Presence of the Wheat Curl Mite, *Aceria tosichella* Keifer (Prostigmata: Eriophyidae), in Uruguay

Castiglioni, Enrique[1] y Navia, Denise[2]

[1]*UDELAR, Facultad de Agronomía, EEMAC. Departamento de Protección Vegetal, Ruta 3 Gral. Artigas km 363, 60000, Paysandú, Uruguay. Correo electrónico:* bbcast@fagro.edu.uy
[2]*Embrapa Recursos Genéticos e Biotecnologia, Cx. Postal 02372, 70.770-900, Brasília, DF, Brazil.*

Recibido: 2/4/09 Aceptado: 10/2/10

Summary

The Wheat Curl Mite (WCM), *Aceria tosichella* (Keifer), a vector of important virus that affect wheat and corn, was recently detected in South America, in Argentina. This found alerted to the risk of dissemination of the pest to neighbor countries in the continent. Aiming to determine the status of the WCM in Uruguay, a survey of eriophyid mites associated with wheat, barley, corn and other common grasses was conducted in the main wheat production areas of this country, in November 2007. WCM specimens were collected from wheat, *Triticum aestivum* L., in Ombúes de Lavalle, Tarariras and San Juan, Department of Colonia and in San Javier, Department of Río Negro; and also from ryegrass, *Lolium multiflorum* Lam (Rosario and San Juan, Colonia; Cardona, Soriano) and brome, *Bromus unioloides* (Willd.) Kunth (Rosario, Colonia). This is the first report of *A. tosichella* in Uruguay and also the first time the mite is found, in field surveys, on other hosts different from wheat in South America.

Key Words: Acari, Eriophyoidea, virus vector, *Triticum aestivum*, brome, ryegrass

Resumen

Presencia del ácaro del enrollamiento del trigo, *Aceria tosichella* Keifer (Prostigmata: Eriophyidae), en Uruguay

El ácaro del enrollamiento del trigo *Aceria tosichella* (Keifer), vector de importantes virosis que afectan trigo y maíz, fue recientemente detectado en Argentina. Este hallazgo alertó el riesgo de diseminación de esta plaga en los países vecinos del Cono Sur. Con el objetivo de determinar la presencia de este ácaro en Uruguay, fue realizada una prospección en trigo, cebada, maíz y otras gramíneas comúnmente asociadas al área de producción de trigo en este país, a principios de noviembre de 2007. Ejemplares de *A. tosichella* fueron colectados en trigo, *Triticum aestivum* L. en Ombúes de Lavalle, Tarariras y San Juan, Departmento de Colonia y en San Javier, Departmento de Río Negro; y también en raigrás, *Lolium multiflorum* Lam (Rosario y San Juan, Colonia; Cardona, Soriano) y cebadilla, *Bromus unioloides* (Willd.) Kunth (Rosario, Colonia). Esta es la primera referencia de *A. tosichella* en Uruguay y la primera vez que este ácaro es encontrado, en prospecciones de campo, en un hospedero diferente de trigo en América del Sur.

Palabras clave: Acari, Eriophyoidea, vector de virus, *Triticum aestivum*, cebadilla, raigrás

Introduction

The Wheat Curl Mite (WCM), *Aceria tosichella* Keifer (Acari: Eriophyidae), a pest of cereal crops is widespread in North America, Europe, Asia, the Middle East, Africa and Oceania (Oldfield and Proeseler, 1996; CABI, 2002; Thomas *et al*., 2004). However in South America the report of the WCM and associated virus is recent. In this continent the WCM was first found in Argentina, in 2004 (Navia *et al*., 2006), a few years after the report of the presence of a WCM transmitted virus, the *Wheat streak mosaic virus* (WSMV), in 2002 (Truol *et al*., 2004). Since the detection of the WSMV in Argentina, serious epiphytes have been observed in wheat crops some years later, especially in the Province of Buenos Aires, with losses that reached 100 % in the most affected areas (Sagadin *et al*., 2008).

