Effect of Seed Treatments with Systemic Insecticides on Germination of Selected Wheat and Oat Cultivars[1]

J.E. Araya, J.E. Foster**, J.J. Roberts****

ABSTRACT

In laboratory tests, the systemic insecticides carbofuran and disulfoton were applied to seeds of wheat cultivars Abe and Caldwell, and oat cultivars Clintland 64 and Porter to protect the seedlings against *Rhopalosiphum padi* (L.) (Homoptera: Aphididae), a primary vector of barley yellow dwarf virus (BYDV). Standard dosages (1 000 ml AI/100 kg seed) of carbofuran did not reduce germination. Increasing dosages of disulfoton were progressively more toxic to the seeds, possibly in part because of the organic solvent of the formulation used. Seedling protection through the use of such treatments may be economically feasible as only slight changes in seeding rate would be required to offset reductions in germination.

COMPENDIO

En estudios de laboratorio, semillas de los cultivares de trigo Abe y Caldwell y de avena Clintland 64 y Porter fueron tratadas con los insecticidas sistémicos carbofuran y disulfoton para proteger a las plántulas contra el áfido *Rhopalosiphum padi* (L.) (Homoptera: Aphididae), uno de los principales vectores del virus del enanismo amarillo de la cebada (barley yellow dwarf virus, o BYDV). Dosis convencionales de carbofuran (1.000 ml IA/100 kg de semilla) no redujeron la germinación. Dosis crecientes de disulfoton fueron progresivamente tóxicas a las semillas, posiblemente en gran parte por el solvente orgánico de la formulación utilizada. La protección de plántulas mediante estos tratamientos puede estar económicamente justificada ya que solo pequeños cambios en la dosis de semilla pueden ser requeridos para corregir la reducción en germinación.

INTRODUCTION

The bird cherry-oat aphid, *Rhopalosiphum padi* (L.) (Homoptera: Aphididae) is an important insect pest of cereals, damaging hosts both by direct feeding and by transmitting barley yellow dwarf virus (BYDV) (17). The greatest damage and yield loss occurs when young seedlings are infected with BYDV (10, 16). Resistant cultivars would provide the best means of control. However, in wheat and oats, only low levels of resistance against *R. padi* and/or BYDV are available. Resistant cultivars are best used in concert with other methods of pest control to achieve maximum and stable pest suppression (1). As suggested by Painter (11) and McMillian *et al* (8), the use of insecticides on resistant crops may provide more effective control than either method alone. Resistant cultivars may require less frequent treatment with a pesticide or insect pathogen, or lower rates of application (9).

The residual action of seed systemics can protect cereal crops from aphids for 2-10 weeks (2). Low dosages of systemic insecticides applied as a seed treatment on aphid/BYDV tolerant cultivars would provide control of *R. padi* and the virus it transmits. Reduced dosages cost less and decrease the risk of damage to the seeds. Seed systemics do not affect the beneficial fauna directly, as has been reported with many foliar insecticides (6, 18), but they often lower germination (15, 19). However, Kirk and Wilson (7) reported that seed treatments with disulfoton had no effect on wheat germination.

This study evaluated the germination of selected wheat and oat seeds with reduced dosages of the systemic insecticides carbofuran and disulfoton.

---

1 Received for publication 20 July, 1987.
This article is based on a portion of the Ph.D. thesis of the senior author, and reports the results of research only. Mention of a proprietary product does not constitute an endorsement or a recommendation for its use by the USDA. Purdue University Agricultural Experimental Station Journal Paper No. 10,206

* Profesor Asociado de Entomologia, Departamento de Sanidad Vegetal, Facultad de Ciencias Agrarias y Forestales, Universidad de Chile. Currently, Postdoctoral Research Associate, Department of Entomology, Purdue University, West Lafayette, Indiana 47907, USA.

** Research Leader, Insect and Weed Control Research Unit, USDA-ARS, and Professor of Entomology, Department of Entomology, Purdue University, West Lafayette, Indiana 47907, USA.

***Wheat Geneticist, USDA-ARS, Department of Agronomy, University of Georgia, Georgia Experiment Station Georgia 30212, USA.

MATERIALS AND METHODS

This research was conducted in the greenhouse facilities of the Insect and Weed Control Research Unit, United States Department of Agriculture, Agricultural Research Service, Purdue University, West Lafayette, Indiana.

