NOTE

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The biological characteristics and distribution of the greenbug, *Schizaphis graminum*, and Russian wheat aphid, *Diuraphis noxia* (Hemiptera: Aphididae), in Argentina and Chile

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Abstract. The aphids *Schizaphis graminum* (Rondani) (greenbug) and *Diuraphis noxia* (Mordvilko) (Russian wheat aphid, RWA) were collected from several localities in Argentina and Southern Chile. Clones were established from aphids collected at each location. The host preferences were studied in free choice tests. Biotypes were characterized on the basis of aphid antibiosis and host plant tolerance. The production of sexuals was assessed under natural conditions, from March to November in 1997-2001, at La Plata ($34^{\circ}55'$ S, $57^{\circ}57'$ W). The greenbug distribution ranged from $24^{\circ}40'$ to $43^{\circ}28'$ S, and was bounded between isothermals $18-20^{\circ}$ C and $8-10^{\circ}$ C, and isohyets 400–600 mm and greater than 1200 mm. The aphids at all localities were collected from a wide range of cultivated and wild hosts. The biotypes in ten out of thirty-four populations were identified. One population was obligatorily parthenogenetic, the remainder cyclically parthenogenetic. No correlation was found between the region they came from and the period required for the induction of sexuals. RWA was found between $26^{\circ}50'$ and $43^{\circ}28'$ S, bounded by the isothermals $20-22^{\circ}$ C and $8-10^{\circ}$ C, and isohyets 400–600 mm and 2000 mm. In Chile, this aphid was only found in Osorno County, which lies on isothermal $8-10^{\circ}$ C and is bounded by the isohyets 1000 mm and 2000 mm. Only a few RWA genotypes (clones) produced sexuals irrespective of the host they were collected from, period of the year, region, current host, or the day length and average temperature of the rearing conditions. For the first time, RWA was found infesting cultivated as well as wild oats in South America. At low latitudes, populations of both aphid species were found only infesting wild *Sorghum halepensis* (L).

INTRODUCTION

The greenbug, Schizaphis graminum (Rondani) and the Russian wheat aphid, RWA, Diuraphis noxia (Mordvilko) are the two economically most important insect pests of wheat and barley throughout much of the Americas. The greenbug is well adapted to conditions in the Americas, whilst the RWA is the last of several recent aphid introductions into Argentina and Chile. Russian wheat aphid was first discovered in Texas, USA, in 1986, and is now widespread in the USA and Canada (Kindler & Springer, 1989; Peairs et al., 1989). This species was first found in Chile in 1988 and in Argentina in 1992 (Ortego & Delfino, 1994). It was found in the main cereal producing region of Argentina, south of Buenos Aires province, in 1994 (Bellone & Almaraz, 1995), and then spread northwards and eastwards infesting barley and wheat (Triticum aestivum and T. durum) in 1995 (Castro et al., 2000, 2001). Parasitoids and chemicals failed to control this pest, possibly because it causes the leaves to curl tightly, which protects the enclosed aphids (Burd et al.,1998). Although RWA prefers cereal crops (Butts & Pakendorf, 1984), it also feeds on other cultivated and wild grasses (Kriel et al., 1984; Kindler & Spomer, 1986).

The biology and ecology of both these aphid pests has been studied in the United States (Puterka et al., 1988, 1993; Shufran et al., 1991, 1997, 2000; Shufran & Wilde, 1994; Kieckhefer et al., 1995; Ullah & Peters, 1996). However, no information is available on the distribution or population biology of these The objectives of this paper were to: 1) study the distribution of the greenbug and RWA in Argentina and Chile; and 2) determine the variability, within and between populations, in biotype composition, the incidence of sexual reproduction and host preferences.

aphids in South America. Important outbreaks of greenbug occurred in 1989, 1990 and 1995 in the centre of Argentina (Arriaga, pers. comm.). In 1998, outbreaks of RWA occurred in Buenos Aires and Córdoba provinces. No change in biotype composition occurred in the greenbug populations collected in the centre of Argentina (Córdoba and Santa Fe provinces) (Almaraz et al., 1990). However, considerable variation was found in their isoenzymes (Gimenez et al, 1991; Castro et al., 1996). The aphids collected from Córdoba and Santa Fe were subsequently analysed for mt (mitochondrial) DNA polymorphisms by Martínez et al., (1993) and Castro (1994). The values of their genetic distances (Nei, 1987) were similar to those found by Powers et al., (1989) for B and C biotypes in the USA. Nonetheless, mtDNA haplotypes of Argentinean and Spanish clones showed no relationship with biotype characterization (Martinez et al., 1993; Castro 1994), which accords with recent results published by Anstead et al. (2002). Since both aphid species are important pests of cereals and virus vectors (Fereres et al., 1993; Pérez et al., 1995), a better understanding of their biology is likely to facilitate their control.

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Fig. 1. Isohyets (-----), isothermals (----) and the geographical location of the collection site of *Schizaphis graminum* and *Diuraphis noxia* in Argentina and Chile.

MATERIAL AND METHODS

Aphids were collected from 34 localities in Argentina and southern Chile, including dry steppe (Fig. 1, locations 10, 12, 19, 21, 29, 31, 34), deserts (3 and 4), humid subtropical regions with warm summers (1, 2), localities with a moderate climate and all year rain fall (8, 9, 11, 13–16, 18, 20, 22–26, 30, 32, 33) and undifferentiated mountains (5–7, 17, 27, 28). The designation of the localities follows the classification used by Koppen (1923). Samples of varying numbers were collected from cereal crops and wild grasses every 50 to 100 km (Table 1), in autumn and spring, from 1996 to 1999.

Aphids were reared on susceptible wheat (cv. 'Buck Ombú') and barley (cv. 'Bordenave Ranquelina') plants growing in pots (500 cc) covered with a plastic cage. Individuals from each population (i.e., collected on the same host and locality in each season) were allowed to reproduce parthenogenetically under controlled conditions (20–22°C, 60–70% relative humidity and 16 h photophase) and then 20 to 30 individuals from each population were used to establish single asexual lineages ("clones"). In most of the regions sampled, greenbug and RWA were found accompanied by *Sitobion avenae* (Fabricius), *Rhopalosiphum padi* (Linnaeus), *R. maidis* (Fitch) and *Metopolophium dirhodum* (Walker). There were twelve localities in which RWA was not found, but only one where greenbug was absent (Table 1, locality 28).

Aphid clones were reared separately on different cultivars of cereals (following Porter et al., 1997) and the aphid biotype identified by its antibiotic responses (reproductive rate, mortality and duration of immature period, compared with that recorded for the same clone on a susceptible cultivar; Ramos et al., 1998, 2003) and the tolerance of the plants to the aphid (chlorotic damage, plant height and number of expanded leaves; Noricga et al., 1998, 2002).

The ability of aphids to produce sexuals was studied by subjecting them to natural conditions from 1^{st} March to 30^{th} November at La Plata ($34^{\circ}55'$ S, $57^{\circ}57'$ W) and recording every other day the presence of sexuals (males and oviparae) and eggs over a four year period, 1997-2001. Populations and clones derived there from were placed outdoors on susceptible plants growing in pots (1000cc) and covered with a plastic, transparent tube with a top made of voile \mathbb{R} .

Aphid host preferences were studied by giving aphids a free choice of plants at the same growth stage (second leaf fully expanded) and each growing in a pot (5 cm diameter \times 10 cm high). Ten different host plants were randomly placed in a circle, with their leaves directed towards the centre of the circle. One hundred adult apterous aphids, equivalent to 10 aphids per plant, were placed in the lid of a Petri dish (20 cm diameter), which was inverted over the leaves in the centre of the circle, following the methodology of J. Pettersson, (pers. comm.). In order to avoid the direction of light influencing plant selection, this assay was carried out in the dark. Each combination was replicated ten times. After 2 h and again after 24 h, the number of adult aphids on each plant was recorded. Since both recordings were not significantly different (P = 0.05), only the results after 24 h are presented (Table 2). For a particular host, the average of the recordings after 24 h was used (Table 2). The cultivars tested were susceptible cultivars of wheat (Triticum aestivum L.) (cv. 'Buck Ombú'), barley (Hordeum vulgare L.) (cv. 'Bordenave Ranquelina'), rye (Secale cereale L.) (cv. 'Don Enrique'), oats (Avena sativa L.) (cv. 'Buck 152'), sorghum (Sorghum bicolor M.) (cv. 'NTK147'), triticale (Triticumsecale) (cv. 'Pampeano'), tritordeum (Triticum x Hordeum chilense M.) (cv. 'Cdb197-2'), bromus (Bromus catharticus L.) (cv. 'Miguel'), Hordeum murinum (L.) (cv. 'FA194'), Poa pratensis (L.) (cv. 'FA4796') and a selection of Sorghum halepensis (cv. 'FA1992/96').