Damages of *A. tosichella* can be direct, due to the feeding of the mites, mainly when there are high infestations, or indirect, due to their action as phytovirus vectors. Direct damage includes discoloration, curling or rolling of leaves, abnormal development of leaves and plant stunting. The stunting occurs because infested leaves do not expand normally, remaining inside older leaves and the plant stays arched (Jeppson *et al*., 1975; CABI, 2002). Yield losses in wheat crops due to WCM high population infestations can reach 30 % (Harvey *et al*., 2002). However the main damage caused by *A. tosichella* is due to the transmission of *Wheat streak mosaic virus* (WSMV) and *High plain virus* (HPV) (Oldfield and Proeseler, 1996; Malik *et al*., 2003ab). The WSMV is the etiological agent of one of the most important virus diseases in wheat crops, causing major yield losses in North America, and also occurring in Europe, the Middle East, Oceania and Asia (Oldfield and Proeseler, 1996; French and Stenger, 2003; Sanchez-Sanchez *et al*., 2001). The HPV was first observed in 1993 in the High Plains of the US from Texas, Idaho, Kansas and Colorado (Jensen *et al*., 1996). Later, it was also found in South Dakota, Nebraska and South Florida (Seifers *et al*., 1997; Mahmood *et al*., 1998; Brown Jr., 2001). HPV presence was also confirmed in the Province of Buenos Aires, Argentina, in mixed infections with WSMV (Truol y Sagadin, 2008). Losses due to HPV infection in corn were estimated to be around 75 % in some regions of the US (AQIS, 2000). Mixed infections of WSMV and HPV have been usually observed in the US, making it difficult to estimate the losses due to each virus separately.

WCM occurs mainly on wheat, but its populations can also develop on corn (*Zea mays* L.), sorghum (*Sorghum* sp.), barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.), rye (*Secale cereale* L.) (Jeppson *et al*., 1975), and a large number of grasses of minor economic importance and weeds, with more than one hundred host plants, all of them in the Poaceae family (Amrine and de Lillo, 2003). The knowledge of *A. tosichella* host plants in an area is important to guide the adoption of management measures. At the end of wheat growing season, *A. tosichella* dispersion forms, also called «airborne mites», migrate to spontaneous wheat, neighbor crops or to grasses around the crop, where they remain until the next wheat season (Somsem, 1966), acting as a «green bridge». There is no information on *A. tosichella* host plants different from wheat in South America.

The occurrence of *A. tosichella* and associated virus in Argentina have alerted to the threat that the pathosystem WCM/WSMV and HPV represents to cereal crops in other countries in South America, especially to neighbor countries presenting close or contiguous cereal production areas. Thus, in 2006 a collaborative project among Argentina, Brazil, Paraguay and Uruguay institutions was initiated, entitled «The mite *Aceria tosichella* Keifer and the transmitted viruses *Wheat streak mosaic virus* and *High plain virus*, a new threat to cereal crops in South America – Pest Risk Assessment, geographic distribution, hosts, characterization and control». Among other objectives this project aimed to contribute to the knowedge of the distribution of the pathosystem in the South Cone Region.

Wheat is a main cereal crop in Uruguay, traditionally included in the double cropping of winter and summer crops for grain production and soil protection along the season. After a period of stagnation, the wheat production area has grown in the South Cone (Díaz y Abadie, 1998), reaching higher yields that confirm a process of technological improvement, added with sustainability associated to no-till, among other agricultural practices (Ernst, 2000). Disease management has always been a major concern in wheat production in Uruguay, because of the risks of losses they represent in the achievement of the expected yields.

In this paper, the results of a survey of eriophyid mites associated with wheat, corn, oat and other common grasses, conducted in the main winter cereal production area of Uruguay, are presented.

Materials and Methods

Surveys were conducted in 13 municipalities of six Departments of Uruguay, between 5th to 8th of november 2007, covering most of the traditional agricultural and wheat production areas of the country (Table 1, Figure 1).

