Profitability of Fungicide, Insecticide and Nematicide Seed Treatments for Spring Wheat

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SYNOPSIS

Pathogenic fungi and nematodes reduce wheat yields in the Pacific Northwest. Seed treatment fungicides, insecticides and nematicides were evaluated in 13 spring wheat trials over three years. During 2011, averaged over four locations in three PNW states, the mean wheat yield and net profit were increased by treating seed with fungicides and insecticide, compared to planting untreated seed. Treatment with Dividend Extreme + Rancona + Cruiser increased the yield by 6.7 bu/acre, for a net profit of $55.49/acre. Treatment with Proceed Concentrate improved yield by about 5.9 bu/acre and the addition of Poncho led to a further increase of 4.6 bu/acre. The remarkable benefit of seed treatment was clearly demonstrated even when there were no recognized pathogens on the crops in some fields. Newer chemical and biological nematicides (Avicta & Votivo) had little effect on yield when they were added to the basic fungicide plus insecticide seed treatments. In contrast, when the nematicide Temik was banded with the seed the mean grain yield was increased by an additional 8.8 bu/acre during 2010 (four trials at Pendleton) and by 18.5 bu/acre during 2011 (four trials in three states). This unregistered use of Temik vividly demonstrated the urgent need to find more profitable ways to reduce the impact of nematodes in fields where these pests are present. Management of fungal pathogens by seed protectants remains essential and management of nematodes will have to await the development of additional products, or to rely upon crop rotation and genetic resistance.

Most wheat fields in the PNW are infested by soilborne plant pathogenic fungi that cause root diseases. Primary diseases of importance on spring wheat include Fusarium crown rot, take-all, Rhizoctonia root rot, and Pythium damping-off and root rot. Nearly all wheat seed in the PNW is treated with protective fungicides and often also with an insecticide. Seed treatments most commonly applied include broad-spectrum fungicides plus a suppressant of *Pythium* species. These fungicide mixtures are often supplemented with an insecticide to suppress early-season damage from wireworm, Russian wheat aphid, or other pests.

Root-lesion nematodes (*Pratylenchus neglectus* and *P. thornei*) are present as individual or mixed populations in a majority of the dryland fields in low-rainfall regions. The cereal cyst nematode (*Heterodera avenae*) is less widespread but occurs in some production areas in at least seven western states. Each of these three plant-parasitic nematodes substantially reduces grain yields of spring and winter wheat and, together, they reduce the farm-gate revenue for wheat in the PNW by at least $54 million annually.

Practices recommended for managing nematodes on wheat are currently limited and are generally economically unrealistic

for routine application. These practices include rotations either to crop species that are not typically produced in the region or to multiple-year periods of bare fallow. While there are no resistant varieties or nematicides available for managing these root parasites, some new nematicides had not been evaluated on wheat.

Avicta is a group of compounds (avermectins) that are produced by the fungus *Steptomyces avermitilis*. They are used to control insects and mites on crops and nematodes in animals. Avicta has been evaluated as a seed treatment to manage the impacts of plant-parasitic nematodes affecting corn, cotton and tobacco, and had also been evaluated in the greenhouse as a protectant for cowpea, soybean, tomato and wheat. Avicta generally improved the plant stand but had negligible or variable benefits on crop yield and in reducing the nematode density in soil. Avicta had been evaluated on wheat to control cereal cyst nematode. Results from pot experiments using a sand medium were promising but tests in larger containers filled with infested field soil were marginal.

Votivo is a formulation of the bacterium *Bacillus firmus*. This biological seed treatment is used to protect corn, cotton and soybean roots against invasion by nematodes. Votivo has reduced damage caused by root-knot nematodes. Yield of corn in fields infested with root-lesion nematode was also slightly improved by treating seed with Votivo.

Avicta and Votivo had not been evaluated for their capacity to increase wheat yields in the PNW. The objectives of this research were to determine the potential for these nematicides pesticides to suppress the density of root-lesion nematode and cereal cyst nematode, and to increase the yield of spring wheat. In selected experiments yields from Avicta treatments were compared to Temik treatments that are often used for research purposes. We also compared yields and profitability of spring wheat produced from seed that was either treated or was not treated with protective fungicides and insecticide.

