Research Note

Control of Ergot in Kentucky Bluegrass (*Poa pratensis* L.) Seed Production Using Adjuvants

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ABSTRACT

Spray adjuvants (primarily surfactants and wetting agents) were evaluated for control of *Claviceps purpurea* (Fr.:Fr. Tul.) the causal agent of ergot in an irrigated Kentucky bluegrass (*Poa pratensis* L.) seed production field in north Idaho during 1995 and 1996. Surfactants [Kinetic (12.7 L ha^{-1}), WECO 357 (1 L ha^{-1}), and Sylgard 309 (2 L ha^{-1})]; wetting agents [Aqua-Gro (10 L ha^{-1}), Pear-clean (3.2 L ha^{-1}), Penaturf (10 L ha^{-1}), and R-11 (1 L ha^{-1})]; a crop oil/ non-ionic surfactant blend [Hasten (0.5 L ha^{-1})]; and a fungicide plus surfactant combination [propiconazole (580 g a.i. ha^{-1}) + Sylgard 309 (1 L ha^{-1})] were applied at late pre-anthesis or mid-anthesis. Adjuvant rates are litres of product. Timing of applications of adjuvants did not alter the level of control. The most effective control of ergot was obtained with the standard grower treatment of propiconazole + Sylgard 309. Adjuvants significantly reduced, but did not eliminate ergot compared to the non-sprayed control. In 1996, Kinetic and Aqua-Gro gave the best ergot control, Penaturf, Pear-clean, and Sylgard 309 were intermediate, and Hasten gave the poorest control. As classes of adjuvants, surfactants and wetting agents provided the same level of control. Bluegrass seed yield, seed weight, and germination were not adversely affected by treatments compared to the non-sprayed control. Adjuvants provide an alternative to propiconazole in ergot control.

***Additional index words:* *Claviceps purpurea*, smoothstalk meadowgrass, surfactant, wetting agent.**

EXPERIMENTAL AND DISCUSSION

Ergot, caused by *Claviceps purpurea* (Fr.:Fr.) Tul., is the most important disease problem in Kentucky bluegrass (*Poa pratensis* L.) seed production fields in the Pacific Northwest of the USA (Alderman, 1993; Schultz, Johnston, Golob and Maguire, 1993). In the spring, following rain or after irrigation, the ergot sclerotia (fruiting bodies) at, or slightly below the soil surface produce ascospores that colonise the bluegrass flower during seed set. Secondary spread of the disease occurs following transfer of honeydew (a sticky panicle exudate) containing conidia from panicle to panicle by insects, wind, or irrigation. Preharvest seed losses result from replacement of bluegrass ovaries with fungal tissue, abortion of damaged ovaries, and diversion of nutrients to infected florets (Luttrell, 1980). During harvest honeydew binds panicles and seeds together and sticks to equipment, which reduces equipment efficiency and increases seed loss (Mark Lonam, CENEX Full Circle, personal communication, 1997). Postharvest seed yields are lowered because of the additional seed cleaning required to remove sclerotia. Sclerotia contaminated seed is hazardous to animals and poses a seed phytosanitary certification problem. Currently, there are no Kentucky bluegrass cultivars completely resistant to ergot (Meyer and Funk, 1989). However Cagas (1996) recently reported that the Czech cultivar Slezanka was highly resistant, and could be recommended for areas with high disease severities.

Adjuvants are almost universal constituents of herbicidal sprays; however, their role as agricultural chemicals is poorly understood and adjuvant terminology is confusing (McWhorter, 1982). This confusion is fostered by a vast array of adjuvant chemistry, mixtures of related materials used in adjuvants, and the incorrect use of adjuvant terms (Hordan, Tafuro, Abrimitis, Bishop and McWhorter, 1982). Adjuvants are materials that facilitate action of a compound or that facilitate or modify characteristics of formulations or spray solutions (McWhorter, 1982). Surfactants are materials that facilitate and accentuate the emulsifying, dispersing, spreading, wetting or other surface-modifying properties of liquids and wetting agents as materials that when added to a spray solution, cause it to contact plant surfaces more thoroughly (McWhorter, 1982). All surfactants and wetting agents are adjuvants, but many adjuvants are neither surfactants nor wetting agents, e.g., crop oils, buffering agents, antifoam agents, etc. Although use of adjuvants is becoming a common means to improve spray efficacy, there has been limited research on their use with fungicides, and even fewer applied field studies (Steurbaut, 1993). Adjuvants can both enhance fungicide

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performance and increase disease severity (Steurbaut, 1993).