Samples were taken from cultivated wheat, barley and corn as well as of common native or spontaneous grasses nearby the crop areas. A total of 11 species of Poaceae including the cultivated grasses were sampled. Samples of wheat, barley and corn were composed of approximately 50 stems with their leaves, randomly collected from a stripe approximately 100 m of length by 5 m of width, on the border of the crop field. Samples of non-sown grasses were composed of approximately ten plants randomly collected surrounding cultivated areas. After removing the roots, the samples were placed inside paper bags appropriately identified. Samples were processed at the end of the day of collection or the day after, in order to preserve the quality of the plants and the eventually associated mites.

For the extraction of the mites, the leaves were detached of the stems, in order to facilitate the release of the eriophyid mites eventually present on the leaf sheaths, and the complete sample of vegetal tissue was submerged in a detergent solution (5 %) shaking gently for a few minutes, aiming the detachment of superficial particles (including arthropods) and leaving for decantation for another 10 minutes. After that time, samples were passed through a pair of granulometric sieves of 500 mesh (open 0.028 mm) and 18 mesh (open 1 mm), in ascending order. The material retained by the 500 mesh sieve was collected and placed in hermetic plastic labeled vials containing ethyl alcohol 70 %.

Samples in the alcoholic solution were examined under stereomicroscope (40x) at the Laboratory of Plant Quarantine, Embrapa Genetic Resources and Biotechnology, Brasilia, Brazil. The eriophyoid mites detected were mounted in permanent microscope preparations using Berlese modified medium (Amrine and Manson, 1996) and then identified using a phase contrast microscope (Amrine *et al*., 2003). Eriophyoid mites identified as belonging to genus *Aceria* Keifer were compared with the description of *A. tosichella* (Keifer, 1969). Some of the mites identified as *A. tosichella* had taxonomic structures measured using a phase contrast microscope (100x objective) and measurements were compared to those of the original description to confirm identification. Micrographs of *A. tosichella* were taken at the Lab. of Plant Quarantine, Embrapa Genetic Resources and Biotechnology, Brasília, Brasil. Specimens of *A. tosichella* collected in this survey were deposited at the Reference Mite Collections of the Laboratories of Plant Quarantine of Brasilia and of the «Ministerio de Ganadería Agricultura y Pesca», Montevideo, Uruguay.

Results and Discussion

Aceria tosichella was found in wheat samples from four municipalities of two Departments of Uruguay: San Javier (Río Negro) and Ombúes de Lavalle, Tarariras and San Juan (Colonia) - points 11, 14, 18 and 19, respectively (Table 1, Figure 1). *A. tosichella* was also found in samples of ryegrass from Cardona (Soriano) and Rosario and San Juan (Colonia) – points 15, 16 and 19, respectively, and of brome from Rosario (Colonia, point 16). Main characters used to identify *A. tosichella*, differentiating it from *A. tulipae*, are described in Navia *et al*. (2006). This is the first report of the presence of *A. tosichella* in Uruguay and also for the occurrence of the WCM in other host species different from wheat, in field surveys, in South America.

The WCM had formerly been found only in wheat in South America, thus the present founding of its occurrence in alternative grass hosts should be considered in the adoption of integrated management measures, because they can act as a «green bridge» to wheat infestations in the following growing season (Somsen, 1966; Nault and Styer, 1969). Mainly because ryegrass and brome are both very common grasses in the area of wheat production.

There were not found symptoms of the WCM or the associated virus on the plants of the samples of crops or grasses. In addition, *A. tosichella* was not found in barley or corn, sampled at five and three points, respectively, which are known to be hosts of this species (Jeppson *et al*., 1975). Based in those considerations it is suggested that the populations of the mites are still low, and poorly disseminated in Uruguay, because their presence was verified in a few proportion of the samples.

