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Characteristics and description of phenotypic components of Quetchehueca Oro C2013 a new durum wheat cultivar for southern Sonora, Mexico.

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Abstract. Quetchehueca Oro C2013, a spring-type durum, originated from hybridizations and selections made from the cross 'Godrin/Gutros//Dukem/3/Thknee_11/4/Dukem_1//Patka_7/Yazi_1 /3/Patka_7/Yazi_1/5/Ajaia_12/F3Local(Sel. Ethio. 135.85)//Plata_13/3/Adamar'. The cross number and history selection is CDSS04B00367T-0TOPY-10Y-0M-4Y-0M-4Y-0B. This cultivar has an average height of 83 cm, 82 days to heading, and 125 days to physiological maturity. Plant growth habit is erect and shows null or low frequency of recurved flag leaves. The spike measures 7.0–8.5 cm and produces from 20 to 22 spikelets. In the mid-third of the ear, the glume shoulder is narrow and sloping, with a short and moderately curved beak. Ear glaucosity is strong, and awns are distributed the entire length and have a white color. Grain coloration, when treated with phenol, is nil or very light.

Introduction. Worldwide production of wheat in 2012 was 670.8 x 10^6 tons (FAO 2012). China was the main producer with 120.5, followed by India with 94.9. Mexico produced 3.3 x 10^6 tons, imported 4.04, and exported 835,908 (FAO 2011). Of the wheat-growing area in Mexico, 71.6% (350,785 ha) corresponded to the states of Sonora, North Baja California, and Sinaloa, during the autumn–winter crop season 2011–12, with an estimated value of USD$838 x 10^6 (SIAP 2014). Since the agricultural season 1994–95, durum wheat has been the dominant class grown in the state of Sonora. Important factors that contributed to shift from bread wheat to durum in this region were the implementation of domestic quarantine No. 16 (SARH 1987), which limited the cultivation of bread wheat in fields where Karnal bunt (*Tilletia indica*) had been detected at levels greater than 2% infected grains, the greater grain yield of durum wheat versus that of bread wheat, international export of durum, and resistance to leaf rust (*Puccinia triticina*) during the 1980s and 1990s. Altar C84 was the most grown cultivar up to 2002–03, despite the fact that its resistance to leaf rust had already been overcome by a wheat race, which caused production losses during 2000–01 and 2001–02. Seed production of cultivar Júpare C2001 (Camacho-Casas et al. 2004; resistant to leaf rust) through a collaborative project between the Mexican National Institute for Forestry, Agriculture, and Livestock Research (INIFAP) and the International Maize and Wheat Improvement Center (CIMMYT) with support by the farmer's union (PIEAES) of the Yaqui Valley, made it the most grown cultivar in southern Sonora from 2003–04 to 2008–09, reaching 119,327 ha (42.3%) during the last season (Table 1) (Fuentes-Dávila et al. 2010). Átil C2000, a high-yielding cultivar released in 2001, which became susceptible to leaf rust in 2001–02 (Figueroa-López et al. 2002), occupied 53,106.07 ha.

Table 1. Area (ha) and percentage of the total area grown with wheat during the 2008–09 agricultural season in southern Sonora, Mexico.

Cultivar	Area (ha)	Percent
Durum wheat		
Júpare C2001	119,327.38	42.34
Átil C2000	53,106.07	18.84
Samayoa C2004	29,062.75	10.31
Banámichi C2004	13,652.76	4.84
Platinum	7,741.92	2.75
Aconchi C89	1,067.14	0.38
Altar C84	491.66	0.17
Rafi C97	478.20	0.17
Nácori C97	10.00	0.004
TOTAL	**224,937.90**	
Bread wheat		
Kronstad F2004	29,818.81	10.58
Tacupeto F2001	23,733.23	8.42
Tarachi F2000	1,615.60	0.57
Rayón F89	1,045.33	0.37
Abelino F2004	638.18	0.23
Navojoa M2007	9.60	0.003
Roelfs F2007	9.60	0.003
TOTAL	**56,870.34**	

Júpare C2001 did not comply with the expected protein content in the grain and color, which are very important parameters of quality. In addition, new races of leaf rust present during 2008–09 overcame its resistance, and the area occupied with this cultivar decreased significantly in 2009–10, whereas that for Átil C2000 increased (Table 2) (Fuentes-Dávila et al. 2011). During the 2010–11 crop season, 292,247 ha were grown with wheat in southern Sonora, 69.90% corresponded to durum wheat (predominating cultivars CIRNO C2008 (87,105 ha) and Átil C2000 (50,236 ha)), and the bread wheat cultivar Tacupeto F2001 (36,819 ha) (Table 3) (OEIDRUS 2011). CIRNO C2008 had a quick increase in area because it was publized as an improved Átil due to its resistance to leaf rust. In the 2011–12 crop season, CIRNO C2008 occupied 154,915 ha and 196,295 in 2012–13; however, a low incidence of yellow rust was detected in 2012–13. Therefore, more options for rust-resistant cultivars for this region must be increased so that they help contribute to the long-lasting use by wheat producers in Sonora and northwest Mexico and, at the same time, meet current minimum quality requirements for export.

Pedigree, selection history, and description of Quetchehueca Oro C2013. After evaluating grain yield since the 2009–10 agricultural season at the Norman E. Borlaug Experimental Station (CENEB), we proposed the release of the experimental durum wheat line 'Godrin/Gutros//Dukem/3/Thknee_11/4/Dukem_1//Patka_7/Yazi_1/3/Patka_7/Yazi_1/5/Ajaia_12/F3Local (Sel. Ethio. 135.85)//Plata_13/3/Adamar' as the cultivar **Quetchehueca Oro C2013** (Fuentes-Dávila et al. 2014). Quetchehueca Oro C2013 is a spring-type durum cultivar that originated from hybridizations made in

Table 2. Area (ha) and percentage of the total area grown with wheat during the 2009–10 agricultural season in southern Sonora, Mexico.

Cultivar	Area (ha)	Percent
DURUM WHEAT		
Átil C2000	81,777	33.07
Júpare C2001	53,164	21.50
Samayoa C2004	23,318	9.43
Sáwali Oro C2008	4,761	1.93
CIRNO C2008	3,256	1.32
CEVY Oro C2008	3,233	1.31
Platinum	2,655	1.07
Patronato Oro C2008	2,325	0.94
Aconchi C89	1,019	0.41
RSM Imperial C2008	980	0.40
Banámichi C2004	826	0.33
RSM Chapultepec C2008	499	0.20
Rafi C97	351	0.14
Río Colorado	296	0.12
Nácori C97	241	0.10
Altar C84	105	0.04
TOTAL	**178,806**	
BREAD WHEAT		
Tacupeto F2001	40,552	16.40
Kronstad F2004	25,021	10.12
Abelino F2004	736	0.30
RSM-Norman F2008	659	0.27
Rayón F89	636	0.26
Tarachi F2000	384	0.16
Roelfs F2007	248	0.10
Navojoa M2007	235	0.10
Monarca F2007	4	0.00
TOTAL	**68,475**	

Table 3. Area (ha) and percentage of the total area grown with wheat during the 2010–11 agricultural season in southern Sonora, Mexico.