Data were analysed by ANOVA, whilst the Duncan's Multiple Range Test was used to compare differences between clones, and the effect of host, region and time of the year when the aphids were collected (SAS, 1998).

RESULTS AND DISCUSSION

Schizaphis graminum

The distribution of the greenbug ranged from $24^{\circ}40'$ to $43^{\circ}28'$ S, bounded by isothermals $18-20^{\circ}$ C and $8-10^{\circ}$ C and isohyets 400-600 mm and >1200 mm (Fig. 1).

This aphid was collected from many plant species (Table 1). At low latitudes it was found mainly on *S. halepensis* (localities 1, 2, 4 and 5).

Ten populations included known biotypes (Table 1). Samples from locality 16 included biotypes B, C, E and F, whereas those from localities 15, 18 and 30 consisted only of biotypes B and C in the ratios 1:1, 1.7:1 and 1:2, respectively. In twenty four of the populations the aphids could not be assigned to a biotype (Ramos et al., 1998, 2003).

There was no apparent correlation between the locality from which aphids were collected and the period required for the induction of sexuals. Most of the populations required an extended period for sexual induction, ranging from 120 days (localities 1 and 2) to 180 days (localities 10, 11, 15, 16, 18, 20, 21, 23, 29, 31, 32, 33). The most precocious populations in this respect were those from localities 3 and 26 (36 days), 4 (42 d), 27 (43 d), 22 and 24 (54 d), 25 (63 d), 30 (67 d), and aphids from locality 34 did not produce sexuals.

