ANATOMICAL ALTERATIONS CAUSED BY *MELOIDOGYNE INCOGNITA* IN ROOTS OF *IPOMOEA PURPUREA*, A WEED OF SOYBEAN CROPS

V. Cabrera[1], N. Dottori[1], P. Lax[2], J. Cuello[3] y M. E. Doucet[2]*

[1]Laboratorio de Morfología Vegetal. Instituto Multidisciplinario de Biología Vegetal. Universidad Nacional de Córdoba. Vélez Sarsfield 299. 5000 Córdoba, Argentina; [2]Laboratorio de Nematología. Centro de Zoología Aplicada. Universidad Nacional de Córdoba. Rondeau 798. 5000 Córdoba, Argentina; [3] Syngenta Argentina. *Corresponding author: mdoucet@efn.uncor.edu

ABSTRACT

Cabrera, V., N. Dottori, P. Lax, J. Cuello and M. E. Doucet. 2013. Anatomical alterations caused by *Meloidogyne incognita* in roots of *Ipomoea purpurea*, a weed of soybean crop. Nematropica 43:35-39.

Soybean acreage in Argentina has increased significantly recently. At the same time, problems related to associated weeds, such as species of the genus *Ipomoea*, also increased. In addition to the damage these weeds naturally cause, they may serve as hosts of economically important plant-parasitic nematodes, especially of the genus *Meloidogyne.* The objective of the present work was to evaluate the nematode-host relationship, based on an analysis of histological changes induced by *Meloidogyne incognita* on roots of *Ipomoea purpurea*. The material was obtained from a cultivated soybean field in the province of Córdoba (Argentina). Macroscopically, galls of variable size containing one or several females were observed. In the histopathological analysis, giant cells surrounded by normal parenchyma cells, as well as a displacement, disorganization and reduction of tissues in the central cylinder were detected. The results show a close parasite-host relationship. The presence of *I. purpurea* in cultivated soybean fields favours the establishment and persistence of *M. incognita* in the area. Hence, weed control, especially of *I. purpurea*, is of particular importance for soybean crop protection.

Key words: histopathology, *Ipomoea, Meloidogyne*, soybean, weed.

RESUMEN

Cabrera, V., N. Dottori, P. Lax, J. Cuello and M. E. Doucet. 2013. Alteraciones anatómicas ocasionadas por *Meloidogyne incognita* en raíces de *Ipomoea purpurea*, una maleza de cultivos de soja. Nematropica 43:35-39.

La superficie cultivada con soja en Argentina se ha incrementado significativamente en los últimos años. Paralelamente, aumentaron los problemas ocasionados por malezas asociadas, tales como especies del género *Ipomoea*. Independientemente de los perjuicios ocasionados por su condición de malezas, pueden ser hospedadoras de nematodos de reconocida patogenicidad, especialmente del género *Meloidogyne*. El objetivo del presente trabajo fue evaluar la relación nematodo-hospedador a partir del análisis de modificaciones histológicas inducidas en raíces de *Ipomoea purpurea* por *Meloidogyne incognita*. El material se obtuvo de un campo sembrado con soja en una localidad de la provincia de Córdoba (Argentina). Macroscópicamente se observaron agallas de tamaño variable, en cuyo interior se encontraba una o varias hembras del nematodo. En el análisis histopatológico se detectaron células gigantes rodeadas de células parenquimáticas normales, así como un desplazamiento, desorganización y reducción de tejidos del cilindro central. Los resultados muestran una estrecha relación parásito-hospedador. La presencia de *I. purpurea* en suelos cultivados con soja favorece la instalación y persistencia de *M. incognita* en el lugar. Por ello, reviste particular importancia el manejo de malezas en general y de ésta en particular.

Palabras clave: histopatología, *Ipomoea*, maleza, *Meloidogyne*, soja.

INTRODUCTION

Soybean, *Glycine max* (L.) Merr., acreage in Argentina has significantly increased recently (Aizen *et al*., 2009), reaching 18,886,634 ha in the 2010/2011 crop season (MAGyP, 2012). Argentina is one of the main producers and exporters of soybean (USDA, 2010), the most widely oilseed consumed worldwide (Wilcox, 2004).

Weeds are one of the biotic agents that negatively affect soybean crop, interfering and/or competing with the crop for essential elements, such as water, space, light, carbon dioxide, and soil nutrients. Weeds disrupt agricultural activities, delay plant development and affect production significantly. They act as reservoirs of insects, fungi, nematodes, bacteria and viruses during the entire cycle crop (Muñoz, 2009). As alternative nematode hosts, they reduce the efficacy of plant parasitic nematode management strategies (Thomas *et al.,* 2005).

