beet planting the year following radish production. A grazing study was conducted on a SBN-infested field (Mosegard) in 1994 and in 1994 and 1995 on uninfested fields at the University of Wyoming, Powell Research and

Extension Center. The experimental design of the grazing studies was a randomized complete block with treatments consisting of unseeded, radish grazed or radish ungrazed. After grazing, all plots were fall-plowed. Treatments were replicated three times. Ammonium nitrate was broadcast at 56 kg N ha^{-1}. Radish was seeded at 24 kg ha^{-1}. Sugar beet was grown on all plots the following year. Because of severe hail damage to sugar beet in 1994 at the Hefenieder (HF93) site, sugar beet yields are not reported.

Soil samples were collected for SBN analysis before and after radish and sugar beet crops and at mid-season of the sugar beet crop. From each sub-plot, 200 cm^3 of soil was elutriated and cysts, eggs and juveniles counted. Growing degree days (GDDs) were calculated with a base temperature of 4.4^0C, the lowest temperature for radish growth (10).

Evaluations included radish top growth (dry matter) and sugar beet yield and quality factors. At the Mosegard site, 50 lambs on each block grazed from 13 October to 2 November 1994 on a total of 2.4 ha of radish. At the Powell R&E, 20 lambs grazed each block from 6 October to 14 December in 1994 and from 24 October 1995 to 15 January 1996.

An enterprise systems analysis of a 292-ha farm, representative of the Big Horn Basin in Wyoming, was conducted (6). A typical rotation (sugar beet- malt barley-malt barley) with nematicide was compared with the same rotation in which trap-crop radish was grown following barley. An analysis was done in which radish was either grazed with lambs or left ungrazed before plowing down. Another alternative was the full-season production of trap-crop radish (substituted for one year of malt barley). Prices and yields over the 12-year period (1985-1996) were used to calculate annual returns from sugar beet and malt barley. Results of previous studies in the Big Horn Basin on sugar beet response to trap-crop radish and on lamb performance with fall grazing of radish were used in developing the trap crop alternative budgets. Cash expenses for growing radish as a secondary crop (following barley) was estimated at \$210 ha^{-1} and full-season radish cost was estimated at \$425 ha^{-1}. A 5% rate of return to land was used to determine risk assessment.

RESULTS

Radish growth varied from 622 to 2518 kg ha^{-1} (Table 1). Radish growth was relatively poor at the Snyder (SN94) location due to delayed planting and volunteer barley competition. Barley was not controlled because of a large amount of seed on the soil surface following a severe hail storm.

Initial SBN population among fields varied from 2.9 to 18.3 eggs and/or juveniles cm^{-3}. Reduction in SBN populations with trap-crop radish varied from 22 to 75% (Table 1). Least control was at the SN94 site, where radish growth was least.

Trap-crop radish reduced SBN populations; however, the reduction was significant only at sugar beet harvest (Fig. 1 and 2). Following radish, the SBN remained below the estimated economic damage threshold, 2.8 eggs cm^{-3} (9), longer than in plots without trap crop, allowing sugar beet seedlings to become established while soil populations were low.

Table 1. Effect of radish growth following malt barley on the soil population of sugar beet nematode (SBN), *Heterodera schachtii*.

Site/year[1]	Planting date	GDDs[2]	Radish production	SBN population[3] Initial	Final	SBN reduction
			kg d.m. ha^{-1}	..... no. cm^{-3}		%
HF92	28 July	1758 (+212)	1561	2.9	1.3	55
HF93	12 August	1171 (+46)	1691	18.3	4.5	75
MS94	4 August	1653 (+146)	2518	14.6	4.0	69
SN94	23 August	1054 (+243)	622[4]	3.6	2.8	22

[1]Cooperating producers and locations were: HF=Hefenieder, Worland, WY; MS=Mosegard, Manderson, WY; SN=Snyder, Worland, WY. Year is the year radish was planted.

[2]Calculated with base temperature, 4.4°C.

[3]Initial population determined before radish was seeded and final counts determined after radish terminated growth.

[4]Volunteer barley was not adequately controlled.

Following malt barley, sugar beet yield increased ($P<0.05$), compared to unseeded plots, at the HF92 site (8.7 Mg ha^{-1}) and at the MS94 site (10.9 Mg ha^{-1}) (Fig. 3). Yield differences at the SN94 site were not different ($P>0.05$), most likely due to the poor radish growth and limited SBN control the previous year. Aldicarb significantly increased sugar beet yield only at the MS94 site, where the yield increase was 4.0 Mg ha^{-1} (Fig. 4). There was no additive effect of radish and aldicarb at any of the location-years. Sugar beet yield following radish grazing, compared to ungrazed radish at the MS94 site, did not differ ($P>0.05$, data not shown).