METHODS

Six spring wheat trials were performed near Pendleton, Oregon and seven trials were performed at four other locations in Idaho, Oregon and Washington. Each field was infested with a complex of plant-pathogenic fungi (*Pythium*, *Rhizoctonia* and *Fusarium*) and nematodes. Six or eight replicates of treatments were compared in randomized complete block designs using 5 × 30 ft plots. All seed treatments were applied to a single seed lot each year by either Syngenta Crop Protection or by Bayer CropScience. Hank was the variety used during 2009 and Alpowa was used during 2010 and 2011. A wheat crop preceded each experiment except during 2011 at Mission, where the experiment followed canola. Standard practices were used to apply fertilizer and to control weeds, stripe rust and insects. Seedling emergence was rated about two weeks after planting. Plots were harvested to measure grain yield and test weight. Soils were sampled before planting and after harvest to count and identify nematodes, which was done by Western Laboratories in Parma, Idaho. All data were analyzed for statistical significance.

During 2009 and 2010 five experiments were performed at the OSU Columbia Basin Agricultural Research Center near Pendleton, OR. Different fields were used for trials each year and each field was infested by the root-lesion nematode *Pratylenchus thornei* at densities ranging from 1,300 to 6,900 nematodes per pound of soil. Two fields used during 2009 and 2010 were managed as no-till 3-year rotations of winter wheat, spring wheat, and chemical fallow. During 2010 we also used a field

that had a history of being planted annually to spring wheat without tillage. During 2009 the trial was planted in early May using a John Deere HZ deep-furrow drill equipped with a cone-seeder and four openers at 14-inch spacing. Seed was either not treated or was treated with Dividend Extreme, with or without additional treatments of Cruiser and Avicta. During 2010 four similar experiments with Syngenta products were conducted on two fields. The trials were planted on each field on each of two planting dates; late March and mid-April. Treatments were Dividend Extreme, Dividend Extreme + Cruiser, and Dividend Extreme + Cruiser + Avicta. Temik was placed below the seed in another Dividend Extreme treatment.

During 2011 two trials were conducted in each of four fields near Mission, OR, Cove, OR, Steptoe, WA, and St. Anthony, ID. One trial at each location evaluated Syngenta treatments and an adjacent trial was used to evaluate Bayer treatments. The Syngenta trials included four treatments; 1) untreated seed, 2) seed treated with Dividend Extreme + Rancona + Cruiser, 3) Avicta also added to treatment #2, and 4) Temik banded with the seed treated as in treatment #2. The Bayer trials evaluated seed treated with Proceed Concentrate, either with or without additional treatment with Votivo. These experiments were performed as described during earlier years except we used a locally-fabricated no-till drill that was equipped with a cone-seeder and two Gandy distributors to dispense fertilizer and, in some plots, the Temik. The front tool bar had fluted opening coulters followed by a sweep for deep-banding the fertilizer. A second toolbar had double-disk openers to dispense seed and Temik. Fertilizer was placed 2-inches below and 1.5-inches to each side of the seed row. Temik was placed into the seed row of selected treatments.

Experiments near Mission were near Pendleton on a field that had a high density of root-lesion nematode (1,500 *Pratylenchus neglectus*/lb of soil) and was maintained without tillage as a 3-year rotation of winter wheat, chemical fallow, and canola.

The experiments near Cove were east of La Grande. The field was cultivated, was recently planted annually to winter wheat, and had high densities of both root-lesion nematode (6,180 *P. neglectus*/lb) and cereal cyst nematode (1,300 *Heterodera avenae*/lb).

The experiments near Steptoe were north of Colfax. The field was recently planted annually to spring wheat and had high densities of both root-lesion nematode (1,183 *P. neglectus*/lb) and cereal cyst nematode (1,060 *H. avenae*/lb).

The experiments near St. Anthony were located northeast of Rexburg. The trial area was managed as a 2-year rotation of spring wheat and cultivated fallow. Our trials followed a crop of spring wheat. The site had a low density of root-lesion nematode (410 *P. neglectus*/lb) and a high density of cereal cyst nematode (3,030 *H. avenae*/lb).