Along with the expansion of soybean production, problems caused by associated weeds also increased. Among soybean-associated weeds are species of the genus *Ipomoea* (Convolvulaceae) (Nobile *et al*., 1994; Leguizamón Frey *et al.*, 2003; Nisensohn *et al*., 2009), which can be hosts of economically important nematodes such as the genus *Meloidogyne* (Antonio and Lehman, 1978; González, 2006). This root-knot nematode limits plant development and causes severe losses in agriculture worldwide (Navarro-Barthelemy *et al*., 2009). *Meloidogyne* spp. induce feeding sites in the parasitized tissues, establishing a complex and specialized relationship with the host (Hussey and Williamson, 1998), producing re-differentiation of root cells into feeding cells, commonly known as "giant" or "transfer" cells. Successful establishment of these cells is essential for parasite development (Caillaud *et al*., 2008).

Ipomoea purpurea (L.) Roth, known as Common Morning Glory, is also found in fields of more than 40 plant species of economic importance, such as maize, *Zea mays* (L.), and bean, *Phaseolus vulgaris* (L.) (Díaz Pontones, 2009). It is considered one of the worst 10 weeds, since it can cause considerable crop yield reductions and interfere with harvest processes (De Andrada *et al.*, 1995; Culpepper and York, 1998; Ortiz *et al.*, 2011). Because *I. purpurea* is tolerant to glyphosate, recently this weed has become an important threat for soybean production in the Argentine Pampas region (Papa *et al.*, 2002; Fernández-Quintanilla *et al.*, 2007). In addition, it has been reported as host for *Meloidogyne* spp., being able to resist severe infestation levels (González, 2006; Mônaco *et al.*, 2009).

Several works have evaluated histological alterations caused by *M. incognita* (Kofoid & White, 1919) Chitwood, 1949 in cultivated plants (Gapasin, 1994; Castillo *et al.*, 2003; Carneiro *et al*., 2005; Mota, 2010). However, studies on weeds parasitized by this species have focused on other aspects, mainly on the nematode reproduction factor (Webster and Davis, 2007; Mônaco *et al.*, 2009); histopathology induced by the parasite still remains poorly known, and the few works conducted deal with infections caused by other *Meloidogyne* species (Doucet and de Ponce de León, 1985; Doucet *et al*., 2000; Castillo *et al.*, 2008). Studies on histological alterations in roots of naturally infected weeds can indicate if the plant-nematode interaction is compatible or incompatible, and provide information on the degree to which the parasite can develop and multiply. Knowing this aspect is of great importance for the understanding and management of root-knot nematodes (Castillo *et al.*, 2008). The objective of the present work was to evaluate the nematode-host relationship based on the analysis of histological alterations induced by *M. incognita* on *I. purpurea* roots.

MATERIALS AND METHODS

Plants of *I. purpurea* were collected from a soybean field from the locality of Pilar (department of Río Segundo, province of Córdoba, Argentina), naturally infested with *M. incognita*. Healthy roots (without galls) and infected (galled) were cut into segments of about 5 mm in length, fixed in FAA (formol 10%, ethyl alcohol 96° 50%, glacial acetic acid 5%, distilled water 35%), dehydrated in a graded series of ethyl alcohol-xylene and embedded in paraffin Histowax ™. Cross sections 7 to 10 µm thick were obtained with a rotary microtome. They were stained with hematoxylin-safranin-fast green and mounted in Canada balsam (Johansen, 1940; Conn *et al*., 1960; O' Brien and Mc Cully, 1981).

RESULTS AND DISCUSSION

The roots of plants of *I. purpurea* had abundant galls of 2-5 mm in length; many of them had egg masses on the surface (Fig. 1 A, B). Histological sections revealed normal anatomy and arrangement of the vascular tissues in the control roots (Fig. 1 C). Infected sections showed the presence of 1 to 2 mature females of *M. incognita*. Between 5 and 11 giant cells were observed surrounding the anterior region of the nematode (Fig. 1 D). The central cylinder was displaced to the periphery due to the volume occupied by the nematode and the giant cells; disorganization and reduction of vascular tissues was noticeable (Fig. 1 E). Cell breakdown was evident, mainly in vessels and xylem parenchyma. Giant cells were multinucleate (due to the occurrence of nucleus division without subsequent cytokinesis), with prominent nucleoli and very dense cytoplasm. Giant cell walls were thickened (4-6 µm) with respect to normal cells (2-4 µm) and rough in texture (Fig. 1 F). Some galls contained two nematodes, each one related to a group of giant cells, which increased disorganization and reduction of the vascular tissues.