The meaning of the presence of *A. tosichella* in the host grasses remains still unknown in terms of risks for the wheat production. It could be an important way of dissemination because of the role of «green bridge» (Somsem, 1966) of these grasses between successive wheat crops (or also in a following corn or barley in the sequence of crops). On the other hand, the WCM could prefer some of these alternative host grasses, as referred by (Skoracka and Kuczynski, 2006) in Polony, where *A. tosichella* infestations on wheat have been less important than on other host grasses.

Table 1. Description of the points where leaf samples of wheat and native or spontaneous grasses were taken to detect the presence of *Aceria tosichella* (Keifer). Uruguay, 5 - 8 november/2007.

Point	Department	Municipality	Longitude	Latitude	Species	Result
1	San José	San José de Mayo	W 56° 41' 28"	S 34° 13.876'	*Triticum aestivum*	-
					Bromus unioloides	-
					Avena sativa	-
					Lolium multiflorum	-
					Cynodon dactylon	-
2	Flores	Trinidad	W 56° 47' 54"	S 33° 44' 13"	*Triticum aestivum*	-
					Avena sativa	-
					Cynodon dactylon	-
					Lolium multiflorum	-
					Calamagrostis sp	-
3	Flores	Marincho	W 57° 01' 26"	S 33° 24' 59"	*Triticum aestivum*	-
					Avena sativa	-
					Lolium multiflorum	-
					Calamagrostis sp	-
					Cynodon dactylon	-
4	Río Negro	Paso del Palmar	W 57° 14' 15"	S 33° 04' 17"	*Triticum aestivum*	-
					Cynodon dactylon	-
					Lolium multiflorum	-
					Bromus unioloides	-
					Calamagrostis sp	-
5	Río Negro	Young	W 57° 41' 05"	S 33° 40' 00"	*Triticum aestivum*	-
					Avena sativa	-
					Lolium multiflorum	-
					Cynodon dactylon	-
					Zea mays	-
6	Río Negro	Young	W 57° 52' 27"	S 32° 29' 58"	*Triticum aestivum*	-
					Hordeum vulgare	-
					Lolium multiflorum	-
					Bromus mollis	-
					Avena sativa	-
7	Paysandú	Lorenzo Geyres	W 57° 52' 37"	S 32° 05' 29"	*Triticum aestivum*	-
					Avena sativa	-
					Lolium multiflorum	-
					Sorghum halepense	-
					Bromus unioloides	-
8	Paysandú	Parada Rivas	W 57° 20' 01"	S 31° 43' 52"	*Hordeum vulgare*	-
					Avena sativa	-
					Sorghum halepense	-
					Lolium multiflorum	-
					Cynodon dactylon	-

Point	Department	Municipality	Longitude	Latitude	Species	Result
9	Paysandú	Lorenzo Geyres	W 57° 37' 36"	S 32° 03' 22"	*Hordeum vulgare*	-
					Avena sativa	-
					Lolium multiflorum	-
10	Paysandú	Lorenzo Geyres	W 57° 49' 56"	S 32° 04' 50"	*Zea mays*	-
					Sorghum halepense	-
11	Río Negro	San Javier	W 58° 00' 56"	S 32° 34' 37"	*Triticum aestivum*	+
					Avena sativa	-
					Sorghum halepense	-
					Lolium multiflorum	-
12	Río Negro	San Javier	W 58° 07' 54"	S 32° 38' 14"	*Triticum aestivum*	-
						-
13	Soriano	Soriano	W 58° 04' 28"	S 33° 20' 59"	*Hordeum vulgare*	-
					Sorghum halepense	-
					Lolium multiflorum	-
					Cynodon dactylon	-
					Avena sativa	-
14	Colonia	Ombúes de Lavalle	W 58° 00' 02"	S 33° 50' 22"	*Triticum aestivum*	+
					Sorghum halepense	-
					Lolium multiflorum	-
					Avena sativa	-
					Bromus unioloides	-
15	Soriano	Cardona	W 57° 24' 35"	S 33° 51' 24"	*Hordeum vulgare*	-
					Avena sativa	-
					Lolium multiflorum	+
					Bromus sp	-
					Calamagrostis sp	-
16	Colonia	Rosario	W 57° 21' 58"	S 34° 02' 03"	*Triticum aestivum*	-
					Lolium multiflorum	+
					Avena sativa	-
					Bromus unioloides	+
					Cynodon dactylon	-
17	Colonia	Rosario	W 57° 21' 51"	S 34° 08' 18"	*Zea mays*	-
						-
18	Colonia	Tarariras	W 57° 34' 30"	S 34° 19' 24"	*Triticum aestivum*	+
					Avena sativa	-
					Lolium multiflorum	-
					Bromus unioloides	-
19	Colonia	San Juan	W 57° 48' 40"	S 34° 11' 19"	*Triticum aestivum*	+
					Calamagrostis sp	-
					Avena sativa	-
					Lolium multiflorum	+
					Bromus mollis	-