Cultivar	Area (ha)	Percent
DURUM WHEAT		
CIRNO C2008	87,105	29.9
Átil C2000	50,236	17.3
Sáwali Oro C2008	14,353	4.9
Patronato Oro C2008	11,753	4.0
Júpare C2001	10,069	3.4
RSM Imperial C2008	7.149	2.4
CEVY Oro C2008	6,197	2.1
Río Colorado	5,111	1.7
Samayoa C2004	4,905	1.6
Rafi C97	1,806	0.6
RSM Chapultepec C2008	1,650	0.5
Others 1,210	0.4	0.20
Platinum	1,173	0.4
Aconchi C89	752	0.2
TOTAL	203,469	0.10
Altar C84	105	0.04
TOTAL	**178,806**	
BREAD WHEAT		
Tacupeto F2001	36,819	12.6
Kronstad F2004	18,681	6.4
Roelfs F2007	10,358	3.6
Navojoa M2007	8,046	2.8
RSM-Norman F2008	4,499	1.5
Cachanilla F2000	3,493	1.2
Rayón F89	2,576	0.9
Abelino F2004	1,355	0.5
Palmerín F2004	964	0.3
Others 538	0.1	
Oasis F86	319	0.1
TOTAL	**87,648**	

the Durum Wheat Breeding Program at CIMMYT. The cross number and history selection is CDSS04B00367T-0TOPY-10Y-0M-4Y-0M-4Y-0B. Shuttle breeding was carried out between the experimental stations of El Batán, state of Mexico (B) (19°30'N and 2,249 msnm), San Antonio Atizapán, state of Mexico (M) (19°17'N and 2,640 msnm), and the Yaqui Valley (Y) (27°20'N and 40 msnm), in Sonora (Table 4).

The most important phenotypic characteristics of this cultivar, according to the International Union for the Protection of New Varieties of Plants (UPOV 1994), are given (Table 5, p. 31). Cultivar Quetchehueca Oro C2013 has an average of 82 days to heading with a range of 76 to 93. The biological cycle averages 125 days to physiological maturity; however, the cycle may be shortened due to the lack of cold hours if planting is late, and may average 113 days when sowing is at the end of December. Quetchehueca Oro C2013 has an average height of 83 cm (Fig. 1, left) with a maximum of 90 and minimum of 70. Plant growth habit is erect and shows null or low frequency of recurved flag leaves. Spike shape in profile view is tapering, density is dense, and the length, excluding awns, is medium; awns are longer than spikes. Spike glaucosity is strong, and awns are distributed throughout the entire length and are white. Glume shape is sloping (spikelet in the mid-third of spike), narrow, and not hairy on the external surface. The length of the beak is short and moderately curved. Grain is elongated (Fig. 1, right), and the length of brush hair in dorsal view is short. Grain coloration, when treated with phenol, is nil or very light.

Table 4. Selection history and localities where cultivar Quetchehueca Oro C2013 was evaluated (F–W = Fall–Winter and S–S = Spring–Summer; RR = regular rainfed, NI = normal irrigation, and RI = reduced irrigation).

Activity	Locality	Season	Irrigation
Simple genetic cross	Cd. Obregon, Sonora	F–W/2003–04	NI
Top genetic cross	El Batan	S–S/2004	RR
F_1 generation	Cd. Obregon, Sonora	F–W/2004–05	NI
F_2 generation	Cd. Obregon	F–W/2005–06	NI
F_3 generation	Atizapan, Mexico	S–S/2006	RR
F_4 generation	Cd. Obregon	F–W/2006–07	NI
F_5 generation	Atizapan	S–S/2007	RR
F_6 generation	Cd. Obregon	F–W/2007–08	NI
Yield trials and spike selection by CIMMYT			
F_7 generation	El Batan	S–S/2008	RR
Spike selection by CIMMYT in different planting dates (15 and 30 November, 15 December, and 1 January.			
Yield trials by INIFAP	Cd. Obregon	F–W/2009–10	NI–RI
		F–W/2010–11	NI-RI
		F–W/2011–12	NI-RI

Fig. 1. Quetchehueca Oro C2013 has an average of 82 days to heading with a range of 76 to 93. Plants are erect and present nil or a very low frequency of recuved flag leaves (left). Grain shape in the dorsal view (right), pubescence is short; grain color after treatment with phenol is nil or very light.

Acknowledgements. The authors wish to thank Dr. Karim Ammar, Head of the Durum Wheat Breeding Progam of the International Maize and Wheat Improvement Center (CIMMYT), for providing the advanced lines from which Quetchehueca Oro C2013 originated.

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Table 5. Characteristics and description of phenotypic components of cultivar Quetchehueca Oro C2013.

Structure	Characteristic	Description
Coleoptile	Anthocyanin coloration	Strong
First leaf	Anthocyanin coloration	Medium
Plant	Growth habit	Erect
	Frequency of plants with recurved flag leaves	Absent or very low
	Length (stem, ear, and awns)	Short
	Seasonal type	Spring
Culm	Hairiness of uppermost node	Absent or very weak
	Glaucosity of neck	Strong
Flag leaf	Glaucosity	Strong
	Glaucosity of blade	Strong
Awn	Anthocyanin coloration	Absent or very weak
	Color	Whitish
Awns at tip of spike	Length in relation to spike	Longer
Spike	Time of emergence	Medium
	Glaucosity	Strong
	Distribution of awns	Whole length
	Length excluding awns	Medium
	Hairiness of margin of first rachis segment	Weak
	Color (at maturity)	White
	Shape in profile view	Tapering
	Density	Dense
Lower glume	Shape (spikelet in mid-third of ear)	Elongated
	Shape of shoulder	Sloping
	Shoulder width	Narrow
	Length of beak	Short
	Shape of beak	Moderately curved
	Hairiness on external surface	Absent
Straw	Pith in cross section (half way between base of ear and stem node below)	Medium
Grain	Shape	Semi-elongated
	Length of brush hair in dorsal view	Short
	Coloration with phenol	Nil or very light

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Characteristics and description of phenotypic components of CIRNO C2008, a durum wheat cultivar widely adopted by farmers in southern Sonora, Mexico.

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Abstract. CIRNO C2008, a spring-type durum, originated from hybridizations and selections made from the cross 'Sooty_9/Rascon_37//Camayo'. The cross number and history selection is CGS02Y00004S-2F1-6Y-0B-1Y-0B-0Y. This cultivar has an average height of 78 cm, 80 days to heading, and 122 days to physiological maturity. Plant growth habit is erect and shows null or low frequency of recurved flag leaves. The spike measures 6.5 to 9.0 cm long and produces from 18 to 20 spikelets. In the mid-third of the ear, the glume shoulder is medium and rounded, with a very short and straight beak. Spike glaucosity is strong, and awns are distributed the entire length and are brown. Grain coloration when treated with phenol is nil.

Introduction. Worldwide, production of wheat in 2012 was 670.8 x 10^6 tons (FAO 2012); China was the main producer with 120.5, followed by India with 94.9. Mexico produced 3.3 x 10^6 t, imported 4.04 t, and exported 835,908 t (FAO 2011). Of the area grown with wheat in Mexico, 71.6% (350,785 ha) corresponds to the states of Sonora, North Baja California, and Sinaloa, during the fall–winter crop season in 2011–12, with an estimated value of US$838 x 10^6 (SIAP 2014).