Treatments were all combinations between two wheat (Abe and Caldwell) and two oat (Clintland 64 and Porter) cultivars, and carbofuran (Furadan® 35% ST) or disulfoton (Disyston® 85% EC) at 0, 250, 500, and 1 000 ml AI/100 kg seed (2). No fungicide was used to avoid interactions as reported by Pike and Glazer (13) and Kirk and Wilson (7).

Seeds were mixed with 10 ml water per kg for 5-10 min before adding the insecticide and mixing for 10 min (12). Once dried, four replicates of 100 seeds per treatment were placed in germination trays with moist absorbent paper. The seeds were processed following the procedures described by Copeland (14), which specify readings of percentage germination, percentage abnormal seedlings, and percentage non-germinated seeds at the fourth and seventh days for wheat, and at the fifth and 10th days for oats. Data obtained were compared through separate analysis of variance (ANOVAs) for each crop, and those means with significant differences ($P <= 0.05$) were separated through contrasts and Student-Neuman-Keuls' tests (2).

RESULTS AND DISCUSSION

Carbofuran treatments, across cultivars, days of reading, and dosages, did not affect the germination of wheat nor that of oats (Table 1). Disulfoton treatments were toxic to both wheat and oat germinating seeds. Because of this, further study of the effects of other formulations of disulfoton and their carriers on the germination of small grains seems warranted.

Carbofuran did not affect the percentage of abnormal wheat seedlings, nor did disulfoton. However, both compounds caused significantly more abnormal seedlings when compared with the controls in oats. This would suggest that a certain level of toxicity exists for both compounds, although carbofuran did not reduce percentage germination.

Both carbofuran and disulfoton resulted in an increased proportion of nongerminated seeds in wheat over the controls, although the effect on carbofuran was relatively small compared to that of disulfoton. In oats, carbofuran-treated seeds did not differ statistically in percent germination from the controls, but disulfoton led to an increased percentage of non-germinated seeds.

Table 1. Effects of seed treatments with carbofuran or disulfoton on germination parameters of wheat and oats, calculated through contrasts across cultivars, days, and dosages*.

Insecticide	Percent germination	Percent abnormal seedlings	Percent non-germinated seeds
a) Wheat**:			
Carbofuran	86.71 a	7.00 a	6.29 b
Disfulfoton	51.50 b	5.21 a	43.29 a
Control	88.31 a	7.25 a	4.44 c
b) Oats***:			
Carbofuran	87.54 a	11.69 a	8.56 a
Disulfoton	72.71 b	12.98 a	14.31 b
Control	88.06 a	3.38 b	8.56 a

* Means in the same column followed by different letters are significantly different ($P <= 0.05$). Results for each crop are from different ANOVAs.

** Means of cvs. Abe and Caldwell; days 4th and 7th; and 250, 500, and 1 000 ml AI/100 kg seed.

*** Means of cvs. Clintland 64 and Porter; days 5th and 10th; and 250, 500, and 1 000 ml AI/100 kg seed.

The effect on germination increased with the dosage of disulfoton (Table 2). These results are in accord with those reported by DePew (6). The almost nonexistent toxicity of carbofuran, as reported in this study, agrees with the results obtained by Ruppel (15).

Different results among cultivars are to be expected when using seed treatments with these insecticides. In the present study, the differences were clear in wheat, but in oats only appeared in the percentage of abnormal seedlings (Table 3).

The negative effect on germination of some treatments concurs with the findings of Kirk and Wilson (7) in barley seeds treated with 180-1 500 g phorate/100 kg seed; DePew (5), with barley seeds treated with disulfoton or phorate at 550-1 000 g AI/100 kg seed; Ruppel (15), in barley, wheat, oats, and rice seeds treated with carbofuran at dosages higher than 3 992 g AI/100 kg seed; Ward *et al.* (19), in wheat seeds treated with disulfoton at 453.6 g AI/100 kg seed; and Arretz and Araya (3, 4) with wheat and barley seeds treated with carbofuran or disulfoton at 1 000 g AI/100 kg seed.

The levels of effects of seed systemic insecticides on germination were such that only slight adjust-

ments in seeding rates could offset reduction in germination. The economic benefit of treatment could thus be significant in a season of heavy cereal aphid infestations.

Table 2. Effect of seed treatments with carbofuran or disulfoton on germination parameters of wheat and oats, calculated through contrasts across cultivars and days*.