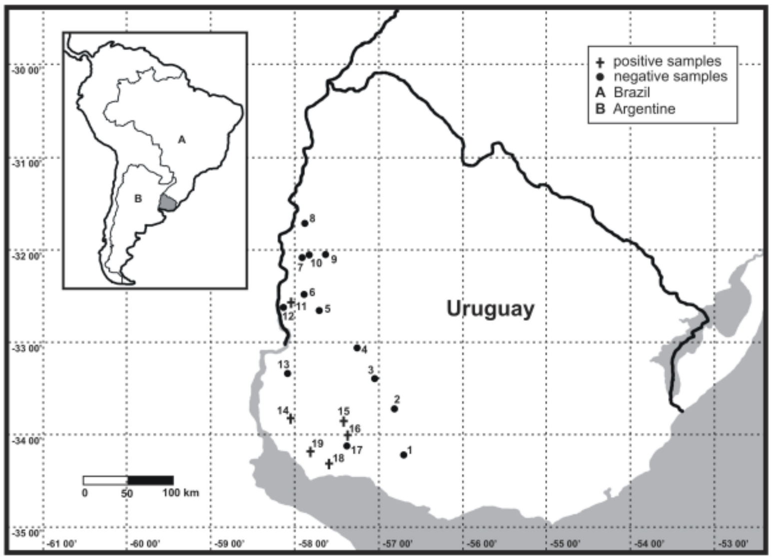

Figure 1. Location of the points with positive (+) and negative (·) results for *Aceria tosichella* (Keifer). Uruguay, 5 - 8 november/2007.

Although there is no information about the way *A. tosichella* arrived in Argentina (Navia *et al.*, 2006), the dissemination of this mite to Uruguay, a neighbor country, probably occurred by natural ways. The most important natural ways to eriophyid mites dissemination, in short and medium distances, are wind, pollinators and water (Lindquist *et al.*, 1996). Although mites actively initiate dispersal, it is a passive process resulting in their random deposition throughout the environment (Bergh, 2001). *A. tosichella* rely on wind currents to passively disperse to other host plants, by using their caudal pad to regulate dispersal time (Liu *et al.*, 2005). The trigger for dispersal is not clear and may depend on a number of factors, including the host it is dispersing from, crowding among mites and declining food quality. However, deteriorating host plant condition is not as important as the size of the source population regarding mite dispersal (Thomas and Hein, 2003).

Recently, studies from Argentina demonstrated that seeds can be a source of dissemination of the virus vectorized by WCM, even at low rates (0.07 to 0.55 %) (Sagadin y Truol, 2006, 2008). However, virus incidence was high in the location where higher rates of seed infection had been found (Sagadin y Truol, 2008). According to Sagadin y Truol (2006), with a transmission of 0.07 %, a hectare could have 1944 infected plants, which represent an important source of inoculum. It should be advertised the importance of controlling the site of entry of imported seed, mainly form Argentina, now that the vector has been found.