Supervise Types Descript Fundation Events Fundation 1. Salua 24440 68503 S graminum S. halepensis - 5 2. Treaumán 26'50' S graminum S. halepensis - 5 3. Ceres 28'36' 6'5'12' S graminum Hordeam spp-1. S. halepensis - 2 4. Frias 28'39' 6'5'09' S graminum S. halepensis - 5 5. Cruz del Eje 29'10' 64'20' S graminum S. halepensis - 5 6. L.V. Mansilla 29'48' 64'43' S graminum Bronue-2. Startia-1 0. noxia S. halepensis - 5 Donxia S. halepensis - 5 9. Paraná 31'52' S graminum Hordeam spp-3. Bronus-5 8. Rafiela 31'10' 6'22'' S graminum Sorghum-5. A. start-5 10. Cárioba Norte 31'40' 62'20'' S graminum Sorghum-5. A. start-5 11. Cárioba Sar 32'25'' 60'39'' S graminum Sorghum-5. A. start-5 11. Cárioba Sar 32'5''' 63'15'''''''' S graminum Sorghu	Populations	GPS Data		Aphide	Biotyne	Number of individuals on each host plant ¹	
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7. La Cumbre $30^{\circ}59^{\circ}$ $64^{\circ}29^{\circ}$ S graminum D noxia D noxia Hordeum spp-5, Bronus-5 8. Rafaela $31^{\circ}10^{\circ}$ $61^{\circ}28^{\circ}$ S graminum D noxia Hordeum spp-5, Bronus-5 9. Paraá $31^{\circ}52^{\circ}$ $60^{\circ}29^{\circ}$ S graminum Sorghum-5, A sart-5 10. Córdoba Norte $31^{\circ}20^{\circ}$ $62^{\circ}20^{\circ}$ S graminum Sorghum-5, A sart-5 11. Córdoba Sur $32^{\circ}240^{\circ}$ $61^{\circ}53^{\circ}$ S graminum Noxia H wig5, A sart-5 12. Va. María $32^{\circ}25^{\circ}$ $63^{\circ}15^{\circ}$ S graminum Sorghum-5, A sart-5 13. Rosario $32^{\circ}25^{\circ}$ $63^{\circ}30^{\circ}$ S graminum Sorghum-5, A sart-5, H vig6, Poa-6 15. Los Hornos $3^{\circ+55^{\circ}$ $57^{\circ}57^{\circ}$ S graminum D noxia Roy-3, Bronus-5, Hordeum spp5 16. B. Bavio $35^{\circ}05^{\circ}$ $57^{\circ}44^{\circ}$ S graminum D noxia Roy-2, Bronus-5, Hordeum spp5 17. Malargue $37^{\circ}08^{\circ}$ S graminum D noxia Roy-3, Bronus-5, Hordeum spp5 18. Ayacucho $37^{\circ}08^{\circ}$ S graminum D noxia T east.3, H vig5, Rye-5, Triticale-5 20. Balcarce $37^{\circ}51^{\circ}$ S graminum D noxia T east.3, H vig5, A sart.6, H vi	0. L. V. Manshia	29 48	04 45	5. graminum D novia		Bromus 1 Sataria 1	
1. La Culture 30 39 64 25 3 grammun Frankensen 8. Rafaela 31°10' 61°23' S grammun Sorghum-5 9. Parmá 31°20' 61°23' S grammun Sorghum-5 9. Parmá 31°20' 62°20' S grammun Sorghum-5, A sat-5 10. Córdoba Sur 32°40' 61°33' S grammun H. vulg-5, A. sat-5 13. Rosario 32°57' 60°30' S grammun H. vulg-5, A. sat-5 13. Rosario 32°57' 60°30' S grammun A sat-5 13. Rosario 32°57' 60°30' S grammun Sorghum-5, H. ordug-5, Bromus-5, Sorghum-5 14. Baradero 33°49' S grammun B, C. K. F. A sat-6, G. Drole-6 16 15. Los Hornos 34°55' S grammun B, C. K. F. A sat-6, Bromus-6, Hordeum spp5 16. B. Bavio 36°05' S grammun B, C. K. F. A sat-6, Sorghum-6, Bromus-9, Poa-6 16. Bavio 35°30' 69°35' S grammun R. ext-5, B. Nulg-5, Romus-5, Hordeum spp5 17. Malargue 35°30' 58°20' S grammun C. T aest-5, H. vulg-6, C. Friticale-5 18. Ayacucho	7 La Cumbra	30°50'	640201	D. noxia S. graminum		Howdown spp 5 Browns 5	
8. Rafaela 31°10' 61°28' S. graminum Florentiation app. of Dotted and a set of the s	7. La Cumbre	30 39	04 29	D poria		Hordeum spp-5, Bromus-5	
Markan String System Description Description 10. Córdoba Norte 31°40° 62°20° S. graminum Sorghum-5, A. sat-5 11. Córdoba Sar 32°40° 61°53° S. graminum A sat-5 11. Córdoba Sar 32°40° 61°53° S. graminum A sat-5 12. Va, María 32°25° 60°30° S. graminum A sat-5 13. Rosario 32°55° 60°30° S. graminum Sorghum-5, A. sat-5 15. Los Hornos 33°40° 59°30° S. graminum B, C. E, F. A. sat-6, Sorghum-6, Hordeum spp6 16. B. Bavio 35°00° 69°33° S. graminum B, C. E, F. A. sat -6, Sorghum-5, Hordeum spp5 16. B. Bavio 35°00° 69°33° S. graminum Rye-2, Bromus-5, Hordeum spp5 16. B. Bavio 37°08° Se?20° S graminum Rye-2, Bromus-5, Hordeum spp5 18. Ayacucho 37°80° Se?1° S graminum C T aast-5, H. vulg-6, Rye-6, Friticale-5 20. Balcarce 37°50° Se?1° S graminum C T aast-4, H. vulg-5,	8 Rafaela	31°10′	61°28′	S graminum		Sorahum-5	
A manual A manual <t< td=""><td>9 Paraná</td><td>31°52'</td><td>60°29'</td><td>S. graminum S. graminum</td><td></td><td>T asst-6 Sorahum-6 Bromus-6</td></t<>	9 Paraná	31°52'	60°29'	S. graminum S. graminum		T asst-6 Sorahum-6 Bromus-6	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	 10 Córdoba Norte 	31°40'	62°20'	S. graminum		Sorahum-5 4 sat-5	
11. Concloue Sult 12. Vo 61 23 5 graminum 11. $vulg = 5, A, sat = 5$ 12. Va, María 32°257 $63°15'$ S graminum A sat = 5 13. Rosario 32°57' $60°39'$ S graminum Sorghum 5, A sat = 5 14. Baradero 33'49' 59'30' S graminum Sorghum 5, A sat = 5 15. Los Hornos 34'55' 57'57' S graminum B, C A sat = 6, H vulg = 6, Poa = 6 16. B. Bavio 35'05' 57'844' S graminum B, C A sat = 6, Hordeum spp. = 6 17. Malargue 35'06'' 58''29'' S graminum Rye=3, Bronus-5, Hordeum spp. = 5 18. Ayacucho 37'08'' 58''29'' S graminum C T aest. = 6, H vulg = 6, Triticale = 5 19. Puán 7''20'' 58''1'' S graminum C T aest. = 5, H vulg = 6, Triticale = 5 20. Balcarce 37''50' 58''1'' S graminum B, C, F H vulg = 5, A sat = 5, Rye = 5, Triticale = 5 21.Bordenave 37''51' 63''01'' S graminum T aest6, Bromus-6, A sat -6, H vulg = 6, T. durum-6 23. Osomo ² 38''13'' 72''20'' S graminum T aest6, Bromus-5, S monus-5 2	11. Córdoba Sur	32°40'	61°53'	S. graminum		H yula 5 4 sat 5	
12. Va. María 32°25 63°15 S. graminum A. sat5 13. Rosario 32°257 60°39' S. graminum T. aest6, H. vulg6, Bromus-5, Sorghum-5 14. Baradero 33°49' 59°30' S. graminum B, C. E., F. A. sat6, H. vulg6, Poa-6 15. Los Hornos 34°55' 57°57' S. graminum B, C. E., F. A. sat6, M. vulg6, Poa-6 16. B. Bavio 35°05' 57°44' S. graminum B, C. E., F. A. sat6, M. vulg6, Poa-6 17. Malargue 35°30' 69°35' S. graminum B, C. E., F. A. sat6, M. vulg6, Poa-6 18. Ayacucho 37°08' 58°29' S. graminum B, C. H. Vulg6, Poa-6 19. Puán 37°03' 62°46' S. graminum C. T. aest5, H. vulg5, Ryc-5, D. noxia 20. Balcarce 37°51' 63°01' S. graminum C. T. aest5, H. vulg3, Triticale-3 21. Bordenave 37°51' 63°01' S. graminum B, C. F. H. vulg5, A. sat5, Ryc-5, Triticale-5 22. G. Chavez 38°13' 72°20' S. graminum Ryc-6, T. aest6, H. vulg6, T. durum-6 23. Osomo ² 38°13' 72°20' S. graminum T. aest6, H. vulg6, T. durum-	11. Colubba Sui	32 40	01 55	D noria		11. vulg5, A. sul5 H. vulg5, A. sat5	
11. dr. Marka 12. 25 60 (3) S. graminum T. data (-) 14. Baradero 33°49' 59°30' S. graminum Sorghum-5, H. vulg-6, Bromus-5, Sorghum-5 14. Baradero 33°49' 59°30' S. graminum B, C. K. sat -6, H. vulg-6, Bromus-5, Sorghum-5, H. ordeum spp6 15. Los Hornos 34°55' 57°57' S. graminum B, C. E, F. A. sat -6, Sorghum-6, H. ordeum spp6 16. B. Bavio 35°50' 59°30' S. graminum B, C. E, F. A. sat -6, Sorghum-6, Hordeum spp5 17. Malargue 35°30' 69°35' S. graminum B, C. E, F. A. sat -6, Sorghum-5, Hordeum spp5 18. Ayacucho 37°08' 58°29' S. graminum C. T. aest5, H. vulg-5, Rye-5 19. Puán 37°33' 62°46' S. graminum C. T. aest5, H. vulg-6, Triticale-5 20. Balcarce 37°51' 63°01' S. graminum D. noxia T. aest5, H. vulg5, Rye-5, Triticale-5 21. Bordenave 37°51' 63°01' S. graminum T. aest6, H. vulg6, T. aest6, H. vulg6, T. durum-6 23. Osorno ² 38°13' 72°20' S. graminum T. aest6, H. vulg6, T. durum-6 24. Miramar 38°25' <td>12 Va María</td> <td>32025'</td> <td>63°15'</td> <td>S graminum</td> <td></td> <td>4 sat -5</td>	12 Va María	32025'	63°15'	S graminum		4 sat -5	