Ergot is controlled with sterol demethylation inhibiting (SDI) fungicides (Schultz *et al.*, 1993) and more effectively controlled when SDI fungicides are combined with a surfactant (Johnston, Golob and Sitton, 1995b). Currently, propiconazole (Tilt) is the only fungicide labelled for the control of ergot in Kentucky bluegrass seed fields in the United States Pacific Northwest. Surfactants when used alone have effectively controlled weeds (Jensen, 1973) and pathogenic fungi on lemons (Strange and Eckert, 1994). In 1990, preliminary investigations (Brede and Williams, 1991; Johnston *et al.*, 1991) indicated some control of ergot using wetting agents alone. Adjuvants are generally recognised to be as safe as most agrochemicals, and considerably safer than many, for humans and the environment (Anonymous, 1992; Steven, 1993). The objective of this investigation was to evaluate a wide spectrum of adjuvants for control of ergot in bluegrass seed production.

Late pre-anthesis or mid-anthesis floral spray applications were made to an irrigated Kentucky bluegrass cv. Plush seed field at Post Falls, Idaho during 1995 and 1996. Individual treatment plots were 3 m x 6 m in a randomised complete-block, split-plot experimental design (application dates were main plots) with four replications. The following materials (percentages listed refer to the percentage of the compound or mixture in the product as stated on the label) were investigated for their ergot control efficacy: esterified vegetable oil and a non-ionic surfactant blend (100%) (Hasten; Wilbur-Ellis Co., Fresno, CA); octyl phenoxy, polyethoxy ethanol, isopropanol, and compounded silicone (90%) (R-11; Wilbur-Ellis Co., Fresno, CA); dialkyl sodium sulfo dicarbonoxylate (75%) (Pear-clean; Wilbur-Ellis Co., Fresno, CA); blend of polyalkyleneoxide modified polydiamethylsiloxane and nonionic surfactants (99%) (Kinetic; Setre Chemical Co., Memphis, TN); organosilicone and non-ionic surfactants (99%) (WECO-357; Wilbur Ellis, Co., Fresno, CA); mixture of polyoxyethylene ester of cyclic acids (42%), polyoxyethylene ester of alkylated phenols (47%), and silicone antifoam emulsion (6%) (Aqua-Gro; Mallincrodt, St. Louis, MO); sodium dodecylbenzene sulfonate (20%) and nine mole ethoxylated C_{11}-C_{15} alcohol (5%) (Penaturf; Chas. H. Lilly Co., Portland, OR); mixture of 2-(3-hydroxypropyl) heptametyl trialloxane, ethoxylated, acetate/125997-17-3, allyoxy polyethylene glycol monoallyl acetate/27252875, and polyethylene glycol diacetate/27252831 (100%) (Sylgard 309; Wilbur-Ellis Co., Fresno, CA); and propiconazole (42%) (Tilt 3.6E; Ciba Corp., Greensboro, NC) in combination with Sylgard 309.

Late pre-anthesis sprays were applied on 29 May 1995 and 3 June 1996, and mid-anthesis sprays were applied on 9 June 1995 and 12 June 1996. Treatments were applied with a hand-propelled, bicycle-wheeled, CO_2-pressurised boom sprayer at 275 kPa. Carrier (water) rate was 262 L ha^{-1}. Each plot was rated for disease severity by visually observing the amount of sclerotia on a 0 to 9 scale (0 = no visible sclerotia and 9 = essentially all panicles with sclerotia and honeydew) on 6 July 1995 and 10 July 1996. In addition, five groups of 20 to 40 panicles were hand-harvested at random per plot at the same dates as the disease ratings. The number of sclerotia per 100 panicles, weight of sclerotia per 100 panicles (1996 only), seed weight per 100 panicles, and 1000-seed weight were determined. Four replicates of two 100 seeds subsamples from each treatment were tested for germination using Association of Official Seed Analysts methods (Association of Official Seed Analysts, 1994). Data were analysed by ANOVA, means were compared using Fisher's protected LSD, and orthogonal single degree of freedom mean contrasts were performed (Abacus Concepts, 1989).

Time of application was not significant and, as a result, the means for the surfactant treatments are an average

Table 1. Effect of adjuvants and propiconazole + Sylgard 309 to control ergot in Kentucky bluegrass at Post Falls, ID in 1995 and 1996.

Treatment and rate (L product or g a.i. ha^{-1})	Disease Index[1]		Sclerotia no./100 panicles		Sclerotia mg/100 panicles	
	1995	1996	1995	1996	1995	1996
Non-sprayed control	2.4	6.7	9	133	—	214
Hasten, 0.5 L	1.8	4.5	32	133	—	271
R-11, 1 L	1.8	4.1	12	80	—	175
WECO 357, 1 L	2.0	5.1	11	78	—	176
Penaturf, 10 L	1.0	3.2	3	76	—	148
Pear-clean, 3.2 L	0.8	3.7	3	51	—	95
Sylgard 309, 2 L	1.1	3.8	9	66	—	142
Aqua-Gro, 10 L	1.1	4.0	2	29	—	64
Kinetic, 12.7 L	0.6	2.9	1	37	—	59
propiconazole, 580 g + Sylgard 309, 1 L	0.0	0.6	0	19	—	36
LSD (P< 0.05)	1.0	1.1	ns	40	—	77