Malik *et al.* (2003b) reported the occurrence of six biotypes of *A. tosichella* deriving from different locations of the United States and from Alberta, Canada. Different responses to resistance genes in different grass hosts have been observed (Harvey *et al.*, 1995, Malik *et al.*, 2003a) and also WCM populations of different geographic origin showed a variation in ability to transmit the virus (Seifers *et al.*, 2002).

Considering that severe WSMV epiphytes and HPV presence have been reported in Argentina (Truol y Sagadin, 2008; Truol *et al.*, 2008), the potential economic risk of WCM / WSMV and HPV in neighbor countries is high (Navia *et al.*, 2007). Also, the possibility of introduction of WSMV and HPV by the seed trade with Argentina, justify the focus on quarantine procedures to seeds originated from this country.

Management of varieties could be of importance, according to the differences observed in the incidence of WSMV and HPV and in the number of WCM individuals in wheat cultivars in Argentina (Truol y Sagadin, 2008), as well as the arrangement of vegetal species in the crop rotation.

This information can be useful for the development of studies aiming to define pest integrated management strategies to be applied in wheat and other cereal crops to minimize the impact of the pathosystem WCM/ WSMV/HPV in South America.

Acknowledgements

To Dr. Pablo Boggiano, «Departamento de Producción Animal y Pasturas, Facultad de Agronomía, Universidad de la República», Uruguay, for identification of Poaceae species. To Claudia Pereyra and Horacio Silva for their help in mite extraction. To Marcella Teles dos Reis for helping in sample inspection and slides preparation. To Paulo Roberto Valle da Silva Pereira, EMBRAPA-Trigo for helping with the map of points location. To CNPq/PROSUL for the support to the project «O Ácaro *Aceria tosichella* Keifer e Viroses Transmitidas *Wheat streak mosaic virus* e *High plain virus*, uma Nova Ameaça aos Cultivos de Cereais na América do Sul – Análise de Risco de Pragas, Distribuição Geográfica, Hospedeiros, Caracterização e Controle». To CNPq for the fellowship to the second author.

References

Amrine Jr.; J. W. and de Lillo, E. 2003. Database on Eriophyoidea (Acarina: Prostigmata) of the world. Filemaker 4.0. West Virginia University, USA.

Amrine, J. W. Jr. and Manson, D. C. M. 1996. Preparation, mounting and descriptive study of eriophyoid mites. *In*: Lindquist, E. E., Sabelis, M. W. and Bruin, J. Eriophyoid mites: their biology, natural enemies and control. Elsevier, Amsterdam. pp. 383-396.

Amrine, J. W. Jr.; Stasny T. A. H. and Flechtmann, C. H. W. 2003. Revised Keys to World Genera of Eriophyoidea (Acari: Prostigmata). Indira Publishing House, West Bloomfield, Michigan, USA, 244p.

AQIS, 2000. Australian Quarantine and Inspection Service. Import risk analysis for the importation of bulk maize (*Zea mays* L.) from the United States of America. Department of Agriculture, Fisheries and Forestry, Australia.

Bergh, J.C. 2001. Ecology and aerobiology of dispersing citrus rust mites (Acari: Eriophyidae) in Central Florida. Environmental Entomology, 30(2): 318-326.

Brown Jr., W. M. 2001. *High Plains Virus* causing damage in some front range sweet corn fields. Pest Alert, 18 (12) August 10, 2001. CAB International. Crop Protection Compendium. Wallingford, 2001. 1 CD-ROM.

CABInternational. 2002. Crop Protection Compendium. Wallingford. 1 CD-ROM.

Díaz, R. y Abadie, T. 1998. Rendimiento potencial y brechas tecnológicas de trigo en el Uruguay y en el Cono Sur. In: Kohli, M. M. y Martino, D. (Eds.). Explorando altos rendimientos en trigo. INIA, La Estanzuela, Colonia Uruguay. Octubre 20-23, 1997. p.1-19.