The polyphagous nature of *M. incognita* (as in other

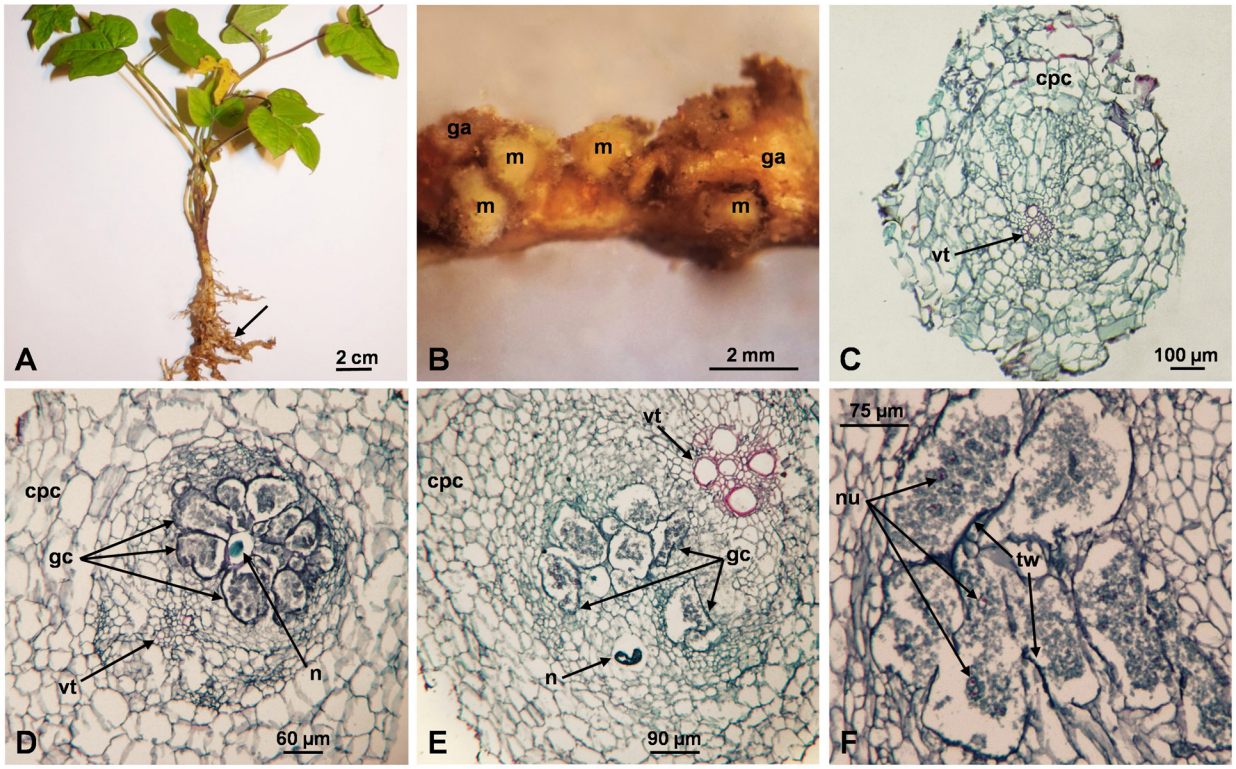

Fig. 1. *Ipomoea purpurea* parasitized by *Meloidogyne incognita*. **A:** general view of the plant, galls present in the root system are indicated. **B:** galls with egg masses. **C:** transverse section of control root. **D**: gall with giant cells and anterior region of nematode. **E**: displacement of vascular tissue. **F**: detail of giant cells. Abbreviatons: cpc: cortical parenchyma cell, ga: gall, gc: giant cell, m: egg masses, n: nematode, nu: nucleus, tw: thickened wall, vt: vascular tissue.

species of the genus) increases its likelihood of finding a host that ensures its establishment, development and reproduction. Accordingly, the presence of giant cells in *I. purpurea* found in this work showed the successful establishment of feeding sites of the nematode, as well as a close parasite-host relationship. The histological alterations indicate the host susceptibility and are in agreement with records reported for other weeds infected with *Meloidogyne* spp. (Doucet and de Ponce de León, 1985, Doucet *et al*., 2000; Castillo *et al.*, 2008). Establishment and persistence of *M. incognita* is enhanced by the presence of *I. purpurea* in soybean-cultivated soils. Therefore, weed control should be extended beyond the critical period of competition, and should include practically the entire crop cycle (Daita *et al.*, 2011).