Since the 1994–95 agricultural season, durum wheat cultivars have become very important for international export in the state of Sonora, Mexico, from Altar C84 to Átil C2000, both of which became susceptible to a leaf rust race in 2001–02 (Figueroa-López et al. 2002). Despite the susceptibility, Átil C2000 occupied 53,106.07 ha in 2008–09, whereas the replacement cultivar, Júpare C2001, occupied 119,327.38 ha (Fuentes-Dávila et al. 2014). The commercial longevity of Júpare C2001 as a resistant cultivar to leaf rust has lasted from 2003–04 to 2008–09. The area sown with this cultivar decreased to 53,164 ha in 2009–10, and 10,069 in 2010–11 in southern Sonora.

Átil C2000 is a high-yielding cultivar (some fields yields have reached 11 t/ha), so many farmers prefer to apply fungicides for leaf rust control. This cultivar occupied 81,777 ha in 2009–10 and 50,236 ha in 2010–11; its relative, CIRNO C2008, newly released in 2008 for commercial cultivation, occupied 3,233 and 87,105 ha, respectively (Fuentes-Dávila et al. 2014). CIRNO C2008 had a rapid increase in area because it was publicized as the improved Átil due to its resistance to leaf rust, conferred by the progenitor Camayo, which has a resistant gene that is not present in any other commercial cultivar. Therefore, wheat farmers will not have to depend on fungicides in order to control the disease. In Mexico, and particularly in the northwestern part of the country, leaf rust is very important economically and, historically, is where it has caused yield losses ranging from 30 to 60%, depending on the cultivar and climatic conditions (Villaseñor et al. 2003). CIRNO C2008 occupied 154,915 ha in the 2011–12 crop season, and 196,295 in 2012–13. However, a low incidence of yellow rust was detected in 2012–13. Options of cultivars resistant to rusts for this region must be increased, so that they contribute to the long-lasting use by wheat producers in Sonora and in northwest Mexico and, at the same, meet current minimum quality requirements for export.

Pedigree, history selection and description of CIRNO C2008. After evaluating grain yield since the 2006–07 agricultural season at the Norman E. Borlaug Experimental Station (CENEB), we proposed to release the experimental durum wheat line 'Sooty_9/Rascon_37//Camayo' as cultivar CIRNO C2008 (Félix-Fuentes et al. 2010). CIRNO C2008 is a spring-type durum cultivar, which originated from hybridizations made in the Durum Wheat Breeding Program of CIMMYT. The cross number and history selection is CGS02Y00004S-2F1-6Y-0B-1Y-0B-0Y. Shuttle breeding was carried out between the experimental stations of El Batán, state of Mexico (B) (19°30'N and 2,249 masl), and the Yaqui Valley (Y) (27°20'N and 40 msnm), in Sonora (Table 6).

Table 6. Selection history and localities where cultivar CIRNO C2008 was evaluated (F–W = Fall-Winter and S–S = Spring–Summer; RR = regular rainfed, NI = normal irrigation, and RI = reduced irrigation). The different planting dates for the INIFP yield trials were 15 and 30 November, 15 December, and 1 January.

Activity	Locality	Season	Irrigation
Simple genetic cross	Cd. Obregon, Sonora	F–W/2001–02	NI
F_1 generation	El Batan, Mexico	S–S/2003	RR
F_2 generation	Cd. Obregon	F–W/2003–04	NI
F_3 generation	El Batan	S–S/2004	RR
F_4 generation	Cd. Obregon	F–W/2004–05	NI
F_5 generation	El Batan	S–S/2005	RR
Yield trials and spike selection by CIMMYT	Cd. Obregon	F–W/2005–06	NI
Yield trials by INIFAP	Cd. Obregon	F–W/2006–07	NI–RI
		F–W/2007–08	NI–RI
		F–W/2008–09	NI–RI

The most important phenotypic characteristics of this cultivar, according to the International Union for the Protection of New Varieties of Plants (UPOV, 1994), are given (Table 7). Cultivar CIRNO C2008 has an average of 80 days to heading with a range of 74 to 89. The cultivar has a biological cycle with an average of 122 days for physiological maturity; however,

Table 7. Characteristics and description of phenotypic components of cultivar CIRNO C2008.

Structure	Characteristic	Description
Coleoptile	Anthocyanin coloration	Strong
First leaf	Anthocyanin coloration	Medium
Plant	Growth habit	Erect
	Frequency of plants with recurved flag leaves	Absent or very low
	Length (stem, ear, and awns)	Short
	Seasonal type	Spring
Culm	Hairiness of uppermost node	Absent or very weak
	Glaucosity of neck	Strong
Flag leaf	Glaucosity	Strong
	Glaucosity of blade	Weak
Awn	Anthocyanin coloration	Absent or very weak
	Color	Brown
Awns at tip of spike	Length in relation to spike	Longer
Spike	Time of emergence	Medium
	Glaucosity	Strong
	Distribution of awns	Whole length
	Length excluding awns	Medium
	Hairiness of margin of first rachis segment	Absent or very weak
	Color (at maturity)	White
	Shape in profile view	Tapering
	Density	Medium
Lower glume	Shape (spikelet in mid-third of ear)	Elongated
	Shape of shoulder	Rounded
	Shoulder width	Medium
	Length of beak	Very short
	Shape of beak	Straight
	Hairiness on external surface	Absent
Straw	Pith in cross section (half way between base of ear and stem node below)	Thin
Grain	Shape	Semi-elongated
	Length of brush hair in dorsal view	Short
	Coloration with phenol	Nil

the cycle may be shortened due to the lack of cold hours if planting is late, and may average 108 days when sowing is done at the end of December. CIRNO C2008 has an average height of 78 cm (Fig. 2, left), a maximum of 90 and minimum of 65. Plant growth habit is erect, and shows nil or low frequency of recurved flag leaves. The spike measures 6.5 to 9.0 cm long and produces from 18 to 20 spikelets (Fig. 2, middle).

Fig. 2. CIRNO C2008 durum wheat cultivar has an average height of 78 cm, erect plants, and no or a very low percent of recurved flag leaves (left). The spike shape is tapering in profile view, of medium density, and of medium length; the awns are longer than the spikes (middle). The grain shape is semi-elongated. In the dorsal view, pubescence is short (right) and grain color after treatment with phenol is nil.

Spike shape in profile view is tapering, density is medium, and the length excluding awns is medium; awns are longer than spikes. Spike glaucosity is strong, and awns are distributed in the entire length and are a brown color. Glume shape is rounded (spikelet in mid-third of spike), medium, and the hairiness on the external surface is absent or very weak. The length of the beak is very short and straight. Grain is semi-elongated (Fig. 2, right), and the length of brush hair in dorsal view is short. Grain coloration when treated with phenol is nil.

CIRNO C2008 has the registration TRI-124-240511 in the Mexican Catalogue of Plant Cultivars.

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Characteristics and description of phenotypic components of Movas C2009, a durum wheat cultivar for northwest Mexico.