Insecticide and dosage (ml AI per 100 kg seed)	Percent germination	Percent abnormal seedlings	Percent non-germinated seeds
a) Wheat**:			
Carbofuran 250	87.25 a	7.56 a	5.19 ab
Carbofuran 500	86.81 a	6.75 a	6.44 ab
Carbofuran 1000	86.06 a	6.69 a	7.25 b
Disulfoton 250	74.19 b	7.88 a	17.94 c
Disulfoton 500	46.88 c	4.31 a	48.81 d
Disulfoton 1000	33.44 d	3.44 a	63.13 e
Control	88.31 a	7.25 a	4.44 a
b) Oats***:			
Carbofuran 250	86.06 b	6.38 b	7.56 a
Carbofuran 500	86.31 b	3.63 a	10.06 b
Carbofuran 1000	90.25 a	1.69 a	8.06 a
Disulfoton 250	82.56 c	6.50 b	10.94 b
Disulfton 500	79.13 d	10.63 c	10.25 b
Disulfoton 1000	54.44 e	21.81 d	21.75 c
Control	88.31 a	3.38 a	8.56 a

* Means in the same column followed by different letters are significantly different ($P <= 0.05$). Results for each crop are from different ANOVAs

** Means of cvs. Abe and Cadwell; and days 4th and 7th.

*** Means of cvs. Clintland 64 and Porter; and days 5th and 10th

Table 3. Effect of seed treatments on the germination of wheat and oat cultivars, calculated through contrasts across insecticides, dosages, and days*.

Cultivars	Percent germination	Percent abnormal seedlings	Percent non-germinated seeds
a) Wheat:			
Abe	73.98 a	6.38 a	19.64 a
Caldwell	69.71 b	6.16 a	24.13 b
b) Oats:			
Clintland 64	81.52 a	6.82 a	11.66 a
Porter	81.00 a	8.61 b	10.39 a

* Means of treatments of carbofuran or disulfoton at 0, 250, 500, and 1 000 ml AI/100 kg seed; days 4th and 7th for wheat, and 5th and 10th for oats. Means in the same column followed by different letters are significantly different ($P <= 0.05$). Results for each crop are from different ANOVAs.

LITERATURE CITED

1. ADKISSON, P.L. 1980. Resistant varieties in pest management systems. In Breeding plants resistant to insects. Ed. by F.G. Maxwell, P.R. Jennings. New York. John Wiley. p. 233-251.

2. ARAYA, J.E. 1985. Studies of biology and control of *Rhopalosiphum padi* (L.) in selected wheat and oat cultivars with seed systemic insecticides. Ph.D. Thesis. West Lafayette, Indiana. Purdue University. 145 p.

3. ARREITZ, P.; ARAYA, J. 1978. Control de áfidos en cebada con insecticidas sistémicos granulares al suelo, a la semilla y al follaje, en dos localidades de la zona central de Chile. Investigación Agrícola (Chile) 4:79-86.

4. ARREITZ, P.; ARAYA, J. 1980. Control de áfidos en trigo mediante insecticidas sistémicos granulares aplicados al suelo, tratamientos a la semilla y aspersiones al follaje. Simiente (Sociedad Agronómica de Chile) 50:50-56.

5. DePEW, L.J. 1964. Systemic insecticides to control greenbugs on spring-planted barley. Journal of Economic Entomology 57:250-252.

6. HELLPAPP, C. 1982. Untersuchungen zür Wirkung verschiedener Inzektizide auf Pradatoren von Getreideblattlausen unter Freilandbedingungen. Anzeiger für Schadlingskunde Pflanzenschutz Umweltschults 55:129-131.

7. KIRK, R.E.; WILSON, M.C. 1960. The effect of seed treatments with phorate and other systemic insecticides on the germination of wheat. Journal of Economic Entomology 53:575-577.

8. McMILLIAN, W.W.; WISEMAN, B.R.; WIDSTROM, N.W.; HARRELL, E.A. 1972. Resistant sweet corn hybrid plus insecticide to reduce losses from corn earworms. Journal of Economic Entomology 65:229-231.

9. ORTMAN, E.E.; PETERS, D.C. 1980. Introduction. In Breeding plants resistant to insects. Ed. by F.G., Maxwell, P.R. Jennings. New York. John Wiley. p. 3-13.