Lambs grazing trap-crop radish in the fall after the crop had gone dormant produced consistently good gains, 0.13 to 0.17 kg day^{-1}, without concentrate or other supplement (Table 2). Averaged over the three location-years, crude protein (CP), acid-detergent fiber (ADF) and neutral-detergent fiber (NDF) were 13.2, 17.6 and 24.5%, respectively (data not shown). Although lower in CP than bud-stage alfalfa, ADF and NDF were lower. Over three location-years, lambs gained 302 kg ha^{-1}.

Results of the enterprise systems analysis are shown in Figure 5. The traditional rotation of growing two crops of barley, a neutral crop with respect to SBN, followed by sugar beet, resulted in an average 4.0% return to land and a rate of return below a 5% target income 5 of 12 years. A substantial economic benefit resulted from substituting trap-crop radish, grown as a second crop following malt barley, for nematicide. The average return increased to 5.8% and the number of years the rate of return fell below target was reduced to 3 of 12 years. Additional benefit accrued if producers grazed lambs in the fall upon maturation of trap-crop radish. Average rate of return to land increased to 9.4% and the number of years below target return decreased to 2 of 12 years. Growing trap-crop radish full season in lieu of a barley crop, compared to the traditional rotation with nematicide, reduced rate of return and increased the number of years below the 5%

target income. This was the result of the higher cost ($425 ha^{-1}) of full-season compared to $210 ha^{-1} for second-crop radish.

These results do not consider possible additional benefits of trap crops, such as erosion control, green manure addition to soil or residual control of SBN through the following rotation. Trap cropping appears to be a major practice for sustaining sugar beet production.

LITERATURE CITED

1. Cooke, D. 1991. Europe goes green to control beet cyst nematode. British Sugar 59(2):44-47.
2. Gardner, J. and E.P. Caswell-Chen. 1993. Penetration, development and reproduction of *Heterodera schachtii* on *Fagopyrum esculentum, Phacelia tanacetifolia, Raphanus sativus, Sinapis alba and Brassica oleracea*. J. Nematol. 25(4):695-702.
3. Gray, F.A. 1995. Distribution and incidence of sugarbeet diseases in the Wind River and Big Horn River Basins of Northwest Wyoming. Univ. of Wyoming Agric. Exp. Sta. Bul. B-1031.
4. Griffin, G.D. 1987. Efficacy of using split and post plant applications of aldicarb for control of *Heterodera schachtii* on sugarbeet. Ann. Appl. Nematol. 1:119-122.
5. Hafez, S.S. and K. Hara. 1989. *Heterodera schachtii* populations can be reduced by planting a trap crop or applying low rates of Temik to rotation crops. J. Sugar Beet Res. 26(1):A10.
6. Jennings, J.W. 1998. Economics of integrating nematode-resistant radishes and lamb enterprises with sugarbeet rotations in Northwest Wyoming. Univ. of Wyoming M.S. Thesis, 186 pp.
7. Koch, D.W. and F.A. Gray. 1997. Nematode-resistant oil radish for control of *Heterodera schachtii*. I. Sugarbeet-barley rotations. J. Sugar Beet Research 34:31-43.
8. Koch, D.W., F.A. Gray and J.M. Krall. 1998. Nematode-resistant oil radish for *Heterodera schachtii* control. II. Sugarbeet-dry bean-corn rotations. J. Sugar Beet Research 35:63-75.
9. Robb, J.G., E.D. Kerr and D.E. Ellis. 1992. Factors affecting the economic threshold for *Heterodera schachtii* control in sugar beet. J. Sugar Beet Research 29:31-43.
10. Roberts, P.A. and I.J. Thomason. 1981. Sugarbeet pest management: Nematodes. University of California, Division of Agricultural Science Special Publ. 3272, 30 pp.
11. Steudel, W. and J. Müller. 1983. Untersuchungen und Modellrechnungen zum Einfluß pflanzenverträlicher Nematizide und nematodenresistenter Zwischenfrüchte auf die Abundanzdynamik des Zucherrubenfruchtfolgen (*Heterodera schachtii*) in Zuckerrübenfruchtfolgen. Zuckerind. 108:365-369.
12. Wilson, R.G., E.D. Kerr, and P. Provance. 1993. Growth and development of oil-radish and yellow mustard in Nebraska. J. Sugar Beet Res. 30:159-167.