11. Ideation 12. 57 36 3 59 36 30 S grammum Sorghum 5, A. sat5. 14. Baradero 33°49' 59°30' S grammum B, C A. sat6, A. sut6, Poue-6 16. B. Bavio 35°30' S grammum B, C. E, F A. sat6, Sorghum -5, Hordeum spp5 17. Malargue 35°30' 69°35' S grammum B, C. E, F A. sat6, Sorghum -5, Hordeum spp5 18. Ayacucho 37°33' 62°46' S grammum B, C Hordeum spp3, Pou-5. 19. Puán 37°51' S grammum C T. aest5, H. vulg6, Rye-6, Triticale-5 20. Balcarce 37°51' S grammum C T. aest5, H. vulg3, Triticale-3 21. Bordenave 37°51' 63°01' S grammum B, C, F H. vulg5, A. sat5, Rye-5, Triticale-5 21. Bordenave 37°51' 63°01' S grammum T. aest6, Bromus-6, A. sat6, H. vulg6, T. durum-6 23. Osorno ² 38°13' 72°20' S grammum T. aest6, Bromus-6, A. sat6, H. vulg6, T. durum-6 24. Miramar 38°15' 57°50' S grammum T. aest6, H. vulg6, T. aest6 25. Tres Arroyos 38°	13 Rosario	32°57'	60°39'	S. graminum S. graminum		T. sur5 T. gest - 6. H. vulg - 6. Bromus-5. Sorghum-5	
In Landerlo34*5557*57S. graminumB. C. A. sat6, H. vulg6, Poa-616. B. Bavio35*05'57*54'S. graminumB. C. E, F. A. sat6, Sorghum-6, Hordeum spp617. Malargue35*05'57*54'S. graminumB, C. E, F. A. sat6, Sorghum-6, Hordeum spp617. Malargue35*05'58*29'S. graminumB, C. E, F. A. sat6, Nordeum spp518. Ayacucho37*08'58*29'S. graminumC. T. aest5, H. vulg6, Rye-6, Triticale-519. Puán37*33'62*46'S. graminumC. T. aest5, H. vulg6, Rye-6, Triticale-520. Balcarce37*50'58*17'S. graminumC. T. aest3, H. vulg3, Triticale-321. Bordenave37*51'63*01'S. graminumB, C. F. H. vulg5, A. sat5, Rye-5, Triticale-522. G. Chavez38*02'60*05'S. graminumRye-6, T. aest6, Bromus-6, A. sat6, H. vulg6, T. durum-623. Osorno ² 38*13'72*20'S. graminumRye-6, T. aest624. Miramar38*15'57*50'S. graminumT. aest6, T. durum-6, H. vulg6, Triticale-625. Tres Arroyos38*23'60*17'S. graminumT. aest6, T. durum-6, H. vulg6, Triticale-627. Temuco ² 38*20'71*21'D. noxiaT. aest6, T. durum-6, H. vulg6, T. tidrale-628. Lonquimay ² 38*26'71*21'D. noxiaA. sat6, H. vulg6, T. aest6, T. durum-629. Cabildo38*30'61*54'S. graminumT. aest5, H. vulg6, T. aest6, T. durum-620. Lonquimay ² 38*26' <td>14 Baradero</td> <td>33°49′</td> <td>50°30′</td> <td>S. graminum</td> <td></td> <td>Sorahum-5 A sat -5</td>	14 Baradero	33°49′	50°30′	S. graminum		Sorahum-5 A sat -5	
11. Constant13. \mathbb{C}^{2} 13. $$	15 Los Hornos	34055'	57°57'	S. graminum S. graminum	BC	A sat-6 H vula-6 Poa.6	
10. 5. bavio 35 03 57 44 3. graminum b, C, F, F, A. M. O. Sogrami-O. Indocum spp5 17. Malargue 35 03 60°35 S. graminum Rye-3, Bronus-5, Hordeum spp5 18. Ayacucho 37°08' S8°29' S. graminum C. T. aest5, H. vulg6, Rye-5 19. Puán 37°33' 62°46' S. graminum C. T. aest5, H. vulg6, Rye-6, Triticale-5 20. Balcarce 37°50' S8°17' S. graminum C. T. aest3, H. vulg3, Triticale-3 21. Bordenave 37°51' 63°01' S. graminum B, C, F H. vulg5, A. sat5, Rye-5, Triticale-5 22. G. Chavez 38°02' 60°05' S. graminum T. aest6, Bromus-6, A. sat6, H. vulg6, T. durum-6 23. Osomo ² 38°13' 72°20' S. graminum R. aest6, T. aest6, H. vulg6, T. curum-6 24. Miramar 38°15' 57°50' S. graminum T. aest6, H. vulg6, T. aest6 24. Miramar 38°15' 57°50' S. graminum T. aest6, H. vulg6, T. curum-6 25. Tres Arroyos 38°23' 60°17' S. graminum T. aest6, H. vulg6, T. aest6 26. La Dulce 38°20' 71°21'	16 D. Davio	34 33	57011	S. graminum	D,C DCEE	A. sat. 6 Souchure 6 Houdown com	
17. Malague 35.30 60.37 3.5 graminum Kyes, Bronuss, Hordeum spp. 5 18. Ayacucho $37^{\circ}08^{\circ}$ $58^{\circ}29^{\circ}$ S. graminum B, C Hordeum spp. 3, Poa-5. 19. Puán $37^{\circ}33^{\circ}$ $62^{\circ}46^{\circ}$ S. graminum C T. aest. 5, H. vulg. 6, Rye-6, Triticale-5 20. Balcarce $37^{\circ}50^{\circ}$ $58^{\circ}17^{\circ}$ S. graminum C T. aest3, H. vulg3, Triticale-3 21.Bordenave $37^{\circ}51^{\circ}$ $63^{\circ}01^{\circ}$ S. graminum B, C, F H. vulg3, Triticale-3 22. G. Chavez $38^{\circ}02^{\circ}$ $60^{\circ}05^{\circ}$ S. graminum T. aest6, Bromus-6, A.sat6, H. vulg6, T. durum-6 23. Osorno ² $38^{\circ}13^{\circ}$ $72^{\circ}20^{\circ}$ S. graminum Rye-6, T. aest6 24. Miramar $38^{\circ}15^{\circ}$ $57^{\circ}50^{\circ}$ S. graminum T. aest6, H. vulg6, Triticale-6 25. Tres Arroyos $38^{\circ}23^{\circ}$ $60^{\circ}17^{\circ}$ S. graminum T. aest6, H. vulg6, Triticale-6 27. Temuco ² $38^{\circ}26^{\circ}$ $72^{\circ}20^{\circ}$ S. graminum T. aest6, H. vulg6, Triticale-6 26. La Dulce $38^{\circ}25^{\circ}$ $58^{\circ}27^{\circ}$ S. graminum <t< td=""><td>10. D. Davio</td><td>35 05</td><td>57 44 60°25'</td><td>S. graminum</td><td>$\mathbf{D}, \mathbf{C}, \mathbf{E}, \mathbf{F}$</td><td>A. sul0, Sorgnum-0, Hordeum spp0</td></t<>	10. D. Davio	35 05	57 44 60°25'	S. graminum	$\mathbf{D}, \mathbf{C}, \mathbf{E}, \mathbf{F}$	A. sul0, Sorgnum-0, Hordeum spp0	
18. Ayacucho 37°08' 58°29' S. graminum B. C. Hordeum spp. 3, Poa-5. 19. Puán 37°33' 62°46' S. graminum C T. aest5, H. vulg5, Rye-5 20. Balcarce 37°50' 58°17' S. graminum C T. aest5, H. vulg3, Triticale-5 20. Balcarce 37°50' 58°17' S. graminum C T. aest3, H. vulg3, Triticale-3 21. Bordenave 37°51' 63°01' S. graminum B, C, F H. vulg5, A. sat5, Rye-5, Triticale-5 22. G. Chavez 38°02' 60°05' S. graminum T. aest6, Bromus-6, A. sat6, H. vulg6, T. durum-6 23. Osorno ² 38°13' 72°20' S. graminum R. aest6, T. aest6 24. Miramar 38°15' 57°50' S. graminum T. aest6, T. durum-6, H. vulg6, T. durum-6 25. Tres Arroyos 38°23' 60°17' S. graminum T. aest6, H. vulg6, T. durum-6 26. La Dulce 38°26' 72°20' S. graminum T. aest6, H. vulg6, T. durum-6 27. Temuco ² 38°20' 72°20' S. graminum T. aest6, H. vulg6, T. aest6 27. Temuco ² 38°30' 61°5	17. Malargue	35 30	09 35	D poria		Rye-2, Bromus-5, Hordeum spp5	
10. right decide 57.50 50.27 b. graminum C Transform 19. Puán $37^{\circ}33^{\circ}$ $62^{\circ}46^{\circ}$ S. graminum C T. aest5, H. vulg5, Rye-5 20. Balcarce $37^{\circ}50^{\circ}$ $58^{\circ}17^{\circ}$ S. graminum C T. aest5, H. vulg5, Rye-5, Triticale-3 21. Bordenave $37^{\circ}51^{\circ}$ $63^{\circ}01^{\circ}$ S. graminum C T. aest3, H. vulg5, Rye-5, Triticale-5 22. G. Chavez $38^{\circ}02^{\circ}$ $60^{\circ}05^{\circ}$ S. graminum T. aest6, Bronus-6, A. sat6, H. vulg6, T. durum-6 23. Osorno ² $38^{\circ}13^{\circ}$ $72^{\circ}20^{\circ}$ S. graminum T. aest6, T. durum-6, H. vulg6, T. durum-6 24. Miramar $38^{\circ}15^{\circ}$ $57^{\circ}50^{\circ}$ S. graminum T. aest6, T. durum-6, H. vulg6, T. durum-6 25. Tres Arroyos $38^{\circ}15^{\circ}$ $57^{\circ}50^{\circ}$ S. graminum T. aest6, T. durum-6, H. vulg6, T. durum-6 26. La Dulce $38^{\circ}25^{\circ}$ $58^{\circ}42^{\circ}$ S. graminum T. aest5, A. sat5 T. aest6, T. durum-6 27. Temuco ² $38^{\circ}26^{\circ}$ $71^{\circ}21^{\circ}$ S. graminum T. aest5, A. sat5 T. aest6, T. durum-6 27. Temuco ²	18 Avacucho	37008'	58°20'	S graminum	BC	Hordeum spp3 Pog-5	
17. Tall 37. 53 62. 40 5. graminum C 17. tast5, H. vulg5, Rye-5, Rye-5 20. Balcarce $37^{\circ}50^{\circ}$ 58°17' S. graminum C T. aest5, H. vulg3, Triticale-5 21. Bordenave $37^{\circ}51^{\circ}$ $63^{\circ}01^{\circ}$ S. graminum C T. aest3, H. vulg3, Triticale-3 21. Bordenave $37^{\circ}51^{\circ}$ $63^{\circ}01^{\circ}$ S. graminum R. aest5, Rye-5, Rye-5, Triticale-5 22. G. Chavez $38^{\circ}02^{\circ}$ $60^{\circ}05^{\circ}$ S. graminum T. aest6, Bromus-6, A.sat6, H. vulg6, T. durum-6 23. Osorno ² $38^{\circ}13^{\circ}$ $72^{\circ}20^{\circ}$ S. graminum Rye-6, T.aest6 24. Miramar $38^{\circ}15^{\circ}$ $57^{\circ}50^{\circ}$ S. graminum Rye-6, T.aest6 25. Tres Arroyos $38^{\circ}23^{\circ}$ $60^{\circ}17^{\circ}$ S. graminum T. aest5, H. vulg6, T. durum-6, H. vulg6, Triticale-6 26. La Dulce $38^{\circ}25^{\circ}$ S. graminum T. aest6, H. vulg6, T. aest6 27. Temuco ² $38^{\circ}26^{\circ}$ $71^{\circ}21^{\circ}$ S. graminum T. aest5, A. sat5 28. Lonquimay ² $38^{\circ}26^{\circ}$ $71^{\circ}21^{\circ}$ D. noxia A. sat5 29. Cabil	10 Puán	37 08	58 23 62°46'	S. graminum	D, C	Torucum spp5, $100-5$.	