Ernst, O. 2000. Siete años de siembra sin laboreo. Cangüé, 20:9-13.

French, R. and Stenger, D. C. 2003. Evolution of Wheat Streak Mosaic Virus: dynamics of population growth within plants may explain limited variation. Annual Review of Phytopathology, 41: 199-214.

Harvey, T. L.; Martin, T. J. and Seifers, D. L. 1995. Survival of five wheat curl mite, *Aceria tosichilla* Keifer (Acari: Eriophyidae), strains on mite resistant wheat. Experimental Applied Acarology, 19(8): 459-463.

Harvey, T. L.; Martin, T. J. and Seifers, D. L. 2002. Wheat yield reduction due to wheat curl mite (Acari: Eriophyidae) infestations. Journal of Agricultural and Urban Entomology, 19(1): 9-13.

Jensen, S. G.; Lane, L. C. and Seifers, D. L. 1996. A new disease of maize and wheat in the high plains**.** Plant Disease, 80: 1387-1390.

Jeppson, L. R.; Keifer, H. H. and Baker, E. W. 1975. Mites injurious to economic plants. University of of California Press, Berkeley. 614p.

Keifer, H. H. 1969. Eriophyid studies C-3. Agricultural Research Service, U.S. Department of Agriculture. 24p.

Lindquist, E. E.; Sabelis, M. W. and Bruin, J. 1996. Eriophyoid mites: their biology, natural enemies and control. Elsevier, Amsterdam, 790p.

Liu, J.; Lee, E. A.; Sears, M.K. and Schaafsma, A. W. 2005. Wheat curl mite (Acari: Eriophyidae) dispersal and its relationship with kernel red streaking in maize. Journal of Economic Entomology, 98(5): 1580-1586.

Mahmood, T.; Hein, G.L. and Jensen, S. G. 1998. Mixed infection of hard red winter wheat with high plains virus and wheat streak mosaic virus from wheat curl mites in Nebraska. Plant Disease, 82(3): 311-315.

Malik, R.; Brown-Guedira, G. L.; Smith, C. M.; Harvey, T. L. and Gill, B. S. 2003a. Genetic mapping of wheat curl mite resistance genes Cmc3 and Cmc4 in common wheat. Crop Science, 43(2): 644-650.

Malik, R.; Brown-Guedira, G. L.; Smith, C. M.; Harvey, T. L. and Gill, B. S. 2003b. Assessment of *Aegilops tauschii* for resistance to biotypes of wheat curl mite (Acari: Eriophyidae). Journal of Economic Entomology, 96(4): 1329-1333.

Nault, L. R. and Styer, W. E. 1969. The dispersal of *Aceria tulipae* and three other grass-infesting eriophyid mites in Ohio. Annals of the Entomological Society of America, 62: 1446-1455.

Navia, D.; Truol, G.; Mendonça, R. S. and Sagadin, M. 2006. *Aceria tosichella* Keifer (Acari: Eriophyidae) from Wheat Streak Mosaic Virus-infected wheat plants in Argentina. International Journal of Acarology, 32(2): 189-193.

Navia, D.; Mendonca, R. S.; Batista, M. F.; Truol, G.; Pereira, P. R. V. S.; Guedes, J. V. C.; Castiglioni, E. and Morel, N. N. E. 2007. The Wheat Curl Mite, *Aceria tosichella* Keifer, and associated viruses, Wheat streak mosaic virus and High plain virus - the risks posed to cereal crops in South America. *In*: XVI International Plant Protection Congress, 2007, Glasgow. Congress Proceedings. Hampshire : The British Crop Production Council. 2: 612-613.

Oldfield, G. N. and Proeseler, G. 1996. Eriophyoid mites as vectors of plant pathogens. *In*: Lindquist, E. E.; Sabelis, M. W. and Bruin, J. (Orgs.). Eriophyoid mites - their biology natural enemies and control. World Crop Pests, 6: 259-275.