Table 2. Forage dry matter production and lamb performance while grazing trap-crop radish.

Location/year	Forage availability[1] Radish	Total	Lamb ADG[2]	Lamb gain ha^{-1}
	...... kg ha^{-1}		kg	kg
Powell, 1994	4701	6647	0.13	293
Powell, 1995	2972	4819	0.15	347
Manderson, 1994	2492	3039	0.17	265
Average	3388	4835	0.15	302

[1]In addition to seeded species, available forage included oat regrowth, volunteer barley and straw stubble from the previous crop.
[2]Average daily gain.

Figure 1. Soil population dynamics for SBN; Hefenieder Farm, Worland, WY; 1992 - 1993.

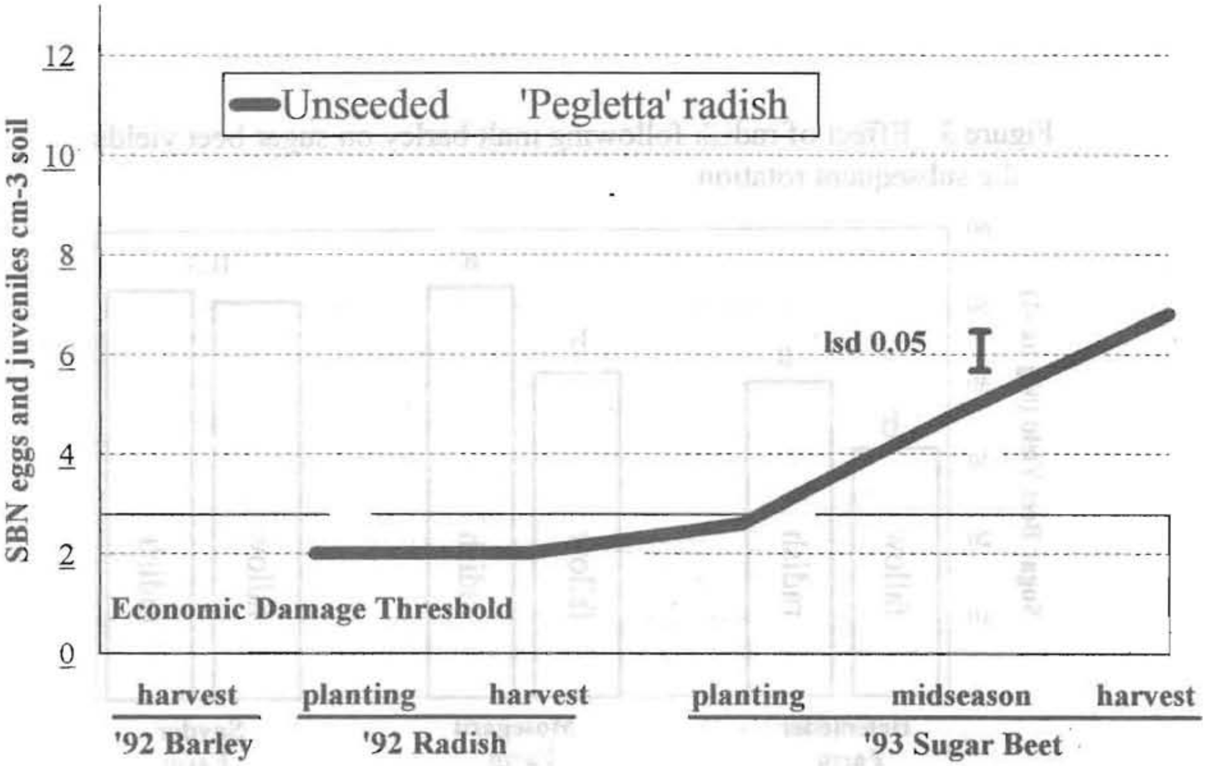


Figure 2. Soil population dynamics for SBN; Mosegard Farm, Manderson, WY; 1994 - 1995.