The economic impact of all seed treatments was determined from the difference between yields in plots planted with treated seed versus plots planted with untreated seed during 2009 and 2011. The gross profit due to treatment was calculated by multiplying the yield increase (bu/acre) by the mean monthly farm-gate price ($/bu) received by growers in individual states during the month immediately following the harvest at that location. Net profit or loss associated with the yield increase or decrease was calculated using commercial prices for application of the appropriate seed treatments by a commercial seed supplier during the year in which the treatment was applied. Differences in yield associated with the addition of non-commercially available seed treatments such as Avicta or of soil

treatments such as Temik were calculated similarly but it was only possible to calculate gross profit because treatment expenses were not available for calculating net profit for these non-commercial treatments.

FINDINGS

2009 – Pendleton (1 expt). Root-lesion nematode was present but we did not detect any root diseases or insects. Treatment of seed with Dividend Extreme + Cruiser led to a 3.6 bu/acre increase in grain yield, as compared to planting of untreated (bare) seed (Table 1). The additional yield equated to a gross income of $18.04 per acre. The fungicides and insecticide in that treatment package would not have been expected to protect against nematodes. By adding the nematicide Avicta to the basic seed treatment the yield was improved by another 1.9 bu/acre, valued at $9.52. During 2009 the Dividend Extreme and Cruiser were priced individually rather than as a package, as is now common. Due to the previous pricing structure the added value of grain produced did not achieve a net profit during 2009. More recent pricing schedules for package treatments would now make that treatment profitable. The addition of Avicta to the treatment would continue to be unprofitable.

Table 1. Fungicide, insecticide, and nematicide seed treatments (ST) and a soil nematicide (Soil) evaluated over three years on spring wheat in fields infested by pathogenic fungi and nematodes.

						Diff. from control	
Year	Trials	Fungicide ST [a]	Insecticide or nematicide ST [b]	Soil [c]	Yield (bu/acre)	bu/acre	$/acre [d]
2009	Pendleton:	None	None	None	32.2	0	0
	(1 expt)	Dividend Extreme	Cruiser	None	35.8	3.6	18.04
		Dividend Extreme	Cruiser + Avicta	None	37.7	5.5	27.56
2010	Pendleton:	Dividend Extreme	None	None	54.8	0	0
	(4 expts) [e]	Dividend Extreme	Cruiser	None	55.9	1.1	5.62
		Dividend Extreme	Cruiser + Avicta	None	54.9	0.1	5.96
		Dividend Extreme	None	Temik	63.6	8.8	47.02
2011	In 3 states	None	None	None	38.4	0	0
	(4 expts) [f]	Dividend Extreme + Rancona	Cruiser	None	45.0	6.6	55.49
		Dividend Extreme + Rancona	Cruiser + Avicta	None	46.3	7.9	66.52
		Dividend Extreme + Rancona	Cruiser	Temik	56.9	18.5	155.77
2011	In 3 states	Proceed Concentrate	None	None	44.3	0	0
	(4 expts) [f]	Proceed Concentrate	Poncho	None	48.9	4.6	39.10

[a] Fungicide seed treatments included Dividend Extreme 0.96FS (difenoconazole + mefenoxam), Rancona 3.8FS (ipconazole), and Proceed Concentrate 123FS (prothioconazole + tebuconazole + metalaxyl).
[b] Insecticide seed treatments included Cruiser 5FS (thiamethoxam) or Poncho 600FS (clothianidin). Nematicide seed treatment included Avicta 500F (abamectin).
[c] Soil-applied nematicide was Temik 15G (aldicarb).
[d] Gross profit is the value of additional production over the control shown in the top row for each year. Profit was calculated from the mean monthly farm-gate value for soft-white spring wheat during the month following harvest; in OR it was $5.01 in 2009 and $5.25 in 2010, and during 2011 it was $7.31/bu in ID and $8.79/bu in OR and WA.
[e] Means of 4 experiments at Pendleton, OR: 2 planting dates in each of 2 fields.
[f] Means of experiments at 4 locations: St. Anthony, ID, Cove and Mission, OR, and Steptoe, WA.