20. Balcarce $37^{\circ}50^{\circ}$ $58^{\circ}17^{\circ}$ S. graminum D. noxiaCT. aest3, H. vulg3, Triticale-3 T. aest3, H. vulg3, Triticale-321. Bordenave $37^{\circ}51^{\circ}$ $63^{\circ}01^{\circ}$ S. graminum D. noxiaB, C, FH. vulg5, A. sat5, Rye-5, Triticale-5 D. noxia22. G. Chavez $38^{\circ}02^{\circ}$ $60^{\circ}05^{\circ}$ S. graminum D. noxiaT. aest6, Bromus-6, A. sat6, H. vulg6, T. durum-6 D. noxia23. Osomo ² $38^{\circ}02^{\circ}$ $60^{\circ}05^{\circ}$ S. graminum S. graminumRye-6, T. aest6 R. Bromus-6, A. sat6, H. vulg6, T. durum-624. Miramar $38^{\circ}13^{\circ}$ $72^{\circ}20^{\circ}$ S. graminum S. graminumT. aest6, H. vulg5, Bromus-525. Tres Arroyos $38^{\circ}23^{\circ}$ $60^{\circ}17^{\circ}$ S. graminum S. graminumT. aest6, T. durum-6, H. vulg6, Triticale-6 D. noxia26. La Dulce $38^{\circ}25^{\circ}$ $58^{\circ}42^{\circ}$ S. graminum D. noxiaT. aest6, H. vulg6, T. aest6 D. noxia27. Temuco ² $38^{\circ}20^{\circ}$ $72^{\circ}20^{\circ}$ S. graminum D. noxiaT. aest5, A. sat528. Lonquimay ² $38^{\circ}26^{\circ}$ $71^{\circ}21^{\circ}$ D. noxiaT. aest4, B. vulg6, T. aest6, T. durum-629. Cabildo $38^{\circ}30^{\circ}$ $61^{\circ}54^{\circ}$ S. graminum D. noxiaT. aest5, T. vulg5, A. sat530. Copetonas $38^{\circ}30^{\circ}$ $61^{\circ}54^{\circ}$ S. graminum D. noxiaC. T. aest5, H. vulg5, A. sat531. Bahia Blanca $38^{\circ}44^{\circ}$ $62^{\circ}16^{\circ}$ S. graminum D. noxiaC. T. aest5, T. durum-5<	19. Fuall	57 55	02 40	D noria	C	T dest -5 , H vulg -6 Rye-6 Triticale 5	
20. Directed 57.90 50.17 D_{10} grammum C_{11} D_{10} size T_{10} cast. $3, H. vulg. 3, Triticale-3 21. Bordenave 37^{\circ}51' 63^{\circ}01' S_{11} grammum D_{10} size T_{10} cast. 3, H. vulg. 3, Triticale-3 22. G. Chavez 38^{\circ}02' 60^{\circ}05' S_{11} grammum T_{10} cast. -5, Rye-5, Triticale-5 23. Osorno3 38^{\circ}02' 60^{\circ}05' S_{11} grammum T_{10} cast. -6, Bromus-6, A. sat. -6, H. vulg6, T. durum-6 23. Osorno3 38^{\circ}13' 72^{\circ}20' S_{11} grammum Rye-6, T_{10} cast. -6 24. Miramar 38^{\circ}15' 57^{\circ}50' S_{11} grammum T_{10} cast. -6, T_{10} durum-6 25. Tres Arroyos 38^{\circ}23' 60^{\circ}17' S_{11} grammum T_{10} cast. -6, T_{10} durum-6, H. vulg. -6, Triticale-6 26. La Dulce 38^{\circ}25' 58^{\circ}42' S_{11} grammum T_{10} cast. -6, T_{10} durum-6 27. Temuco2 38^{\circ}20' 72^{\circ}20' S_{11} grammum T_{10} cast. -5, T_{10} durum-6 29. Cabildo 38^{\circ}30' 61^{\circ}54' S_{11} grammum C_{11} cast. -5, T_{10} durum-5 30. Copetonas $	20 Balcarce	37°50'	58°17'	S graminum	С	T dest -3 H yulg -3 Triticale-3	
21.Bordenave $37^{\circ}51'$ $63^{\circ}01'$ S. graminum D. noxia B, C, F H. vulg5, A. sat5, Rye-5, Triticale-5 22. G. Chavez $38^{\circ}02'$ $60^{\circ}05'$ S. graminum D. noxia T. eest6, Bromus-6, A.sat6, H. vulg6, T. durum-6 D. noxia 23. Osorno ² $38^{\circ}13'$ $72^{\circ}20'$ S. graminum D. noxia Rye-6, T. aest6, Bromus-6, A.sat6, H. vulg6, T. durum-6 24. Miramar $38^{\circ}15'$ $57^{\circ}50'$ S. graminum D. noxia Rye-6, T. aest6 24. Miramar $38^{\circ}15'$ $57^{\circ}50'$ S. graminum D. noxia Rye-6, T. aest6, T. durum-6, H. vulg6, Triticale-6 24. Miramar $38^{\circ}23'$ $60^{\circ}17'$ S. graminum D. noxia T. aest6, T. durum-6, H. vulg6, Triticale-6 25. Tres Arroyos $38^{\circ}23'$ $60^{\circ}17'$ S. graminum D. noxia T. aest6, T. durum-6, H. vulg6, Triticale-6 26. La Dulce $38^{\circ}25'$ $58^{\circ}42'$ S. graminum D. noxia T. aest6, H. vulg6, T. aest6, T. durum-6 27. Temuco ² $38^{\circ}26'$ $71^{\circ}21'$ D. noxia T. aest5, A. sat5 28. Lonquimay ² $38^{\circ}26'$ $71^{\circ}21'$ D. noxia T. aest5, T. tiordeo-5 29. Cabildo $38^{\circ}30'$ 6	20. Darcaree	57 50	50 17	D. noxia	C	T. aest3, H. vulg3, Triticale-3	
21.004 curve21.0120.0120.0121.01<	21 Bordenave	37°51'	63°01'	S graminum	B.C.F	H yulg - 5 A sat - 5 Rye-5 Triticale-5	
22. G. Chavez $38^{\circ}02'$ $60^{\circ}05'$ S. graminum D. noxia T. aest6, Bromus-6, A.sat6, H. vulg6, T. durum-6 23. Osorno ² $38^{\circ}13'$ $72^{\circ}20'$ S. graminum D. noxia Rye-6, T. aest6, Bromus-6, A.sat6, H. vulg6, T. durum-6 24. Miramar $38^{\circ}15'$ $57^{\circ}50'$ S. graminum D. noxia Rye-6, T. aest6, Bromus-5, Bromus-5 25. Tres Arroyos $38^{\circ}23'$ $60^{\circ}17'$ S. graminum D. noxia T. aest6, H. vulg6, T. durum-6, H. vulg6, Triticale-6 26. La Dulce $38^{\circ}25'$ $58^{\circ}42'$ S. graminum D. noxia T. aest6, H. vulg6, T. aest6 27. Temuco ² $38^{\circ}20'$ $72^{\circ}20'$ S. graminum D. noxia T. aest5, A. sat5 28. Lonquimay ² $38^{\circ}26'$ $71^{\circ}21'$ D. noxia A. sat5 29. Cabildo $38^{\circ}30'$ $61^{\circ}54'$ S. graminum D. noxia T. aest5, H. vulg5, A. sat5 31. Bahía Blanca $38^{\circ}44'$ $62^{\circ}16'$ S. graminum D. noxia T. aest5, H. vulg5, A. sat5 32. Castro ² $42^{\circ}29'$ $73^{\circ}45'$ S. graminum D. noxia T. aest5 33. Esquel $42^{\circ}25'$ $71^{\circ}20'$ S. graminum D. noxia T. aest5	21100100100	57 51	00 01	D. noxia	2, 0, 1	<i>H. vulg5, A. sat5</i> , Rye-5, Triticale-5	
D. noxiaT. aest6, Bromus-6, A.sat6, H. vulg6, T. durum-623. Osorno ² 38°13'72°20'S. graminumRye-6, T. aest624. Miramar38°15'57°50'S. graminumT. aest5, H. vulg5, Bromus-525. Tres Arroyos38°23'60°17'S. graminumT. aest6, T. durum-6, H. vulg6, Triticale-626. La Dulce38°25'58°42'S. graminumF, CA. sat6, H. vulg6, T. aest627. Temuco ² 38°20'72°20'S. graminumT. aest5, A. sat6, H. vulg6, T. aest627. Temuco ² 38°20'72°20'S. graminumT. aest5, A. sat528. Lonquimay ² 38°26'71°21'D. noxiaA. sat529. Cabildo38°30'61° 54'S. graminumCT. aest5, Tritordeo-530. Copetonas38°30'60° 28'S. graminumCT. aest5, H. vulg5, A. sat531. Bahía Blanca38°44'62°16'S. graminumCT. aest5, T. durum-532. Castro ² 42°29'73°45'S. graminumCT. aest5, T. durum-533. Esquel42°55'71°20'S. graminumCT. aest5, T. durum-534. Teka43°28'70°50'S. graminumT. aest5, Bromus-5D. noxiaT. aest5, Bromus-5J. noxiaT. aest5, Bromus-534. Teka43°28'70°50'S. graminumT. aest5, Bromus-5	22. G. Chavez	38°02'	60°05'	S. graminum		T. aest6, Bromus-6, A.sat6, H.vulg6, T. durum-6	
23. $Osorno^2$ $38^\circ 13'$ $72^\circ 20'$ $S. graminum$ $Pye-6, T.aest6$ 24. Miramar $38^\circ 15'$ $57^\circ 50'$ $S. graminum$ $T. aest5, H. vulg5, Bromus-5$ 25. Tres Arroyos $38^\circ 23'$ $60^\circ 17'$ $S. graminum$ $T. aest6, T. durum-6, H. vulg6, Triticale-6$ 26. La Dulce $38^\circ 25'$ $58^\circ 42'$ $S. graminum$ $F, C. A. sat6, H. vulg6, T. aest6 27. Temuco2 38^\circ 20' 72^\circ 20' S. graminum T. aest5, A. sat5 28. Lonquimay2 38^\circ 26' 71^\circ 21' D. noxia T. aest5, A. sat5 29. Cabildo 38^\circ 30' 61^\circ 54' S. graminum C. T. aest5, T. futordeo-5 30. Copetonas 38^\circ 30' 60^\circ 28' S. graminum D. noxia T. aest5, T. durum-5 31. Bahía Blanca 38^\circ 44' 62^\circ 16' S. graminum C. T. aest5, T. durum-5 32. Castro2 42^\circ 29' 73^\circ 45' S. graminum T. aest5 32. Castro2 42^\circ 29' 73^\circ 45' S. graminum T. aest5 33. Esquel 42^\circ 25' 71^\circ 20' S. graminum $				D. noxia		T. aest6, Bromus-6, A.sat6, H. vulg6, T. durum-6	
D. noxiaRye-6, T.aest624. Miramar $38^{\circ}15'$ $57^{\circ}50'$ S. graminumT. aest5, H. vulg5, Bromus-525. Tres Arroyos $38^{\circ}23'$ $60^{\circ}17'$ S. graminumT. aest6, T. durum-6, H. vulg6, Triticale-626. La Dulce $38^{\circ}25'$ $58^{\circ}42'$ S. graminumF, CA. sat6, H. vulg6, T. aest627. Temuco ² $38^{\circ}20'$ $72^{\circ}20'$ S. graminumT. aest5, A. sat528. Lonquimay ² $38^{\circ}26'$ $71^{\circ}21'$ D. noxiaA. sat529. Cabildo $38^{\circ}30'$ $61^{\circ}54'$ S. graminumCT. aest5, A. sat520. Copetonas $38^{\circ}30'$ $61^{\circ}54'$ S. graminumT. aest5, H. vulg5, A. sat531. Bahía Blanca $38^{\circ}44'$ $62^{\circ}16'$ S. graminumCT. aest5, T. durum-532. Castro ² $42^{\circ}29'$ $73^{\circ}45'$ S. graminumCT. aest5, T. durum-533. Esquel $42^{\circ}55'$ $71^{\circ}20'$ S. graminumT. aest534. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. graminumT. aest5D. noxiaT. aest5J. moxiaT. aest534. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. graminumT. aest5D. noxiaT. aest5J. proviaT. aest534. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. graminumT. aest534. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. graminumT. aest535. Septender $70^{\circ}50'$ S. graminumT. aest536. Tech<	23. Osorno ²	38°13'	72°20'	S. graminum		Rye-6, <i>T.aest.</i> -6	