Sagadin, M.; Rodríguez, S. M. y Truol, G. 2008. Transmisión por semilla de *Wheat streak mosaic virus* (WSMV) en infecciones naturales y experimentales. *In*: VII Congreso Nacional de Trigo, 2 a 4 Julio 2008, Santa Rosa, La Pampa, Argentina (trabajos@anguil.inta.gov.ar). INTA/UNLPam. 5pp.

Sagadin, M. y Truol, G. 2006. Determinación del porcentaje de transmisión por semilla del Wheat streak mosaic virus (WSMV) según su incidencia en infecciones naturales del cultivo de trigo. XXXIII Jornadas Científicas, Asociación de Biología de Tucumán. Argentina.

Sagadin, M. y Truol, G. 2008. Enfermedades virales asociadas al cultivo de trigo en Argentina. Virus transmitidos por semilla y de importancia en el marco de las exportaciones. *Wheat streak mosaic virus* (WSMV) (Mosaico estriado del trigo), transmisión por semilla. Informe N°5, INTA-IFFIVE, Córdoba, Argentina, ISBN 987-521-031-5, 4 pp.

Sanchez-Sanchez, H.; Henry, M.; Cardenas-Soriano, E. and Alvizo-Villasana, H. F. 2001. Identification of Wheat Streak Mosaic Virus and its vector *Aceria tosichella* in Mexico. Plant Disease, 85(1): 13-17.

Seifers, D. L; Harvey, T. L.; Martin, T. J. and Jensen, S. G. 1997. Identification of the wheat curl mite as the vector of the High Plains Virus of corn and wheat. Plant Disease, 81(10): 1161-1166.

Seifers, D. L.; Harvey, T. L.; Louise, R.; Gordon. D. T. and Martin, T. J. 2002. Differencial transmission of isolates of the High Plain Virus by different sources of wheat curl mite. Plant Disease**,** 86: 138-142.

Skoracka, A. and Kuczynski, L. 2006. Infestation parameters and morphological variation of the wheat curl mite *Aceria tosichella* Keifer (Acari: Eriophyoidea). *In*: Gabryœ, G. and Ignatowicz, S. (Eds.) *Advances in Polish Acarology,* p.330-339, SGGW, Warszawa (460 pp).

Somsen, H. W. 1966. Development of the migratory form of wheat curl mite. Journal of Economic Entomology, 59: 1283-1284.

Thomas, J. A. and Hein, G. L. 2003. Influence of volunteer wheat plant condition on movement of the wheat curl mite, *Aceria tosichella*, in winter wheat. Experimental Applied Acarology, 31(3/4): 253-268.

Thomas, J. B.; Conner, R. L. and Graf, R. J. 2004. Comparison of different sources of vector resistance for controlling wheat streak mosaic in winter wheat. Crop Science, v.44, p.1, p. 125-130.

Truol, G.; French, R.; Sagadin, M. and Arneodo J. 2004. First report of Wheat Streak Mosaic Virus infecting wheat in Argentina. Australian Plant Pathology. 33: 137-138.

Truol, G. y Sagadín, M. 2008. Monitoreo de *Aceria tosichella* Keifer vector de *Wheat streak mosaic virus* (WSMV) y de *High plain virus* (HPV) en trigos de la provincia de Buenos Aires y Córdoba. In: VII Congreso Nacional de Trigo, 2 a 4 julio 2008, Santa Rosa, La Pampa, Argentina (trabajos@anguil.inta.gov.ar). INTA/UNLPam. 5p.

Truol, G.; Sagadin, M.; Melchiorre, G. e Izaurralde, J. 2008. Enfermedades virales asociadas al cultivo de trigo en Argentina: Virus transmitidos por semilla y de importancia en el marco de las exportaciones. Detección en Argentina de sitios geográficos con presencia de *Wheat streak mosaic virus* (WSMV). Informe N° 6, INTA-IFFIVE, Córdoba, Argentina, ISBN 987-521-031-5. 3p.