

EFFICACY OF GENETIC CONTROL AND CHEMICAL CONTROL FOR MANAGING WHITE RUST IN SPINACH, 1998: A field experiment was conducted at the Long Island Horticultural Research Laboratory in Riverhead, NY, on Riverhead sandy loam soil. White rust developed in this field in 1996 and 1997. Rows of Seven R spinach were planted on 8 Jun and 22 Jul along two sides and through the center of the field to provide an opportunity for white rust to become established before the experiment was conducted. Plants in the second planting were inoculated with a spore suspension using a pressurized garden sprayer during a light rain on 18 Aug. The suspension was prepared from infected leaves collected from this field and frozen before disking in June. Fertilizer (1000 lb/A of 10-10-10) was broadcast and incorporated on 22 Jun. The experimental plots were planted on 26 Aug. Weeds were controlled by disking before planting, applying Ro-Neet 6E (1.5 qt/A) on 25 Aug, and hand weeding. Ridomil Gold (1 pt/A) was applied with Ro-Neet to control damping-off. Average monthly high and low temperatures (F) were 79/61 in Sep and 65/51 in Oct. Rainfall (in.) was 3.03 and 2.35 for these months, respectively. To provide conditions favorable for disease development, a sprinkler irrigation system that delivers 0.08 in/hr was run for 2 hr during early evening on 6, 24, and 19 Oct. Beet armyworm and cabbage looper were managed by applying Larvin 3.2 (24 oz/A) on 11 Sep, 8 Oct and 19 Oct. The 18 treatments consisted of three varieties and six fungicide programs arranged in a factorial design with four replications. Seven R (Asgrow Seed Co.) is susceptible to white rust; Fall Green (Alf Christianson Seed Co.) and Vancouver (Asgrow Seed Co.) are moderately resistant. Plots were three 25-ft rows spaced 17 in. apart on raised beds. Fungicides were applied on 27 Sep; 4, 12, 19, and 26 Oct; and 4 Nov with a CO₂-pressurized backpack sprayer and hand-held boom equipped with three Blue XR TeeJet (8003VS) nozzles spaced 17 in. apart that delivered 40 gpa at 50 psi. For the Kocide and Aliette treatment, Kocide was applied on the first three dates then Aliette was applied on the last three dates. Harvesting was done from 9 - 19 Nov using two methods. For fresh market spinach harvest, at least 25 plants were cut at the soil line from each plot. White rust severity was recorded for each expanded leaf on each of five plants. Plants with white rust were counted. Leaves with white rust or chlorotic/necrotic tissue were removed, categorized, counted and weighed. The categories were: B Grade due to white rust (total lesion size of at least 0.75 in. diam), A Grade with white rust (total lesion size less than 0.75 in.), and B Grade other (25% of tissue not green for reasons other than disease). Leaf tissue with no white rust also was weighed. For processing spinach harvest, leaves were cut with hand-held clippers two in. above the soil line from 6 ft of row. Leaves were separated into three categories (A Grade, B Grade due to disease and B Grade other), then weighed. The overall quality of the cut leaves for each plot was rated A, B, or substandard if the weight of B Grade leaves was less than 5% of the total yield, greater than 5%, or greater than 12%, respectively. Economic benefit of each fungicide program was calculated by subtracting the value of the nontreated crop from the net return for the treated crop (net return = crop value minus treatment cost). Prices used to calculate crop value were \$7.16 for a 25-lb crate of fresh market spinach, \$175/T for A grade processing spinach, and \$145/T for B grade processing spinach. Substandard spinach was priced the same as B grade; a processor could choose to reject it. Fungicide costs/A were \$3.30 for Kocide, \$18.90 for Aliette, \$6.38 for Maneb, and \$4.75 for Syllit. Treatment cost included \$6.60/A to make an application. In addition to conducting a standard analysis of variance, planned comparisons were conducted between each nontreated resistant variety and Seven R treated with Kocide + Aliette, a standard commercial fungicide program.

Disease pressure was high. White rust was first observed in most plots on 4 Oct. It became quite severe, especially on nontreated Seven R. Both chemical control (fungicides) and genetic control (host plant resistance) significantly reduced white rust severity, incidence and % B Grade yield. Impact of control practices on severity was often greater than on Grade A yield because leaves severely affected by white rust and leaves with just one large lesion were both considered Grade B. For example, rust severity was 25 times greater on non-treated Seven R than on Syllit-treated Seven R whereas percent of fresh market yield that was B Grade due to rust was only 11 times greater. Varieties differed significantly in total yield (T/A), with susceptible Seven R producing the most. Syllit, which has a tolerance on spinach, but is not registered on the crop, was the most effective fungicide and one of the least expensive (\$68/A for 6 applications). Maneb, which is no longer registered, was the overall next best fungicide. Kocide, which is registered, suppressed white rust but did not improve yield compared to the control. Economic benefit of the fungicide programs was greater for Seven R than for the resistant varieties. There was economic benefit to treating resistant varieties grown for fresh market but not when grown for processing. The percent B grade processing spinach for all treatments was greater than 12% and resulted in substandard rating. Chemical control and genetic control were equally effective. Susceptible Seven R treated with Kocide + Aliette produced a similar amount of A grade fresh market spinach as nontreated Fall Green ($p=0.79$) and nontreated Vancouver ($p=0.44$).