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Abstract. Movas C2009, a spring-type durum, originated from hybridizations and selections made from the cross 'CMH83.2578/4/D88059//WARD/YAV79/3/ACO89/5/ 2*Sooty-9/Rascon-37/6/1A.1D5+106/3*Mojo/3/Ajaia-12/F3Local (Sel. Ethio. 135.85)//Plata-13'. The cross number and history selection is CDSS02B00720S-0Y-0M-8Y-1M-04Y-0B. This cultivar has an average height of 88 cm, 79 days to heading, and 120 days to physiological maturity. Plant growth habit is erect and shows null or low frequency of recurved flag leaves. The spike measures 7.0–8.0 cm long and produces from 18 to 20 spikelets. In the mid-third of the spike, the glume is strongly elongated, the shoulder is narrow and sloping, with a short and slightly curved beak. Spike glaucosity is medium, and the awns are distributed the entire length and have a light brown color. Grain coloration when treated with phenol is nil.

Introduction. Worldwide production of wheat in 2012 was 670.8 x 10^6 tons (FAO 2012); China was the main producer with 120.5, followed by India with 94.9. Mexico produced 3.3 x 10^6 t, imported 4.04 t, and exported 835,908 t (FAO 2011). Of the area grown with wheat in Mexico, 71.6% (350,785 ha) corresponded to the states of Sonora, North Baja California, and Sinaloa, during the 2011–12 fall–winter crop season, with an estimated value of US$838 x 10^6 (SIAP 2014).

Since the 1994–95 agricultural season, durum wheat cultivars have become very important for international export in the state of Sonora, Mexico. From Altar C84 to Átil C2000, Júpare C2001, and CIRNO C2008 (Fuentes-Dávila et al. 2014). Cultivar CIRNO C2008 went from 3,233 ha in 2009–10 to 87,105 ha in 2010–11, 154,915 ha in 2011–12, and 196,295 ha in 2012–13 in southern Sonora. However, a low incidence of yellow rust was detected in 2012–13.

One of the main objectives of the collaborative project on wheat breeding in northwestern Mexico between the Mexican National Institute For Forestry, Agriculture, and Livestock Research (INIFAP) and the International Maize and Wheat Improvement Center (CIMMYT) with support by the farmer´s union (PIEAES) of the Yaqui Valley, is to diversify the genetic resistance to rusts, and particularly to leaf rust, to avoid any epiphytotics.

Although CIRNO C2008 had a rapid increase in area since it was publicized as the improved Átil due to its resistance to leaf rust conferred by the progenitor Camayo, which has a resistant gene that is not present in any other commercial cultivar, the generation of resistant durum wheat cultivars to rusts for this region must be increased in order to reach the appropriate levels of diversification. Movas C2009 is one of several cultivars released for commercial cultivation in the last five years. The area grown with Movas C2009 in southern Sonora during the 2011–12 crop season was 18 ha (Table 8, p. 36) and 6,227 in 2012–13 (Table 9, p. 36).

Pedigree, history selection and description of Movas C2009. After evaluating grain yield since the 2007–08 agricultural season at the Norman E. Borlaug Experimental Station (CENEB), we proposed to release the experimental durum wheat line 'CMH83.2578/4/D88059//Ward/YAV79/3/ACO89/5/2*Sooty-9/Rascon-37/6/1A. 1D5+106/3*Mojo/3/Ajaia-12/F3Local(Sel. Ethio. 135.85)//Plata-13' as cultivar **Movas C2009** (Félix-Fuentes et al. 2011). Movas C2009 is a spring-type durum cultivar, which originated from hybridizations made in the Durum Wheat Breeding Program of CIMMYT. The cross number and history selection is CDSS02B00720S-0Y-0M-8Y-1M-04Y-0B. Shuttle breeding was carried out between the experimental stations at El Batán, state of Mexico (B) (19°30'N and 2,249 masl); San Antonio Atizapán, state of Mexico (M) (19°17'N and 2,640 masl); and the Yaqui Valley (Y) (27°20'N and 40 masl), in Sonora (Table 10, p. 36).

Table 8. Area (ha) and percentage of the total area grown with wheat during the 2011–12 agricultural season in southern Sonora, Mexico.

Cultivar	Area (ha)	Percent
Durum wheat		
CIRNO C2008	154,915	69.409
Átil C2000	11,343	5.082
Patronato Oro C2008	7,226	3.238
RSM Imperial C2008	3.236	1.450
Sáwali Oro C2008	2,183	0.978
RSM Chapultepec C2008	1,072	0.480
Samayoa C2004	990	0.444
CEVY Oro C2008	931	0.417
Júpare C2001	913	0.409
Platinum	335	0.150
Huatabampo Oro C2009	59	0.026
Movas C2009	18	0.008
TOTAL	**183,221**	
Bread wheat		
Tacupeto F2001	17,278	7.741
Roelfs F2007	7,108	3.185
Kronstad F2004	6,671	2.999
Navojoa M2007	5,213	2.336
RSM-Norman F2008	2,665	1.194
Abelino F2004	740	0.332
Japaraqui F2003	244	0.109
Ónavas F2009	29	0.013
Tepahui F2009	17	0.008
Rayón F89	6	0.003
TOTAL	**39,971**	

Table 9 Area (ha) and percentage of the total area grown with wheat during the 2012–13 agricultural season in southern Sonora, Mexico.

Cultivar	Area (ha)	Percent
Durum wheat		
CIRNO C2008	196,295.35	79.59
Movas C2009	6,227.00	2.52
Huatabampo Oro C2009	5,081.00	2.06
RSM Imperial C2008	4,494.30	1.82
Átil C2000	4,080.18	1.65
Patronato Oro C2008	3,182.57	1.29
Sáwali Oro C2008	1,180.00	0.48
RSM Chapultepec C2008	847.60	0.34
CEVY Oro C2008	184.54	0.07
TOTAL	**221,573.35**	
Bread wheat		
Tacupeto F2001	8,823.71	3.58
Roelfs F2007	5,223.02	2.12
Kronstad F2004	4,166.04	1.69
Navojoa M2007	2,301.30	0.93
Villa Juárez F2009	1,479.00	0.60
Ónavas F2009	1,395.00	0.57
RSM-Norman F2008	1,236.00	0.50
Abelino F2004	159.50	0.06
Ocoroni F86	148.69	0.06
Tepahui F2009	92.00	0.04
Japaraqui F2003	20.00	0.01
TOTAL	**25,054.27**	

Table 10. Selection history and localities where cultivar Movas C2009 was evaluated (F–W = Fall-Winter and S–S = Spring–Summer; RR = regular rainfed, NI = normal irrigation, and RI = reduced irrigation). The different planting dates for the INIFP yield trials were 15 and 30 November, 15 December, and 1 January.

Activity	Locality	Season	Irrigation
Simple genetic cross	El Batan, Mexico	S–S/2002	RR
F_1 generation	Cd. Obregon, Sonora	F–W/2002–03	NI
F_2 generation	Cd. Obregon	F–W/2003–04	NI
F_3 generation	Atizapan, Mexico	S–S/2004	RR
F_4 generation	Cd. Obregon	F–W/2004–05	NI
F_5 generation	El Batan	S–S/2005	RR
F_6 generation	Cd. Obregon	F–W/2005–06	NI
F_7 generation Yield trials by CIMMYT	El Batan	S–S/2006	RR
Yield trials by INIFAP	Cd. Obregon	F–W/2007–08	NI
		F–W/2008–09	NI

The most important phenotypic characteristics of this cultivar, according to the International Union for the Protection of New Varieties of Plants (UPOV, 1994), are shown (Table 11, p. 37). Cultivar Movas C2009 has an average of 79 days to heading with a range of 74 to 85. This cultivar has a biological cycle with an average of 120 days for physiological maturity; however, the cycle may be shortened due to the lack of cold hours if planting is late, and may average 110 days when sowing is done at the end of December. Movas C2009 has an average height of 88 cm (Fig. 3 (top), p. 38), a maximum of 100 and minimum of 75. Plant growth habit is erect, and shows nil or low frequency of recurved flag leaves. The spike measures 7.0 to 8.0 cm long and produces from 18 to 20 spikelets (Fig. 3 (middle), p. 38).