Direct seeding, the use of glyphosate-tolerant transgenic cultivars, and the intensive application of this product contribute to the modification of the range of weeds present in diverse cultivars (Rodriguez, 2004). Furthermore, many of the weeds have become resistant to the herbicide (Dellaferrera *et al*., 2007; Rainero, 2008) due to selection pressure. For example, "crabgrass", *Digitaria sanguinalis* (L.) Scop. (Poaceae), frequently occurs in soybean production areas (Scursoni and Satorre, 2010), even in areas previously treated with glyphosate (Culpepper *et al.*, 2001). A similar situation occurs with other widely dispersed weeds of different families, such as: *Anoda cristata* (L.) Schltdl. (Malvaceae), *Commelina virginica* L. (Commelinaceae), *Convolvulus arvensis* L. (Convolvulaceae), *Cyperus rotundus* L. (Cyperaceae), *Portulaca oleracea* L. (Portulacaceae) and *Wedelia glauca* (Ortega) O. Hoffm. ex Hicken (Asteraceae) (Vitta *et al*., 2000). It should be noted that species of some of these and other families have been cited as good hosts of numerous plant-parasitic nematodes in Argentina, among which are several species of the genus *Meloidogyne* (Doucet 1992, 1999). However, information on the host range of *Meloidogyne* spp. is incomplete and sometimes contradictory (Rich *et al.*, 2009).

On the other hand, the high reproductive potential of *M. incognita*, its short life cycle and the wide host range ensure the development of several generations during a single crop cycle (Gómez *et al.,* 2010). This

raises awareness about the need to control not only *I. purpurea* but also other weeds that may act as reservoirs of the parasite. Weed control is of great importance for the successful management of the nematode, as well as the analysis of the nematode-host relationship from a histological perspective, focusing not only on cultivated plants but also on weeds.

ACKNOWLEDGEMENT

The authors thank the Secretaría de Ciencia y Tecnología (SECyT) of the Universidad Nacional de Córdoba and the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) for financial support.

LITERATURE CITED

Aizen, M. A., L. A. Garibaldi and M. Dondo. 2009. Expansión de la soja y diversidad de la agricultura argentina. Ecología Austral 19:45-54.

Antonio, H. and P. S. Lehman. 1978. Nota sobre a ocorrência de nematóides do gênero *Meloidogyne* em algumas ervas daninhas nos estados do Paraná e do Rio Grande do Sul. Pp. 29-32 *in* Anais da III Reunión de Nematología, Mossoró.

Caillaud, M. C., G. Dubreuil, M. Quentin, L. Perfus-Barbeoch, P. Lecomte, J. De Almeida Engler, P. Abad, M. N. Rosso and B. Favery. 2008. Root-knot nematodes manipulate plant cell functions during a compatible interaction. Journal of Plant Physiology 165:104-113.

Carneiro, R. M. D. G., D. I. Neves, R. Falcão, N. S. Paes, E. Cia and M. de F. G. Sá. 2005. Resistência de genótipos de algodoeiro a *Meloidogyne incognita* raça 3: reprodução e histopatologia. Nematologia Brasileira 29:1-10.

Castillo, P., A. I. Nico, H. F. Rapoport and R. M. Jiménez Díaz. 2003. Nematodos fitoparásitos en viveros de olivo. Boletín de Sanidad Vegetal. Plagas 29:255-263.

Castillo, P., H. F. Rapoport, J. E. Palomares Rius and R. M. Jiménez Díaz. 2008. Suitability of weed species prevailing in Spanish vineyards as hosts for root-knot nematodes. European Journal of Plant Pathology 120:43-51.

Conn, H. J., M. A. Darrow and V. M. Emmel. 1960. Staining procedures. I-XII. Williams & Wilkins Co., Baltimore.

Culpepper, A. S. and A. C. York. 1998. Weed management in glyphosate-tolerant cotton.The Journal of Cotton Science 2:174-185.