10. OSWALD, J.W.; HOUSTON, B.R. 1953. Host range and epiphytiology of the cereal yellow dwarf virus. Phytopathology 43:309-313.

11. PAINTER, R.H. 1951. Insect resistance in crop plants. Kansas, EE.UU. The University Press of Kansas. 520 p.

12. PIKE, K.S. 1978. Greenbug protection in seed-treated winter wheat. Journal of Economic Entomology 71:827-832.

13. PIKE, K.S.; GLAZER, M. 1980. Compatibility of insecticide-fungicide wheat seed treatments with respect to germination, seedling emergence, and greenbug control. Journal of Economic Entomology 73:759-761.

14. RULES FOR testing seeds. 1978. Association of Official Seed Analysis. Ed. by L.O. Copeland.

15. RUPPEL, F.R. 1971. Effect of seed treatment with carbofuran and propoxur on germination of small grains. Journal of Economic Entomology 64:1 554-1556.

16. SMITH, H.C. 1967. The effects of aphid numbers and stage of plant growth in determining tolerance to barley yellow dwarf virus in cereals. New Zealand Journal of Agricultural Research 10:445-466.

17. STERN, V.M. 1967. Control of the aphids attacking barley and analysis of yield increases in the Imperial Valley, California. Journal of Economic Entomology 60:485-490.

18. VAZQUEZ, G.M.; CARRILLO S., J.L. 1972. Efecto de diversos insecticidas sobre la fauna benéfica presente en el trigo en el Valle de Mexicali durante 1970-71. Agricultura Técnica en México 3: 145-149.

19. WARD, C.R.; OWENS, J.C.; HUDDLESTON, E.W.; ASHDOWN, D.; BAILEY, C.F. 1972. Phytotoxic and residual properties of disulfoton used on wheat. Journal of Economic Entomology 65:561-563.

Conservación de la Capacidad Caulogénica de Callos de *Arachis major* (Leguminosae) durante Prolongados Subcultivos[1]

E.A. Prado, A.N. Secchi*, L.A. Mroginski***

ABSTRACT

Anthers with uninucleated pollen grains of *Arachis major* Krap. and Greg. have been cultured on Murashige and Skoog medium (MS) containing different concentrations of naphtaleneacetic acid (NAA) and benzyladenine (BAP). The best medium for callus induction was MS + NAA$_1$ ($\sim\beta$]) X BAP 3 mg/l. The calluses that have been maintained – without cultures – for 7 or 9 months in the dark grew slowly, but did not develop shoots. This occurred when the calluses were exposed to light. The caulogenetic capacity was maintained during 15 transferences (24 months of incubation) in MS + NAA 2 mg/l + BAP 0.5 mg/l medium. The regenerated shoots transferred to a MS + NAA 1 mg/l kinetin 0.04 mg/l medium developed roots.

COMPENDIO

Anteras de *Arachis major* Krap. y Greg. conteniendo granos de polen uninucleados fueron cultivadas en el medio de Murashige y Skoog (MS) suplementado con diversas combinaciones entre ácido naftalenacético (ANA) y 6-bencilamino purina (BAP). El mejor medio para la inducción de callos fue MS + ANA 1 mg/l + BAP 3 mg/l. Los callos que fueron mantenidos – sin ser subcultivados – durante 1, 7 ó 9 meses en oscuridad crecieron lentamente pero no diferenciaron vástagos, lo cual ocurre cuando son expuestos a la luz. Sucesivos subcultivos de callos en MS + ANA 2 mg/l + BAP 0,5 mg/l posibilitan el mantenimiento de la capacidad caulogénica aún después de 15 transferencias (24 meses de incubación). Los vástagos obtenidos fueron enraizados mediante su cultivo en MS + ANA 1 mg/l + cinetina 0.04 mg/l.

INTRODUCCION

La aplicación de las técnicas de cultivo *in vitro* de protoplastos, células y tejidos, en el fitomejoramiento, requiere la utilización de sistemas que posibiliten la regeneración de plantas enteras. En las leguminosas, estos sistemas han sido desarrollados para

1 Recibido para publicación el 27 de junio de 1987.

* Cátedra de Genética, Facultad de Ciencias Agrarias (UNR) Santa Fe 2051, Rosario (2000), Argentina.

** Facultad de Ciencias Agrarias (UNNE), Instituto de Botánica del Nordeste, C.C. 209, Corrientes (3400), Argentina.