Table 11. Characteristics and description of phenotypic components of cultivar Movas C2009.

Structure	Characteristic	Description
Coleoptile	Anthocyanin coloration	Weak
First leaf	Anthocyanin coloration	Absent or very weak
Plant	Growth habit	Erect
	Frequency of plants with recurved flag leaves	Absent or very low
	Length (stem, ear, and awns)	Long
	Seasonal type	Spring
Culm	Hairiness of uppermost node	Absent or very weak
	Glaucosity of neck	Medium
Flag leaf	Glaucosity	Strong
	Glaucosity of blade	Weak
Awn	Anthocyanin coloration	Absent or very weak
	Color	Light brown
Awns at tip of spike	Length in relation to spike	Longer
Spike	Time of emergence	Medium
	Glaucosity	Medium
	Distribution of awns	Whole length
	Length excluding awns	Medium
	Hairiness of margin of first rachis segment	Absent or very weak
	Color (at maturity)	White
	Shape in profile view	Tapering
	Density	Medium
Lower glume	Shape (spikelet in mid-third of ear)	Strongly elongated
	Shape of shoulder	Sloping
	Shoulder width	Narrow
	Length of beak	Short
	Shape of beak	Slightly curved
	Hairiness on external surface	Present
Straw	Pith in cross section (half way between base of ear and stem node below)	Thin
Grain	Shape	Semi-elongated
	Length of brush hair in dorsal view	Short
	Coloration with phenol	Nil

Spike shape in profile view is tapering, density is medium and the length excluding awns is medium; awns are longer than the spikes. Spike glaucosity is medium, and awns are distributed the entire length and have a light brown color. Glume shape is strongly elongated (spikelet in mid-third of the spike), narrow, and hairy on the external surface. The length of the beak is short and slightly curved. Grain is semi-elongated (Fig. 3 (bottom), p. 38), and the length of brush hair in dorsal view is short. Grain coloration when treated with phenol is nil.

Movas C2009 has the registration TRI-118-270510 in the Mexican Catalogue of Plant Cultivars.

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Fig. 3. Durum wheat cultivar Movas C2009 has an average height of 88 cm, 79 days to heading, and 120 days to physiological maturity. Plants are erect and present no or very low frequency of recurved flag leaves (top). The spike of Movas C2009 is tapering in profile, density is medium, and the length, excluding the awns is medium. Awns are longer than the spikes. Spikes measrue 7.0–8.0 cm and produce 18–20 spikelets (middle). Grain spahe of Movas C2009 is semi-elongated. In dorsal view, pubescence is short. Grain color after treatment with phenol is nil (bottom).

Characteristics and description of phenotypic components and quality of durum wheat cultivar Sáwali Oro C2008.

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Abstract. Sáwali Oro C2008, a spring-type durum wheat, originated from hybridizations and selections made from the cross 'Musk_1//ACO89/FNFoot_2/4/Musk_4/3/Plata_3// Crex/Alla/5/Olus*2/ Ilbor//Patka_7/Yazi_1'. The cross number and history selection is CDSS02Y00786T-0TOPB-0Y-0M-2Y-0M-0Y. This cultivar has an average height of 89 cm, 81 days to heading, and 122 days to physiological maturity. Plant growth habit is erect and shows no or low frequency of recurved flag leaves. The spike measures 8.0–8.5 cm long and produces from 19 to 20 spikelets. In the mid-third of the spike, the glume is elongated and the shoulder is narrow and rounded, with a very short and straight beak. Spike glaucosity is medium, and awns are distributed the entire length and have are light brown. Grain coloration when treated with phenol is nil or very light.

Introduction. The area used for wheat cultivation in Mexico in year 2012 was 578,836.38 ha. The state of Sonora covered 254,759.70 (44%), with a production of 1´784,562.72 t (SIAP 2014). The most important wheat-producing region in Sonora is comprised of the following districts of rural development: 148 Cajeme (Yaqui Valley) with 174,983 ha occupying 68.7% of the state area, and 149 Navojoa (Mayo Valley) with 49,018 ha occupying 19.2% of the state area. Since the 1994–95 agricultural season, durum wheat cultivars have become very important for international export in the state of Sonora, Mexico. From Altar C84 to Átil C2000, Júpare C2001, and CIRNO C2008 (Fuentes-Dávila et al. 2014). This last cultivar went from 3,233ha in 2009–10 to 87,105 in 2010–11, 154,915 in 2011–12, and 196,295 ha in 2012–13. However, low incidence of yellow rust was detected in 2012–13.

One of the main objectives of the collaborative project on wheat breeding in northwestern Mexico between the Mexican National Institute for Forestry, Agriculture, and Livestock Research (INIFAP) and the International Maize and Wheat Improvement Center (CIMMYT) with support by the farmer's union (PIEAES) of the Yaqui Valley, is to diversify the genetic resistance to rusts, and particularly to leaf rust, to avoid any epidemics.

Although CIRNO C2008 had a rapid increase in area since it was publicized as the improved Átil, due to its resistance to leaf rust conferred by the progenitor CAMAYO, which has a resistant gene that is not present in any other commercial cultivar, the generation of resistant durum wheat cultivars to rusts for this region must be increased, in order to reach the appropriate levels of diversification. Sáwali Oro C2008 is one of several cultivars released for commercial cultivation in the last five years. The area grown with this cultivar in southern Sonora during the 2009–10 crop season was 4,761 ha, 14,353 ha in 2010–11 (Fuentes-Dávila et al. 2014), 2,183 ha in 2011–12, and 1,180 ha in 2012–13 (Felix-Fuentes et al. 2014).

Pedigree, history selection and description of Sáwali Oro C2008. After evaluations of grain yield carried out since the 2006–07 agricultural season at the Norman E. Borlaug Experimental Station (CENEB), we proposed to release the experimental durum wheat line 'Musk_1//ACO89/FNFoot_2/4/Musk_4/3/Plata_3//Crex/Alla/5/Olus*2/Ilbor//Patka_7/Yazi_1' as cultivar **Sáwali Oro C2008** (Figueroa-López et al. 2010). Sáwali Oro C2008 is a spring-type durum cultivar, which originated from hybridizations made in the Durum Wheat Breeding program of CIMMYT (Table 12). The cross number and history selection is

Table 12. Selection history and localities where cultivar Sáwali Oro C2008 was evaluated (F–W = Fall-Winter and S–S = Spring–Summer; RR = regular rainfed, NI = normal irrigation, and RI = reduced irrigation). The different planting dates for the INIFP yield trials were 15 and 30 November, 15 December, and 1 January.