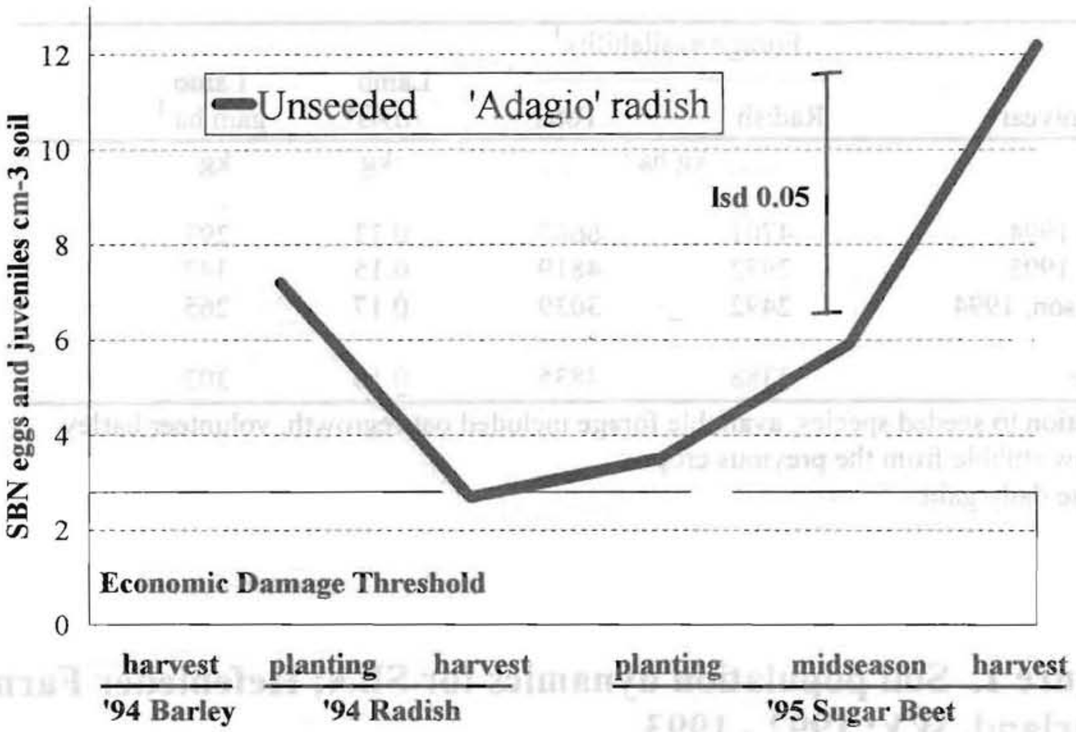


Figure 3. Effect of radish following malt barley on sugar beet yields in the subsequent rotation.