2010 – Pendleton (4 expts). Seed treated with Dividend Extreme was used as the basis for comparing other treatments (Table 1). Addition of Cruiser increased the grain yield by 1.1 bu/acre ($5.62/acre). Additional treatment with Avicta led to variably higher or lower yields depending on the individual experiment. Overall, there was no net positive influence of Avicta on yield. However, when the unregistered nematicide Temik was banded with the seed the yield was boosted by 8.8 bu/acre ($47.02). This clearly demonstrated the need to find better ways to control the damage that is being caused by root-lesion nematodes. It also showed that older nematicides continue to be valuable for use in research that attempts to determine the potential value of newer nematicides. Application of Temik in our trials provided a conservative estimate of the potential productivity that we 'left on the table' because of root damage caused by the nematode. While this was not a registered use it would have also been grossly unprofitable even if it had been registered, due to the high cost of product we applied during this research. All grain from plots treated with unregistered products must be destroyed.

Table 2. Yield and grain value of spring wheat grown from seed that was planted without treatment (bare) or was treated with Dividend Extreme + Rancona + Cruiser during 2011.

	Yield (bu/acre)			Profit ($/acre)[a]	
Location	Untreated	Treated	Diff.	Gross	Net
Mission, OR	50.3	55.0	4.7	47.00	41.67
Steptoe, WA	47.2	54.2	7.0	70.59	65.25
Cove, OR	24.1	33.4	9.3	92.96	87.63
St. Anthony, ID	31.7	35.6	3.9	32.74	27.41
4-location mean	38.3	45.0	6.7	60.82	55.49

[a] Gross profit is the value of additional production based upon the mean monthly farm-gate value for soft-white spring wheat during the month following harvest; $7.31/bu in Idaho and $8.79/bu in Oregon and Washington. Net profit is the value of increased grain production minus the expense for the seed treatment applied by a commercial seed supplier; $4.09/cwt, or $4.75/acre.

2011 – 3 States (8 expts). Spring wheat grown from seed treated with protectant fungicides was always more productive and more profitable compared to seed that had not been treated with any protectant. Eight trials were conducted at four locations. Four trials were with Syngenta Crop Protection products and four were with Bayer CropScience products. One location was infested by root-lesion nematode (Mission), two sites had cereal cyst nematode as well as root-lesion nematode (Cove and Steptoe), and one site had mostly cereal cyst nematode (St. Anthony).

Seed treated with Dividend + Rancona + Cruiser increased the average yield for the four trials by 6.6 bu/acre (Table 1). The gross value of the extra grain from that treatment would have been $60.82. Because that treatment was available commercially it was also possible to calculate the net profit from seed treatment at each location (Table 2). Overall, treating seed with fungicides and insecticide at four locations during 2011 generated a net profit of $55.49/acre, compared to planting untreated seed. All these plantings were made relatively late for each region during a relatively cool, wet spring. The range of net profit varied from

$27/acre to $88/acre, depending on location. This range presumably reflected different levels of seedling and root injury caused by root pathogens. Our results clearly demonstrated the economic return that can be expected when seed is treated with fungicides and insecticide.

When the nematicide Avicta was added to the basic Dividend Extreme + Rancona + Cruiser treatment the yield was improved by another 1.3 bu/acre ($11.05), which probably would not have been profitable. However, when Temik was banded with seed that had been treated with Dividend Extreme + Rancona + Cruiser the yield was increased by another 11.9 bu/acre ($101.15), providing a conservative estimate of the economic damage that was being caused by the nematodes.

Although the Bayer trials did not include an untreated seed control, the Bayer trials were side-by-side or end-to-end with the Syngenta trials that did include untreated seed. While these comparisons are therefore only approximate due to variability within each field, the treatment of seed with Proceed Concentrate improved yield by about 5.9 bu/acre ($50.15) compared to untreated seed of the same variety in the nearby trials (Table 1). When Poncho insecticide was added to the Proceed Concentrate treatment the yield was increased by another 4.6 bu/acre ($39.10).

During 2011 we also evaluated Votivo, a biological seed treatment nematicide (*Bacillus firmus*), and Movento, a foliarly applied insecticide/nematicide (spirotetramat). Movento was also studied during 2009 and 2010. Neither Votivo nor Movento improved grain yield. They are therefore not reported here. However, Movento did reduce the number of cereal cyst nematode in soil, making it comparable to crop rotations that reduce the density of this nematode in soil.

This research clearly demonstrated the high return that can be expected by treating spring wheat seed with fungicides and insecticides in the PNW. However, all nematicides except the unregistered Temik were of variable or negligible value for suppressing damage by nematodes commonly encountered in our wheat fields. Future emphasis for controlling nematodes should be placed on crop rotations and varieties that are both tolerant and resistant.

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