(Continued)

| Variety | Treatment & rate/A | Fresh market spinach yield | | | | | | Processing spinach yield | | | |
|---------------------------|-------------------------------|----------------------------|-----------------------------|-------------|-------------------------------|-------------------|------------------------|--------------------------|-------------|---------------|------------------------|
| | | Rust Severity ¹ | Rust incidence ² | Total (T/A) | B Grade rust (%) ³ | A Grade (crate/A) | Fungicide Benefit (\$) | Total (T/A) | B Grade (%) | A Grade (T/A) | Fungicide Benefit (\$) |
| | Control | 3.4 | 84 | 10.7 | 25 | 558 | | 4.9 | 54 | 2.3 | |
| | Kocide LF 1qt | 0.8 | 35 | 10.0 | 8 | 505 | -439 | 4.6 | 46 | 2.4 | -103 |
| | Aliette 80WDG 3 lb | 2.2 | 80 | 11.6 | 16 | 647 | 504 | 5.5 | 52 | 2.6 | -46 |
| | Kocide 1 qt, Aliette 2 lb ... | 0.6 | 36 | 12.1 | 5 | 650 | 553 | 4.5 | 48 | 2.3 | -164 |
| | Maneb 75DF 2.1 lb | 0.2 | 29 | 11.5 | 4 | 671 | 731 | 5.7 | 44 | 3.0 | 38 |
| | Syllit 65W 0.5 lb | 0.2 | 13 | 10.5 | 2 | 780 | 1,521 | 5.7 | 31 | 3.8 | 48 |
| Seven R | | 2.0 | 62 | 12.0 | 20 | 671 | | 5.6 | 62 | 2.3 | |
| Vancouver | | 0.7 | 44 | 11.3 | 6 | 629 | | 5.3 | 48 | 2.7 | |
| Fall Green | | 0.6 | 32 | 9.9 | 4 | 606 | | 4.5 | 27 | 3.2 | |
| Seven R | Control | 10.2 | 98 | 10.0 | 44 | 569 | | 4.4 | 65 | 1.7 | |
| Seven R | Kocide | 1.5 | 54 | 11.4 | 13 | 522 | -396 | 5.3 | 60 | 2.2 | 71 |
| Seven R | Aliette | 4.8 | 100 | 13.7 | 38 | 626 | 275 | 5.9 | 78 | 1.3 | 84 |
| Seven R | Kocide, Aliette | 0.9 | 51 | 12.2 | 12 | 619 | 252 | 4.5 | 67 | 1.5 | -92 |
| Seven R | Maneb | 0.7 | 51 | 11.6 | 10 | 781 | 1,440 | 7.0 | 68 | 2.3 | 299 |
| Seven R | Syllit | 0.4 | 18 | 13.2 | 4 | 908 | 2,359 | 6.8 | 32 | 4.6 | 280 |
| Vancouver | Control | 1.8 | 82 | 10.1 | 17 | 520 | | 5.4 | 58 | 2.2 | |
| Vancouver | Kocide | 0.4 | 25 | 10.3 | 6 | 451 | -553 | 4.0 | 51 | 1.9 | -262 |
| Vancouver | Aliette | 0.9 | 63 | 12.7 | 4 | 663 | 891 | 6.2 | 45 | 3.6 | -17 |
| Vancouver | Kocide, Aliette | 1.2 | 49 | 11.8 | 3 | 751 | 1,548 | 5.2 | 48 | 2.5 | -135 |
| Vancouver | Maneb | 0.1 | 28 | 13.2 | 1 | 630 | 710 | 5.5 | 44 | 2.9 | -63 |
| Vancouver | Syllit | 0.2 | 18 | 9.6 | 2 | 762 | 1,665 | 5.8 | 44 | 2.9 | -10 |
| Fall Green | Control | 1.7 | 71 | 11.9 | 13 | 585 | | 4.9 | 40 | 2.9 | |
| Fall Green | Kocide | 0.7 | 26 | 8.4 | 5 | 543 | -360 | 4.5 | 27 | 3.1 | -117 |
| Fall Green | Aliette | 2.1 | 78 | 8.4 | 7 | 651 | 339 | 4.5 | 31 | 3.0 | -191 |
| Fall Green | Kocide, Aliette | 0.0 | 7 | 12.4 | 0.5 | 581 | -135 | 3.9 | 28 | 2.8 | -251 |
| Fall Green | Maneb | 0.0 | 7 | 9.8 | 0 | 603 | 51 | 4.6 | 21 | 3.6 | -121 |
| Fall Green | Syllit | 0.0 | 3 | 8.7 | 0 | 670 | 540 | 4.6 | 16 | 3.8 | -112 |
| ANOVA analyses (p-values) | | | | | | | | | | | |
| Replication | | 0.0003 | 0.0001 | 0.0001 | 0.0001 | 0.0018 | | 0.0253 | 0.0001 | 0.0079 | |
| Variety | | 0.0001 | 0.0001 | 0.0176 | 0.0001 | 0.4533 | | 0.0098 | 0.0001 | 0.0142 | |
| Fungicide | | 0.0001 | 0.0001 | 0.3021 | 0.0001 | 0.0102 | | 0.0699 | 0.0139 | 0.0115 | |
| Variety X Fungicide | | 0.0854 | 0.2873 | 0.1004 | 0.0615 | 0.7064 | | 0.3546 | 0.3953 | 0.1199 | |

¹ Average white rust severity (0-100) on 5 oldest leaves.² Incidence of plants with white rust at harvest.³ Percentage of leaves that were B grade because of white rust.