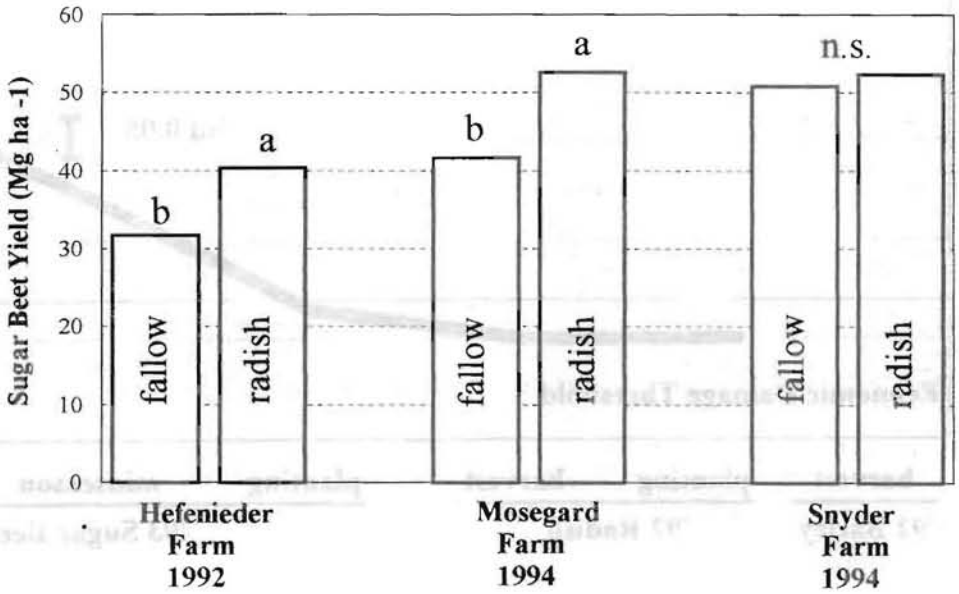
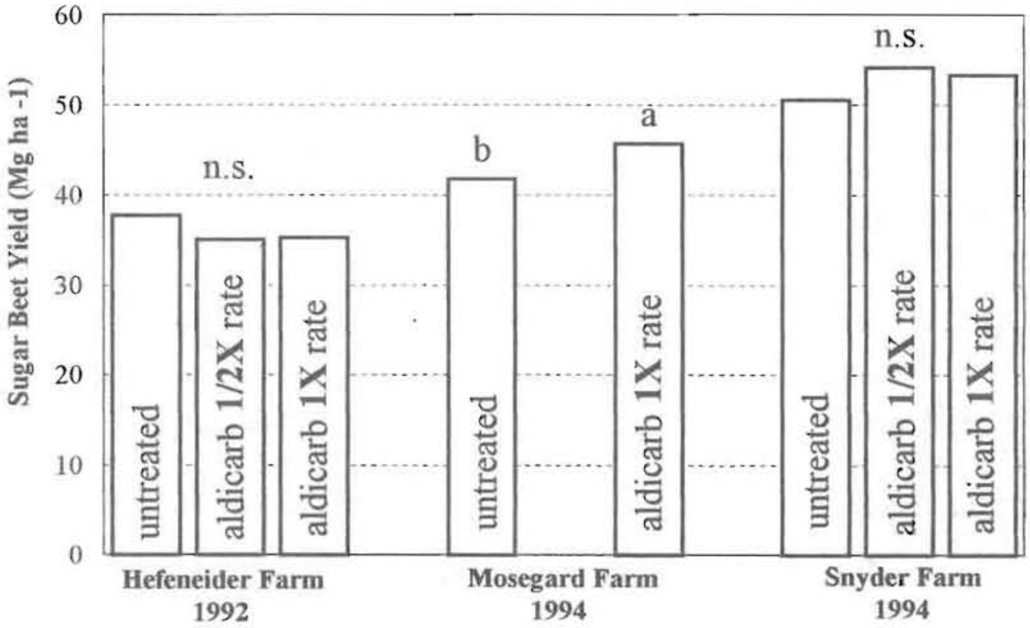


Figure 4. Effect of aldicarb, banded at sugar beet seeding, on sugar beet yields.



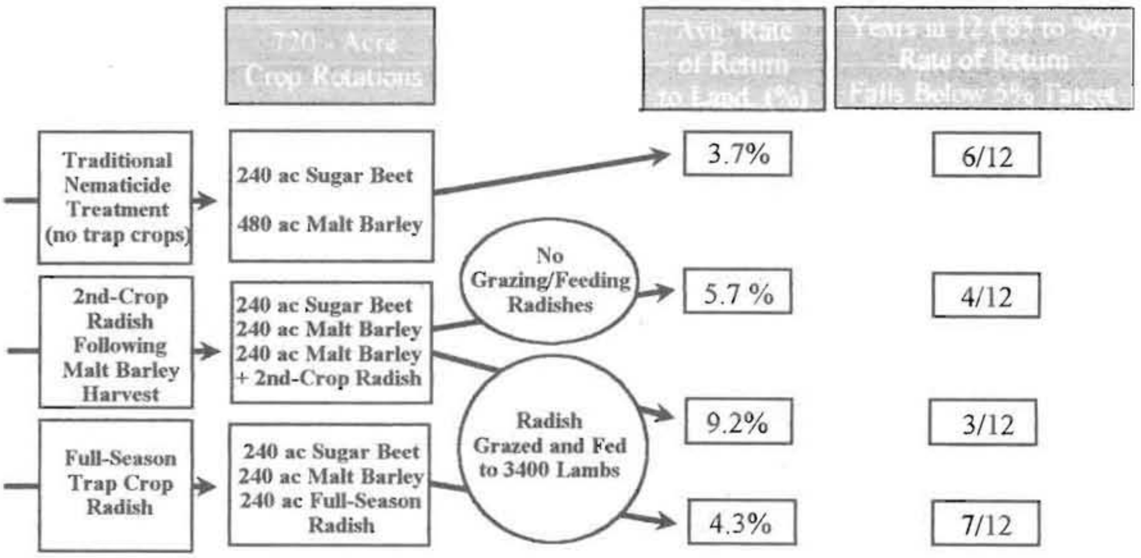


Figure 5. Rates of return and downside risk for alternative farming systems, either with or without trap crop radish.