Culpepper, A. S., A. E. Giménez, A. C. York, R. B. Batts and J. W. Wilcut. 2001. Morning glory (*Ipomoea* spp.) and large crabgrass (*Digitaria sanguinalis*) control with glyphosate and 2,4DB mixtures in glyphosate-resistant soybean (*Glycine max*). Weed Technology 15:56-61.

Daita, E. J., F. E. Zorza and E. Fernandez. 2011. Control de *Ipomoea purpurea* (L.) Roth con diferentes dosis de sulfentrazone en cultivo de soja. Mercosoja 2011. V Congreso de la Soja del Mercosur. I Foro de la Soja Asia - Mercosur. Rosario, Argentina.

De Andrada, N., H. Robinet, O. Arce, B. Díaz, S. Guillen, N. Mansilla and E. Gallo. 1995. Relevamiento y determinación de la distribución de malezas frecuentes en la zona sojera del noreste de Tucumán, República Argentina. Pp. 50-60 *in* XII Congreso Latinoamericano de Malezas. Montevideo, Uruguay.

Dellaferrera, I., N. Guarise and A. Amsler. 2007. Relevamiento de malezas en cultivos de soja en sistema de siembra directa con glifosato del departamento San Justo (Provincia de Santa Fe). Revista FAVE - Ciencias Agrarias 5/6:1-2.

Díaz Pontones, D. M. 2009. *Ipomoea*: un género con tradición. Contactos 73:36-44.

Doucet, M. E. 1992. Asociaciones entre nematodos fitófagos y malezas en la República Argentina. Agriscientia 9:103-112.

Doucet, M. E. 1999. Nematodos del suelo asociados con vegetales en la República Argentina. Academia Nacional de Agronomía y Veterinaria, República Argentina. Serie N° 24. Buenos Aires, Argentina.

Doucet, M. E. and E. L. de Ponce de León. 1985. *Chenopodium album* L.: eficiente hospedador de *Nacobbus aberrans* (Thorne, 1935) Thorne & Allen, 1944 y *Meloidogyne javanica* (Treub, 1885) Chitwood, 1949 en la provincia de Córdoba. IDIA 437-440:36-43.

Doucet, M. E., E. L. de Ponce de León, P. Milanesio, C. Azpilicueta and E. Maero. 2000. Asociacion entre *Taraxacum officinale* y *Meloidogyne hapla* detectada en Argentina. Nematología mediterranea 28:63-66.

Fernández-Quintanilla, C., J. Dorado, E. Leguizamón and L. Navarrete. 2007. Manejo de malas hierbas en la Agricultura de Conservación. Revista de la Asociación Española de Agricultura de Conservación /Suelos Vivos 5:42-47.

Gapasin, R. M. 1994. Histopathology of resistant and susceptible sweet potato cultivars infected with root-knot nematode (*Meloidogyne incognita*). Philippine Phytopathology 30:74-80.

Gómez L., E. González, R. Enrique, M. A. Hernández and M. G. Rodríguez. 2010. Uso de la biofumigación para el manejo de *Meloidogyne* spp., en la producción protegida de hortalizas. Revista de Protección Vegetal 25:119-123.

González, H. 2006. Asociación malezas-nematodos: un peligro para la fruticultura nacional. Tierra adentro 67:32-35.

Hussey, S. R. and V. M. Williamson. 1998. Physiological and molecular aspects of nematode parasitism. Pp. 87-108 *in* K. R. Barker, G. A. Pederson and G. L. Windham (eds.). Plant and nematode interactions. Agronomy Monograph No. 36. ASA CSSA SSA.