Activity	Locality	Season	Irrigation
Top genetic cross	Cd. Obregon, Sonora	F–W/2001–02	NI
F_1 generation	El Batan, Mexico	S–S/2002	RR
F_2 generation	Cd. Obregon	F–W/2002–03	NI
F_3 generation	Atizapan, Mexico	S–S/2003	RR
F_4 generation	Cd. Obregon	F–W/2003–04	NI
F_5 generation	Atizapán	S–S/2004	RR
F_6 generation Yield trials by CIMMYT	Cd. Obregon	F–W/2004–05	NI
Yield trials by INIFAP	Cd. Obregon	F–W/2006–07	NI
		F–W/2007–08	NI
		F–W/2008–09	NI

CDSS02Y00786T-0TOPB-0Y-0M-2Y-0M-0Y. Shuttle breeding was carried out between the experimental stations of El Batán, state of Mexico (B) (19°30'N and 2,249 masl); San Antonio Atizapán, state of Mexico (M) (19°17'N and 2,640 masl); and the Yaqui Valley (Y) (27°20'N and 40 masl), in Sonora.

Phenotypic components. The most important phenotypic characteristics of Sáwali Oro C2008, according to the International Union for the Protection of New Varieties of Plants (UPOV 1994), are given (Table 13). Cultivar Sáwali Oro C2008 has an average of 81 days to heading with a range of 72 to 90. This cultivar has a biological cycle with an average of 122 days for physiological maturity, with a minimum of 110 and a maximum of 134. Sáwali Oro C2008 has an average height of 89 cm (Table 14, p. 41), a maximum of 95 and minimum of 75. Plant growth habit is erect, and shows none or a low frequency of recurved flag leaves. The spike measures 8.0 to 8.5 cm long and produces from 19 to 20 spikelets (Fig. 4, p. 41). Each spikelet produces three to five grains in the lower one-third of the spike with a predominance of four; from three to five in the middle one-third, with a predominance of four or five; and one to five in the upper one-third, with a predominance of four, three, or two.

Table 13. Characteristics and description of phenotypic components of cultivar Sáwlai Oro C2008.

Structure	Characteristic	Description
Coleoptile	Anthocyanin coloration	Medium
First leaf	Anthocyanin coloration	Weak
Plant	Growth habit	Erect
	Frequency of plants with recurved flag leaves	Absent or very low
	Length (stem, ear, and awns)	Long
	Seasonal type	Spring
Culm	Hairiness of uppermost node	Absent or very weak
	Glaucosity of neck	Medium
Flag leaf	Glaucosity	Strong
	Glaucosity of blade	Weak
Awn	Anthocyanin coloration	Absent or very weak
	Color	Light brown
Awns at tip of spike	Length in relation to spike	Longer
Spike	Time of emergence	Early
	Glaucosity	Medium
	Distribution of awns	Whole length
	Length excluding awns	Medium
	Hairiness of margin of first rachis segment	Weak
	Color (at maturity)	White
	Shape in profile view	Parallel sided
	Density	Medium
Lower glume	Shape (spikelet in mid-third of ear)	Elongated
	Shape of shoulder	Rounded
	Shoulder width	Narrow
	Length of beak	Very short
	Shape of beak	Straight
	Hairiness on external surface	Absent
Straw	Pith in cross section (half way between base of ear and stem node below)	Medium
Grain	Shape	Semi-elongated
	Length of brush hair in dorsal view	Medium
	Coloration with phenol	Nil or very light

Spike shape in profile view is parallel sided, density is medium and the length excluding awns is medium; awns are longer than the spikes. Spike glaucosity is medium, and awns are distributed the entire length and are light brown. Glume shape is elongated (spikelet in mid-third of spike), the shoulder is narrow and rounded, and the hairiness on the

Fig. 4. Durum wheat cultivar Sáwali Oro C2008 has an average height of 89 cm, 81 days to heading, and 122 days to physiological maturity. Plant growth habit is erect and shows no or low frequency of recurved flag leaves (top). Spikes of this cultivar are parallel sided in profile, medium dense, and the awns are longer than the spikes. Spike length, excluding the awns, measures 8.0–8.5 cm long and produces from 19 to 20 spikelets (middle). Grain shape is semi-elongated in the dorsal view, pubescence is medium. Grain coloration when treated with phenol is nil or very light (bottom).

external surface is absent. The length of the beak is very short and straight. Grain is semi-elongated (Fig. 4), 6.9 mm long by 3 mm wide, with an average weight of 50 mg. The length of brush hair in dorsal view is medium. Grain coloration when treated with phenol is nil or very light.

Quality. An important characteristic of the Mexican durum wheat which influences its demand abroad, is the high level of semolina extraction. Wheat semolina quality for pasta-making is determined by the content and quality of the protein and the pigment (Fig. 5) present in the grain endosperm of durum wheat. Sáwali Oro C2008 has a high protein content average (14%) and color Minolta b value of 27.8 (Table 14). This cultivar is consistently superior to cultivar check Júpare C2001 in protein content and yellow pigment in the grain endosperm. The grain of Sáwali Oro C2008 has an average specific weight of 83.2 kg/hL.

Sáwali Oro C2008 has the registration TRI-109-240209 in the Mexican Catalogue of Plant Cultivars.

Table 14. Characteristics of the industrial quality of Sáwali Oro C2008 and the check cultivar Júpare C2001.

Characteristic	Sáwali Oro C2008	Júpare C2001
Specific weight (kg/hL)		
Minimum	81.4	79.0
Average	83.2	83.6
Maximum	85.2	85.9
Grain protein (%)		
Minimum	12.6	12.9
Average	14.0	13.8
Maximum	15.0	15.1
Color (Minolta b value)		
Minimum	25.7	18.7
Average	27.8	20.7
Maximum	30.3	26.2

Fig. 5. Durum wheat cultivar Sáwali Oro C2008 produces a great concentration of pigment (right) compared to that of the check cultivar Júpare C2001 (left).

Acknowledgements. The authors wish to thank Dr. Karim Ammar, Head of the Durum Wheat Breeding Progam of the International Maize and Wheat Improvement Center (CIMMYT), for providing the advanced lines from which Sáwali Oro C2008 originated.

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Incidence of Karnal bunt in experimental plots sown with infected wheat seed during several crop seasons.

Guillermo Fuentes-Dávila.

Abstract. This work evaluated the effect of different quantities of infected seed/kg for sowing on the natural incidence of Karnal bunt. Experiments were conducted at the Norman E. Borlaug Experimental Station, in Sonora, Mexico. A set of treatments, which consisted of 5, 10, 100, 250, and 500 infected seeds/kg and an untreated, healthy check, was applied during the 1989–90 to 1993–94 crop seasons. Another set, consisting of 500, 1,000, 2,500, and 5,000 infected seeds/kg and the untreated, healthy check, with two replicated plots per season, was applied during 1991–92 to 1994–95. The experiments were established in the same land during the different crop seasons. For the first experiment, the healthy check showed the greatest number of infected grains in two crop seasons and was the second in two other seasons. The treatment with 500 infected seeds had the lowest number of infected grains in two crop seasons. For the second experiment, the healthy check showed the greatest number of infected grains in both replicates in the 1992–93 crop season, and in one in the 1994–95 crop season. The treatment with 5,000 infected seeds had the highest number of infected grains in both replicates in 1991–92, but the lowest one in both replicates in 1994–95 and in one replicate in 1992–93.