24. Miramar $38^{\circ}15'$ $57^{\circ}50'$ S. graminum T. aest5, H. vulg5, Bromus-5 25. Tres Arroyos $38^{\circ}23'$ $60^{\circ}17'$ S. graminum T. aest6, T. durum-6, H. vulg6, Triticale-6 26. La Dulce $38^{\circ}25'$ $58^{\circ}42'$ S. graminum F, C A. sat6, H. vulg6, T. aest6 27. Temuco ² $38^{\circ}20'$ $72^{\circ}20'$ S. graminum T. aest5, A. sat5 28. Lonquimay ² $38^{\circ}26'$ $71^{\circ}21'$ D. noxia A. sat5 29. Cabildo $38^{\circ}30'$ $61^{\circ}54'$ S. graminum C T. aest5, H. vulg5, A. sat5 30. Copetonas $38^{\circ}30'$ $60^{\circ}28'$ S. graminum R. C T. aest5, H. vulg5, A. sat5 31. Bahía Blanca $38^{\circ}44'$ $62^{\circ}16'$ S. graminum C T. aest5, H. vulg5, A. sat5 32. Castro ² $42^{\circ}29'$ $73^{\circ}45'$ S. graminum C T. aest5, T. durum-5 33. Esquel $42^{\circ}55'$ $71^{\circ}20'$ S. graminum T. aest5 J. durum-5 34. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. graminum T. aest5 J. durum-5				D. noxia		Rye-6, T.aest6	
25. Tres Arroyos $38^{\circ}23'$ $60^{\circ}17'$ S. graminum D. noxiaT. aest6, T. durum-6, H. vulg6, Triticale-626. La Dulce $38^{\circ}25'$ $58^{\circ}42'$ S. graminum D. noxiaF, CA. sat6, H. vulg6, T. aest627. Temuco ² $38^{\circ}20'$ $72^{\circ}20'$ S. graminum D. noxiaT. aest5, A. sat528. Lonquimay ² $38^{\circ}26'$ $71^{\circ}21'$ D. noxiaA. sat529. Cabildo $38^{\circ}30'$ $61^{\circ}54'$ S. graminum D. noxiaCT. aest5, T. fitordeo-5 T. aest4, Tritordeo-530. Copetonas $38^{\circ}30'$ $60^{\circ}28'$ S. graminum D. noxiaCT. aest5, H. vulg5, A. sat531. Bahía Blanca $38^{\circ}44'$ $62^{\circ}16'$ S. graminum D. noxiaCT. aest5, T. durum-5 T. aest5, T. durum-532. Castro ² $42^{\circ}29'$ $73^{\circ}45'$ S. graminum S. graminumT. aest5, Bromus-5 D. noxia34. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. graminum D. noxiaT. aest5, Bromus-5 D. noxia	24. Miramar	38°15'	57°50'	S. graminum		T. aest5, H. vulg5, Bromus-5	
D. noxiaT. aest6, T. durum-6, H. vulg6, Triticale-626. La Dulce $38^{\circ}25'$ $58^{\circ}42'$ S. graminum D. noxiaF, CA. sat6, H. vulg6, T. aest627. Temuco ² $38^{\circ}20'$ $72^{\circ}20'$ S. graminum D. noxiaT. aest5, A. sat528. Lonquimay ² $38^{\circ}26'$ $71^{\circ}21'$ D. noxiaA. sat529. Cabildo $38^{\circ}30'$ $61^{\circ}54'$ S. graminum D. noxiaCT. aest5, Tritordeo-530. Copetonas $38^{\circ}30'$ $60^{\circ}28'$ S. graminum D. noxiaB, CT. aest5, H. vulg5, A. sat531. Bahía Blanca $38^{\circ}44'$ $62^{\circ}16'$ S. graminum D. noxiaCT. aest5, T. durum-532. Castro ² $42^{\circ}29'$ $73^{\circ}45'$ S. graminum S. graminumD. actylis spp533. Esquel $42^{\circ}55'$ $71^{\circ}20'$ S. graminum S. graminum D. noxiaT. aest5, Bromus-534. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. graminum S. graminum D. noxiaT. aest5, Bromus-5 D. provin	25. Tres Arroyos	38°23'	60°17'	S. graminum		T. aest6, T. durum-6, H. vulg6, Triticale-6	
26. La Dulce $38^{\circ}25'$ $58^{\circ}42'$ S. graminum D. noxiaF. CA. sat6, H. vulg6, T. aest6 A. sat6, H. vulg6, T. aest6, T. durum-627. Temuco² $38^{\circ}20'$ $72^{\circ}20'$ S. graminum D. noxiaT. aest5, A. sat5 T. aest5, A. sat528. Lonquimay² $38^{\circ}26'$ $71^{\circ}21'$ D. noxiaA. sat529. Cabildo $38^{\circ}30'$ $61^{\circ}54'$ S. graminum D. noxiaCT. aest5, Tritordeo-5 T. aest4, Tritordeo-530. Copetonas $38^{\circ}30'$ $60^{\circ}28'$ S. graminum D. noxiaB, CT. aest5, H. vulg5, A. sat531. Bahía Blanca $38^{\circ}44'$ $62^{\circ}16'$ S. graminum D. noxiaCT. aest5, T. durum-532. Castro² $42^{\circ}29'$ $73^{\circ}45'$ S. graminum D. noxiaDactylis spp533. Esquel $42^{\circ}55'$ $71^{\circ}20'$ S. graminum D. noxiaT. aest534. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. graminum D. noxiaT. aest5				D. noxia		T. aest6, T. durum-6, H. vulg6, Triticale-6	
D. noxiaA. sat6, H. vulg6, T. aest6, T. durum-6 $27.\text{Temuco}^2$ $38^\circ 20'$ $72^\circ 20'$ S. graminum D. noxiaT. aest5, A. sat5 $28. \text{ Lonquimay}^2$ $38^\circ 26'$ $71^\circ 21'$ D. noxiaA. sat5 $29. \text{ Cabildo}$ $38^\circ 30'$ $61^\circ 54'$ S. graminum D. noxiaCT. aest5, Tritordeo-5 $29. \text{ Cabildo}$ $38^\circ 30'$ $61^\circ 54'$ S. graminum D. noxiaCT. aest5, Tritordeo-5 $30. \text{ Copetonas}$ $38^\circ 30'$ $60^\circ 28'$ S. graminum D. noxiaB, CT. aest5, H. vulg5, A. sat5 $31. \text{ Bahía Blanca}$ $38^\circ 44'$ $62^\circ 16'$ S. graminum D. noxiaCT. aest5, T. durum-5 $32. \text{ Castro}^2$ $42^\circ 29'$ $73^\circ 45'$ S. graminum D. noxiaDactylis spp5 $33. \text{ Esquel}$ $42^\circ 55'$ $71^\circ 20'$ S. graminum D. noxiaT. aest5 $34. \text{ Teka}$ $43^\circ 28'$ $70^\circ 50'$ S. graminum D noxiaT. aest5 $aest - 5$ Bromus-5 $b.$ noxiaT. aest5 $b.$ noxia<	26. La Dulce	38°25'	58°42'	S. graminum	F, C	A. sat6, H. vulg6, T. aest6	
27.Temuco ² $38^{\circ}20'$ $72^{\circ}20'$ S. graminum D. noxiaT. aest5, A. sat528. Lonquimay ² $38^{\circ}26'$ $71^{\circ}21'$ D. noxiaA. sat529. Cabildo $38^{\circ}30'$ $61^{\circ}54'$ S. graminum D. noxiaCT. aest5, Tritordeo-520. Copetonas $38^{\circ}30'$ $60^{\circ}28'$ S. graminum D. noxiaCT. aest5, H. vulg5, A. sat530. Copetonas $38^{\circ}30'$ $60^{\circ}28'$ S. graminum D. noxiaB, CT. aest5, H. vulg5, A. sat531. Bahía Blanca $38^{\circ}44'$ $62^{\circ}16'$ S. graminum D. noxiaCT. aest5, T. durum-532. Castro ² $42^{\circ}29'$ $73^{\circ}45'$ S. graminum D. noxiaDactylis spp533. Esquel $42^{\circ}55'$ $71^{\circ}20'$ S. graminum D. noxiaT. aest5, Bromus-534. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. graminum D. noxiaT. aest5, Bromus-5 D. noxia				D. noxia		A. sat6, H. vulg6, T. aest6, T. durum-6	
D. noxiaT. $aest5$, A. $sat5$ 28. Lonquimay2 $38^{\circ}26'$ $71^{\circ}21'$ D. noxiaA. $sat5$ 29. Cabildo $38^{\circ}30'$ $61^{\circ}54'$ S. $graminum$ CT. $aest5$, Tritordeo-520. Copetonas $38^{\circ}30'$ $60^{\circ}28'$ S. $graminum$ B, CT. $aest5$, H. $vulg5$, A. $sat5$ 30. Copetonas $38^{\circ}30'$ $60^{\circ}28'$ S. $graminum$ B, CT. $aest5$, H. $vulg5$, A. $sat5$ 31. Bahía Blanca $38^{\circ}44'$ $62^{\circ}16'$ S. $graminum$ CT. $aest5$, T. $durum-5$ 32. Castro ² $42^{\circ}29'$ $73^{\circ}45'$ S. $graminum$ Dactylis spp533. Esquel $42^{\circ}55'$ $71^{\circ}20'$ S. $graminum$ T. $aest5$, Bromus-534. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. $graminum$ T. $aest5$, Bromus-5	27.Temuco ²	38°20′	72°20′	S. graminum		T. aest5, A. sat5	
28. Lonquimay ² $38^{\circ}26'$ $71^{\circ}21'$ D. noxia A. sat 5 29. Cabildo $38^{\circ}30'$ $61^{\circ}54'$ S. graminum C T. aest5, Tritordeo-5 30. Copetonas $38^{\circ}30'$ $60^{\circ}28'$ S. graminum B, C T. aest5, H. vulg5, A. sat5 31. Bahía Blanca $38^{\circ}44'$ $62^{\circ}16'$ S. graminum C T. aest5, T. durum-5 32. Castro ² $42^{\circ}29'$ $73^{\circ}45'$ S. graminum Dactylis spp5 33. Esquel $42^{\circ}55'$ $71^{\circ}20'$ S. graminum T. aest5 34. Teka $43^{\circ}28'$ $70^{\circ}50'$ S. graminum T. aest5, Bromus-5 D. noxia T. aest5 Bromus-5				D. noxia		T. aest5, A. sat5	
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TABLE 1. The place, geographical location in Argentina and Chile (by latitude and longitude), aphid species, biotypes, number of individuals collected and host plant (wheat: *T. aest.*; barley: *H. vulg.*; oat: *A.sat.*; *Hordeum* spp: *H. murinum*, *H. marinum*, *H. chilense*; Sorghum: *S. halepensis*, *S. bicolor* and *S. sacharata*).