[1] *Disease index (0 to 9); 0 = no visible sclerotia; 9 = essentially all panicles with sclerotia and honeydew.*

of pre-anthesis and mid-anthesis application dates. Kinetic, Aqua-Gro, Pear-clean, Penaturf, and Sylgard 309 generally reduced the severity of ergot when compared to the non-sprayed control, but were not as efficacious as the combination of propiconazole + Sylgard 309, especially in 1996 (Table 1). R-11 and WECO 357 were less effective in controlling ergot; however, they were generally better than the non-sprayed control in a year with a high incidence of ergot. Hasten provided little or no control of ergot.

Orthogonal contrasts of surfactants (Kinetic, Sylgard 309, and WECO 357) versus wetting agents (Aqua-Gro, Pear-clean, Penaturf, and R-11) for ergot disease index and sclerotia number per 100 panicles were nonsignificant (P=0.77 and P=0.64, respectively) during 1995. Contrasts between surfactants and wetting agents for disease index, sclerotia weight per 100 panicles and sclerotia number per 100 panicles were also nonsignificant (P=0.52, P=0.80, and P=0.88, respectively) during heavy ergot infection in 1996. Treatments had no effect on bluegrass seed yield, seed weight, or germination in 1995 or 1996.

Some adjuvants, at the rates used in this study, provided protection against ergot in Kentucky bluegrass seed fields, compared to the non-sprayed control. Overall, Kinetic and Aqua-Gro performed the best; Penaturf, Pear-clean, and Sylgard 309 were intermediate, and Hasten was poorest. The most effective ergot control was provided by the standard grower treatment of propiconazole tank mixed with Sylgard 309. However, if propiconazole resistant *C. purpurea* strains should develop, or the efficacy of this fungicide should decline, the activity of adjuvants used alone will be of value. Since propiconazole is the only fungicide currently labelled for the control of ergot in the Pacific Northwest, the potential for development of resistant stains is enhanced. Previous work has shown that Sylgard 309 increased the efficacy of propiconazole by reducing the amount needed to achieve a given level of control, which presumably would reduce the potential of propiconazole resistant *C. purpurea* stains developing (Johnston *et al.*, 1995a). Surfactant and wetting agents are generally recognised as safe for humans and the environment; therefore, in an ergot control protocol they would presumably have value (Anonymous, 1992; Steven, 1993; Strange, 1994).

There appears to be no reason to focus future research on a particular class of adjuvants, since surfactants (Kinetic, Sylgard 309, and WECO 357) and wetting agents (Aqua-Gro, Pear-clean, Penaturf, and R-11) gave the same ergot control. Hasten, designed to combine the epicuticular wax and cuticle penetrating activity of an esterfied vegetable oil and the wetting and spreading characteristics of a non-ionic surfactant, did not discretely fit into either group, and was omitted from the contrasts. In general, Hasten gave the poorest ergot control.

The mode of action of the various adjuvants used was not investigated. This study does not explain whether the spores or honeydew containing conidia were washed off the floral stigmatic surfaces, or the adjuvants are fungistatic, as reported in other studies with surfactants (Hoy and Ogawa, 1984).

Ergot severity increases with rain and overcast weather that prolongs the flowering period and provides a more favourable environment, generally with heavy dew, which would enhance spore survival and germination (Alderman, 1993). Adjuvants, e.g. Penaturf, are labelled to drain dew from foliage. In a dew prevention study (W.J. Johnston and C.T. Golob, unpublished), wetting agents Hydrozyme [Ferment, a derivative from a combination of sugar, molasses, malt, yeast, and kelp (25%); linear primary alcohol ethoxylate, fatty acid ethoxylate, and sodium lauryl sulfate (4.5%)] (51 L ha^{-1}) and Penaturf (102 L ha^{-1}) reduced dew by 50 and 75%, respectively, on perennial ryegrass (*Lolium perenne* L.) for 10 to 14 days. Mitigating dew formation or persistence on flowering heads might provide another mechanism for ergot reduction.

Seedheads treated with adjuvants have less honeydew, or are not as sticky, as non-sprayed heads (Schultz *et al.*, 1993). Since seedheads were hand harvested in this study, no increase in seed yield due to increased machinery efficiency during swathing and combining when heads are not "glued" together in the field or windrow was observed (Mark Lonam, CENEX Full Circle, personal communication, 1997).

More work is needed to test the efficacy of adjuvants, in particular Kinetic and Aqua-Grow, alone and in combination with propiconazole and other fungicides with the potential to be labelled to control ergot in Kentucky bluegrass seed fields. Also, a more critical investigation to determine the precise mode of action of the various adjuvants used in this investigation should be initiated.

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