Introduction. Karnal bunt, caused by *Tilletia indica* Mitra (syn. *Neovossia indica* (Mitra) Mundkur), was first identified in India (Mitra 1931) and later in Mexico (Duran 1972), Pakistan (Munjal 1975), Nepal (Singh et al. 1989), Brasil (Da Luz et al. 1993), the United States of America (APHIS 1996), Iran (Torarbi et al. 1996), and the Republic of South Africa (Crous et al. 2001). More recently, the CIMMYT-blog/tag/karnal-bunt (CIMMYT 2011) states that 'Karnal bunt has long been present in Afghanistan, with favorable climatic conditions promoting occasional outbreaks, and a recent survey by ARIA indicated that several popular wheat varieties are susceptible to the disease. It is particularly prevalent in the eastern region bordering Pakistan, which has emerged in recent years as an important seed-producing area within Afghanistan'. Despite this, no public information is available regarding the history of Karnal bunt in that country, disease incidence, and the area affected.

Teliospores of *T. indica* are resistant to extreme cold, heat, chemical treatments (Smilanick et al.,1985), and can survive up to three (Bonde et al. 2004) to four years in field soil (Krishna and Singh 1982), making control difficult. Fairly good chemical control with fungicide applications during flowering can be accomplished (Salazar-Huerta et al. 1997); however, in northwest Mexico, due to quarantine regulations (SARH 1987), this measure is still not profitable for commercial use.

Although the effect of Karnal bunt on yield is not serious (Salazar-Huerta et al. 1997), the economic impact in flour quality, and the costs due to the quarantine measures established in northwest Mexico, are of great importance (Brennan et al. 1990). Such measures were imposed to avoid dissemination of the pathogen to other wheat-producing areas within and outside Mexico (SARH 1987). Regarding seed production and distribution, seed produced in the quarantined areas and destined for seed in such areas should comply with the norm of 0% damaged or infected grains of Karnal bunt and should be treated chemically as specified. Despite this, tolerance levels of 5, 10, and 25 infected grains were allowed in years of high incidence, with the objective to suffice the seed demand (García Valle 1991). Since 1981–82, when the Mexican Department of Agriculture and Water Resources established a systematic process of sampling in southern Sonora, disease incidence was observed to increase when weather conditions favored development and dissemination of the fungus (high relative humidity, cloudiness, and rain), whether or not the seed to be used for sowing was infected (García Valle 1991). At that time, a very economically important restriction imposed by the government, which accounted for about 29% of the total calculated annual loss caused by Karnal bunt in northwest Mexico (Brennan et al. 1990), was the quarantine of fields which showed more than 2% infected grain. This measure was highly debated and refuted by scientists, because a highly contaminated soil with teliospores of the causal agent and where wheat is the main crop, restrictions on sowing wheat would not serve as a control measure, mainly because of the longevity of the teliospores in the soil. Although this restriction is no longer in effect (SAGARPA 2002), our objective was to evaluate the effect of different quantities of infected seed/kg for sowing on the natural incidence of Karnal bunt. Part of this work was presented at the Annual meeting of the American Phytopathological Society (Fuentes-Dávila 1995, 1996).

Materials and methods. The Experiments were conducted at the Norman E. Borlaug Experimental Station, previously known as CIANO, located in the Yaqui Valley, Sonora, Mexico (27°20´N, 105°55´W, elevation 39 masl), during the 1989–90 to 1994–95 crop seasons, in block 910 in a clay soil with pH 7.8. Plots consisted of 10-m rows with 10 beds of two rows sown with the susceptible cultivar Bacanora T88 (Salazar-Huerta and Fuentes-Dávila 1993) at the rate of 75 kg/ha. A set of treatments, which consisted of 5, 10, 100, 250, and 500 infected seeds/kg and an untreated, healthy check, were sown in the 1989–90 to 1993–94 crop seasong, and another set, consisting of 500, 1,000, 2,500, and 5,000 infected seeds/kg and the untreated, healthy check, with two replicated plots per season, were sown during the 1991–92 to 1994–95 seasons. The different treatments were repeated using the same land during the time of the study so as to determine the effect of adding a certain amount of infected seed on the natural incidence of the disease. To minimize the spread of teliospores from one plot to another during the different crop seasons, treatments were separated by untreated buffer plots, with the dimensions already described, and sown with the same susceptible cultivar. Each experiment also was established in a strip starting with the untreated check and, then, from the lowest to the highest rate. In addition, the only agricultural practices performed were harrowing and bed formation. The entire plots were harvested and the number of infected grains was determined by visual inspection, counting the number of infected and healthy grains.

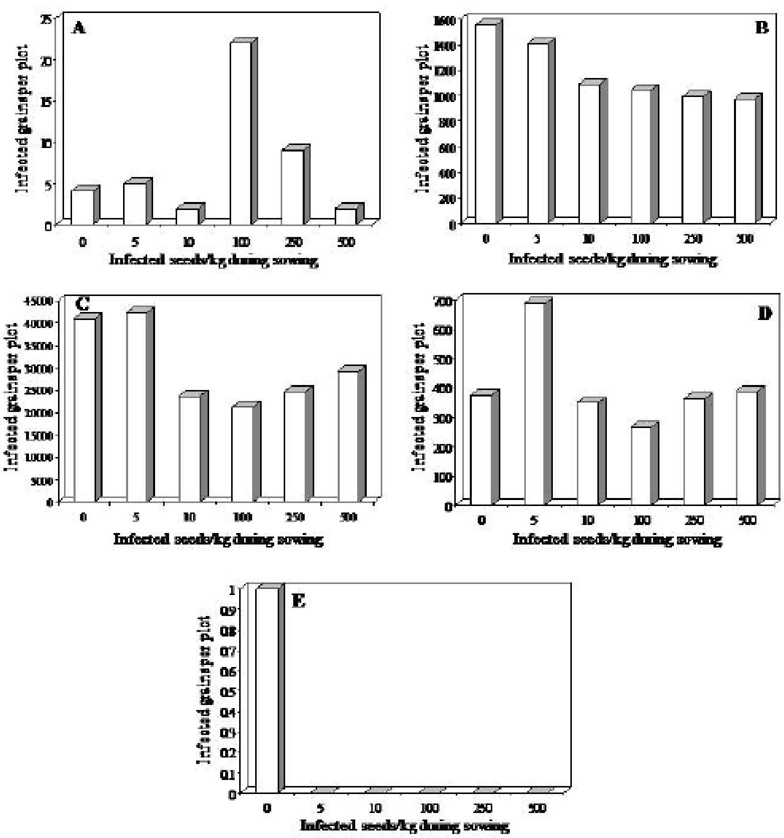

Fig. 6. Number of grains infected with Karnal bunt under natural infection from plots sown with 5–500 infected seed/kg of the susceptible cultivar Bacanora T88 in the Yaqui Valley, Sonora, Mexico, during the 1989–90 (A), 1990–91 (B), 1991–92 (C), 1992–93 (D), and 1993–94 (E) croping seasons.

Results. ***Low rates of infected seed.*** The total number of infected grain/plot was low during 1989-90 with a range of 2-22 (Fig. 6A). The greatest number of infected grains was obtained with the treatment of 100 seed/kg, however, the treatment with 500 seed/kg had a little less than the check. In 1990–91, the range was 973–1,559, the check had the greatest number of infected grains and, as the rate increased, the number of infected grains decreased (Fig. 6B, p. 43). During 1991–92, disease incidence was even higher, with a range of 21,242–42,298, the highest being the treatment with 5 seed/kg followed by the check with 40,886, whereas the treatment with 500 seed/kg had 29,194 (Fig. 6C). During 1992–93, the range was 266–688; the treatment with 5 infected seed/kg had the greatest number of infected grains. The treatment with 100 infected seed/kg had the lowest number of infected grains, whereas the rest of the treatments were similar (Fig. 6D). During 1993–94, the only treatment that showed infected grains was the check with 1, and the rest did not show any infected grain (Fig. 6E).