Madison, Wisconsin.
Johansen, D. A. 1940. Plant microtechnique. Mc Graw-Hill Book Co., New York.
Leguizamón Frey E. S., J. P. Lewis, G. Ferrari, A. Contigiani, J. P. Bodrero, P. S. Torres, E. Zorza, F. Daita and F. Sayazo. 2003. Efecto de la longevidad del sistema de siembra directa sobre las comunidades de malezas de soja de tres áreas de la región pampeana argentina. Pp. 118-122 *in* Actas del Congreso de la Sociedad Española de Malherbología. Barcelona, España.
MAGyP. 2012. Producción, área sembrada y cosechada, cotizaciones nacionales e internacionales. Cereales, oleaginosas, cultivos industriales, frutos y hortalizas. Online. http://www.siia.gov.ar/index.php/series-por-tema/agricultura.
Mônaco, A. P. A., R. G. Carneiro, W. M. Kranz, J. C. Gomes, A. Scherer and D. C. Santiago. 2009. Reação de espécies de plantas daninhas a *Meloidogyne incognita* raças 1 e 3, a *M. javanica* e a *M. paranaensis*. Nematologia Brasileira 33:235-242.
Mota, F. de C. 2010. Análise de novas fontes de resistência do algodoeiro a *Meloidogyne incognita* raça 3 e caracterização histopatológica da interação planta-nematóide. Dissertação (Mestrado em Fitopatologia). Universidade de Brasília, Brasília.
Muñoz, J. A. 2009. Manejo integrado de malezas en el cultivo de soya. El cultivo de la soya en Venezuela. Online. http://www.planetasoja.com.ar/index.php?sec=21&tra=36880&tit=36881.
Navarro-Barthelemy L., L. Gómez, R. Enrique, F. M., González and M. G. Rodríguez. 2009. Comportamiento de genotipos de tomate (*Solanum lycopersicum* L.) frente a *Meloidogyne incognita* (Kofoid & White) Chitwood. Revista de Protección Vegetal 24:54-56.
Nisensohn, L., D. Faccini, E. Puricelli, D. Tuesca, L. Allieri and S. Vecchi. 2009. Malezas de reciente difusión en los agroecosistemas de la región sojera núcleo. Parte I. 2da edición. Facultad de Ciencias Agrarias, Universidad Nacional de Rosario. Dow AgroSciences Argentina S. A. Buenos Aires, Argentina.
Nobile, R., A. L. Pascualides, N. B. Von Muller and D. Abal Solis. 1994. Contribución ilustrada al conocimiento de malezas del género *Ipomoea* en cultivos de soja del área central de Córdoba. Pp. 79-85 *in* XII Reunión Argentina sobre la Maleza y su Control. Mar del Plata, Argentina.
O' Brien, T. P. and M. E. Mc Cully. 1981. The study of plant structure: principles and selected methods. Termarcarphi PTY Ltd., Melbourne, Australia.
Ortiz H. M. A., A. L. Bedoya, M. E. B. Vera and E. C. Ramírez. 2011. Caracterización ecológica y fitoquímica de la batatilla *Ipomoea purpurea* (L.) Roth (Solanales, Convolvulaceae) en el Municipio de Manizales. Boletín Científico del Centro de Museos 15:19-39.
Papa, J. C, E. Puricelli and J. C. Felizia. 2002. Malezas tolerantes a herbicidas en soja. IDIA XXI:64-67.
Rainero, H. P. 2008. Problemática del manejo de malezas en sistemas productivos actuales. Publicaciones Regionales. Boletín de Divulgación Técnica Nº 3. INTA EEA Manfredi. Córdoba, Argentina.
Rich, J. R., J. A. Brito, R. Kaur and J. A. Ferrell. 2009. Weed species as hosts of *Meloidogyne*: a review. Nematropica 39:157-185.
Rodriguez, N. 2004. Malezas con grado de tolerancia a glifosato. Proyecto regional de agricultura sustentable. Boletín Nº 1. INTA EEA Manfredi. Córdoba, Argentina.
Scursoni, J. A. and E. H. Satorre. 2010. Glyphosate management strategies, weed diversity and soybean yield in Argentina. Crop Protection 29:957-962.
Thomas, S. H., J. Schroeder and L. W. Murray. 2005. The role of weeds in nematode management. Weed Science 53:923-928.
USDA. 2010. Oferta y demanda mundial. Online. http://www.siia.gov.ar/sst_pcias/usda.php?nro=2222000.
Vitta, J., D. Tuesca and L. Nisensohn. 2000. Soja. La difusión de los cultivares RR y la tecnología de control de malezas: ¿hay un avance?. Agromensajes. Online. http://www.fcagr.unr.edu.ar/Extension/Agromensajes/02/1AM2.htm
Webster T. M and R. F. Davis. 2007. Southern root-knot nematode (*Meloidogyne incognita*) affects common cocklebur (*Xanthium strumarium*) interference with cotton. Weed Science 55:143-146.
Wilcox, J. R. 2004. World distribution and trade of soybean. Pp. 1-14 *in* H. R. Boerma and J. E. Specht (eds.). Soybean: improvement, production and uses. Agronomy Monograph 16. ASA CSSA SSA. Madison, WI. 3rd edition.

Received: *Accepted for publication:*
25/IX/2012 *29/I/2013*
Recibido: *Aceptado para publicación:*