1. Number of aphids collected: 1 = 10-19; 2 = 20; 3 = 21-49; 4 = 50; 5 = 50-100; 6 = > 100

2. Chile

TABLE 2. Number of adult aphids recorded on each of the hosts in the choice test after 24 h for greenbug (**A**) and RWA (**B**). Values in brackets are SEs. Values in a column with different letters are significantly different ($\mathbf{P} = 0.05$).

<u>A</u>					
Test host	Ν	Greenbug co	ollected from		
		Cereals*	Grasses*		
Barley	10	30.4ª (± 4.25)	12.54° (± 1.26)		
Wheat	10	22.1 ^b (± 3.20)	$9.23^{d} (\pm 1.03)$		
Oat	10	10.2° (± 1.32)	15.10 ^b (± 1.14)		
Triticale	10	10.3° (± 1.21)	$7.10^{d} (\pm 1.17)$		
Tritordeo	10	$10.0^{\circ} (\pm 1.18)$	$8.09^{d} (\pm 1.30)$		
S. bicolor	10	$6.10^{d} (\pm 0.64)$	$24.23^{a} (\pm 3.25)$		
S. halepensis	10	$6.09^{d} (\pm 0.62)$	$22.12^{a} (\pm 2.68)$		
Rye	10	4.17° (± 0.58)	2.03° (± 0.34)		
В					
Test host	fest host N		Russian wheat aphid collected from		
		Cereals*	Grasses*		
Barley	10	16.83 ^{ab} (± 2.02)	$9.54^{a} (\pm 2.30)$		
Oat	10	14.17 ^b (± 1.56)	15.46 ^b (± 1.78)		
Wheat		$11.21^{cd} (\pm 1.27)$	9.47° (± 1.15)		
Tritordeo	10	$11.02^{cd} (\pm 1.21)$	10.28° (± 1.35)		
Triticale	10	$9.87^{de} (\pm 1.08)$	$8.77^{cd} (\pm 1.03)$		
Rye	10	$8.96^{ef} (\pm 0.97)$	$5.64^{g} (\pm 0.67)$		
Bromus spp.	10	$7.85^{\text{fg}} (\pm 0.84)$	$7.15^{\rm f} (\pm 0.82)$		
Poa spp.	10	$7.02^{g} (\pm 0.87)$	$7.38^{\text{ef}} (\pm 0.88)$		
Hordeum spp.	10	$6.84^{g} (\pm 0.86)$	$8.13^{de} (\pm 0.82)$		
S. halepensis	10	$6.29^{g} (\pm 0.74)$	9.68° (± 1.04)		

*The host from which the aphids were collected in the field.

Seven populations and their derived clones did not produce eggs, either because only male individuals were produced (localities 6, 7, and 10) or only sexual females (5 and 17). Moreover, only one sex, either male or oviparae, was recorded for clones collected from localities 3 and 4. From the samples collected at locality 3, six clones produced males, six oviparae and eight produced only parthenogenetic individuals. From the samples collected from locality 4, eight clones produced females, four males and nine only parthenogenetic individuals. In the populations from localities 3 and 4, aphids produced both sexes, but not simultaneously, and consequently did not mate.

For ten of the populations studied, every clone produced sexuals and eggs (1, 2, 8, 9, 14, 20, 23, 24, 26 and 32). For eight localities (16, 18, 19, 25, 28-31), 50-90% of the twenty clones produced sexuals and eggs. The aphids from locality 12 produced eggs, but none of the twenty clones derived from this population produced eggs. Eight of the clones only produced oviparae, four only males and the rest only parthenogenetic individuals. None of the clones produced both sexes. Of the ten clones from locality 11, seven produced sexuals, but only four of these produced eggs as three produced only females. Similar results were obtained for the aphids collected at locality 13 (of over fifteen clones, three produced both sexes, two produced only males, and the rest were obligately parthenogenetic), 15 (all twenty clones produced sexuals but only half produced both sexes), 21 and 33 (90 % of twenty clones produced sexuals and 80 % eggs), 22 (60% of 20 clones produced sexuals and only

20% eggs) and 27~(60% of 20 clones produced sexuals and 30% eggs).

Whether clones produce sexual forms is under genetic control and subject to environmental modulation, as in other cereal aphid species; however, clones producing only sexual females are not recorded (Simon et al., 1997; Rispe et al., 1999). In those populations composed of clones that produced both sexes and others that produced only females, sexual reproduction occurred, but in the populations from localities 6, 7 and 10, which did not produce sexual females, only parthenogenetic reproduction occurred.

The production of sexuals by greenbugs occurred at day lengths shorter than 9h (mean 8.00h \pm 40') ($P \ge 0.01$). For those clones that required 32-70 days before producing sexuals (clones from populations 3, 4, 22, 24, 25, 26 and 27) this was independent of temperature, as day/night temperatures from March to June ranged from 25-17°C/ 20-12°C in La Plata. Moreover, several of these clones produced sexuals under controlled conditions at a constant temperature ($20 \pm 2^{\circ}C$) in an insectary (Noriega et al., 2000). Aphids collected at lower latitudes (localities 1, 2) required a shorter day length for sexual production (they started producing sexuals in July when the photoperiod was 9L : 16D, 120 \pm 3 days from 1st March) than those collected at higher latitudes (160-180 days to elapse before producing sexuals: populations 10, 11, 15-18, 20, 21, 23, 29, 31, 32, 33), since they produced sexuals from 1st August to 20th August when day-length is 10 h to 10 h 30'. Greenbugs collected from grasses at lower latitudes (localities 3, 4, 5, 6) did not differ from those from cereals in the induction period required for sexual production (70.6 \pm 6 days vs 68.4 \pm 7.2 days, respectively, $P \ge 0.05$). However, aphids collected from grasses at higher latitudes, locality 34, did not produce sexuals.

Greenbugs collected from wheat and barley preferred these hosts to oats, rye, triticale and tritordeum in free choice tests (Table 2A), whilst those collected from oats showed a significantly lower preference for wheat and barley. Lastly, aphids from grasses preferred sorghums and oats. This host preference may indicate that *S. graminum* is better adapted to sorghums and oats than to wheat and barley. Sorghums include *Sorghum halepensis*, an aggressive weed that can be found in the field throughout the year in regions with warm winters. It may host aphids that could infest cultivated cereals and possibly transmit virus to other economically important crops of the region, although this has yet to be proven.

Diuraphis noxia

RWA was found between $26^{\circ}50'$ S to $43^{\circ}28'$ S (Table 1), bounded by isothermals $20-22^{\circ}$ C and $8-10^{\circ}$ C and isohyets 400-600 mm and 2000 mm (Fig. 1). In Chile, this species was only found in Osorno county, which lies on the isothermal $8-10^{\circ}$ C, bounded by isohyets 2000 mm and 1000 mm, on crops at an advanced stage of growth in late spring. It was uncommon in the Central Valley and close to the Pacific Ocean, yet abundant above an altitude of 1000 m, where the rainfall is greater than at sea level (Prado, pers. comm.). Ortego & Delfino (1994) report that RWA is found up to an altitude of 1800 m in Chile. Two localities (27 and 28) where RWA was collected in Chile are at 1000 and 2400 m above sea level, respectively, and locality 23 is in the Central Valley. In Argentina, populations were collected at localities 2, 5–7, 17 and 33, which are at different altitudes ranging from 400 to 1200 m.

RWA from locality 34 ($43^{\circ}28'$ S) was the most southerly population reported, and that found at locality 2 ($26^{\circ}50'$ S), the most northerly in all of South America (Table 1). The aphid was found in regions with 2000 mm of rainfall (localities 2, 27, 28, 33), which contrasts with the findings in the USA. In the

Northern Hemisphere, this species occurs in areas bounded by the isohyets 750 and 1000mm. On both subcontinents, however, its distribution follows the isotherm 5-10 °C.

In the field RWA colonises a great range of hosts, e.g. rye, barley, triticale and grasses such as *Poa*, *Bromus* and *Hordeum* spp., and in South America even oats, not previously reported as a host (Table 1). At low latitudes, RWA was found infesting *S. halepensis*, and at high latitudes, samples were collected in spring and autumn from cultivated and/or wild grasses.

Only a few of the RWA clones (20%) produced sexuals irrespective of host, the period of year, or region from which they were collected (localities 11, 17, 20, 23, 28, 31). Bellone et al. (1999) report that the low production of sexuals by RWA is independent of the conditions under which they are reared (12% of clones reared under 9.0 h light and 12°C versus 14% of those reared under 9.0 h light and 20 °C). Probably the temperature and extreme short day conditions prevailing at La Plata (34°55' S) are unsuitable for the induction of sexuals, whereas in the field at Mendoza (35°30' S), this species produces sexuals (Ortego, pers. comm.).

RWA collected from cereals and other grasses showed a preference for cereals in the free choice tests (Table 2B), but those collected from *S. halepensis* equally preferred this host, wheat, tritordeum and triticale, as previously reported by Castro et al. (2000). This suggests that *S. halepensis* could be an alternative host to cereals for this aphid.

Genetic structure

Variability in restriction fragment length polymorphisms (RFLPs) of greenbug mtDNA (Martinez et al., 1993; Castro, 1994) and isoenzymes (Giménez et al., 1991; Castro et al., 1996) can be attributed to the long period of colonisation and the existence of sexual reproduction in the region from 24°40' to 42°55' S, and between 57°44' and 73°45' W. One would expect greenbug populations in Argentina and Chile to have a different genetic structure compared to those from the USA, because of the very different and contrasting climates of the two regions.

RWA showed variability in certain traits. This accords with high intra- and interpopulation variability in isoenzymes and allozymes reported by Castro et al. (1997). Such variability may be a consequence of the diverse environments in which both completely parthenogenetic and sexual clones coexist, living on a variety of hosts. Nonetheless, this pest was only recently introduced into the region.

CONCLUSIONS

The present results increase our understanding of the population biology of these two pest aphids in Argentina and Chile, information that may facilitate their control. In greenbug, sexual reproduction is wide-spread throughout Argentina and Chile, and whilst it appears widespread in RWA, only 20% of the clones tested actually produced sexuals. Thus there is the potential for more economically damaging clones to be produced by sexual reproduction. Yet so, further research is required on the relation between host preference, reproductive behaviour and the spatial and temporal distributions of both pest-aphid species in Argentina and Chile.

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