High rates of infected seed. 1991-92. Replicate A. The total number of infected grains/plot was high during the 1991–92 growing season with a range of 4,126–5,523 (Fig. 7A). The greatest number of infected grains was obtained with the 5,000 treatment, followed by the 1,000 treatment. The check had the lowest number of infected grain. Replicate B. The outcome of this experiment was rather similar to replicate A; the highest number of infected grains was obtained with the treatment of 5,000, but followed by 500 (Fig. 7B). The check also had the lowest number of infected grains. 1992–93.

1992–93. Replicate A. The total number of infected grains/plot was moderate during this season with a range of 217–1,111 (Fig. 8A). The greatest number of infected grains was obtained with the check, followed by the plot with 1,000 infected grains. The lowest number of infected grains was obtained with the treatment of 5,000. ***Replicate B.*** As in the previous crop season, the outcome of this experiment was rather similar to replicate A; the highest number of infected grains was obtained with the check, but followed by the plot with 500 infected grains (Fig. 8B). The range was 221–921. The lowest number of infected grains was obtained with the treatment of 2,500 infected grains.

1994-95, Replicate A. No infected grains were found in any of the treatments of the two replicates in 1993–94 (Figs. 9A and 9B). The total number of infected grains/plot was high during this season, with a range of 5,052–10,190 (Fig. 10A, p. 45). The greatest number of infected grains was obtained with the check, followed by 1000. The lowest number of infected grains was obtained with the treatment of 5000. ***Replicate B.*** The greatest number of infected grains was obtained with the treatment of 1,000, followed by the check (Fig. 10B, p. 45). The lowest number of infected grains was obtained with the treatment of 5,000 infected grain.

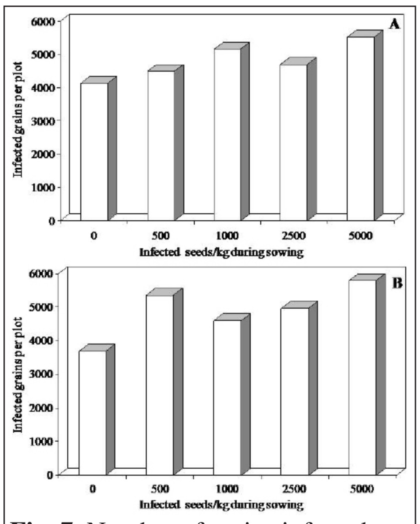

Fig. 7. Number of grains infected with Karnal bunt under natural conditions in plots sown with different numbers of infected seed/kg of the susceptible cultivar Bacanora T88 in the 1991–92 cropping season (A = replicate 1, B = replicate 2).

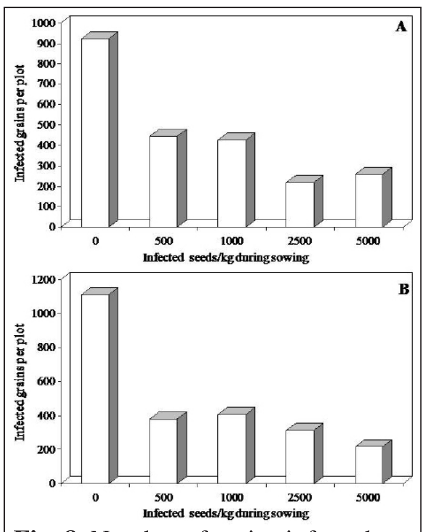

Fig. 8. Number of grains infected with Karnal bunt under natural conditions in plots sown with different numbers of infected seed/kg of the susceptible cultivar Bacanora T88 in the 1992–93 cropping season (A = replicate 1, B = replicate 2).

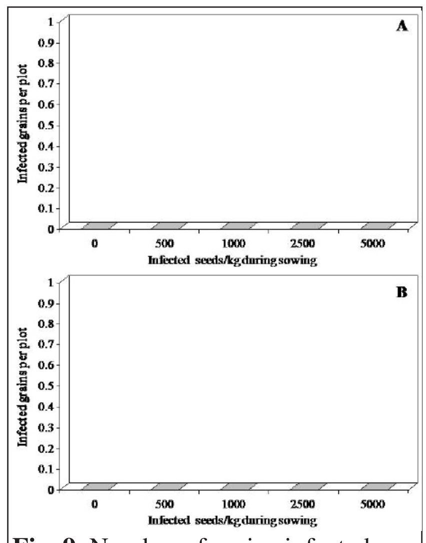

Fig. 9. Number of grains infected with Karnal bunt under natural conditions in plots sown with different numbers of infected seed/kg of the susceptible cultivar Bacanora T88 in the 1993–94 cropping season (A = replicate 1, B = replicate 2).

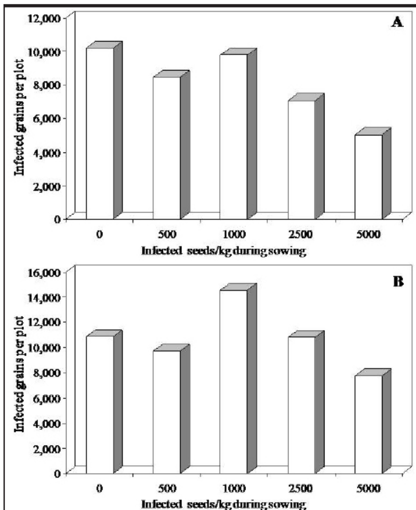

Fig. 10. Number of grains infected with Karnal bunt under natural conditions in plots sown with different numbers of infected seed/kg of the susceptible cultivar Bacanora T88 in the 1994–95 cropping season (A = replicate 1, B = replicate 2).

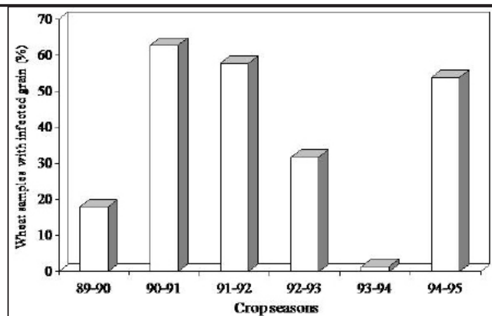

Fig. 11. Percentage of wheat grain samples infected with Karnal bunt during the 1989–90 to 1994–95 cropping seasons in the Yaqui Valley, Sonora, Mexico.

Karnal bunt incidence in the Yaqui Valley, Sonora, was low in 1989–90, high during 1990–91 and 1991–92, moderate during 1992–93, very low in 1993–94, and high again in 1994–95 (Fig. 11). Our results reflect those obtained in the surveysof the Department of Agriculture and the Local Councils of Plant Health in the Yaqui Valley during the 1989–90 to 1994–95 crop seasons. These results also confirm the observations and arguments that scientists have expressed in many meetings with plant health authorities of several countries. Based on the life cycle of *T. indica* and on accumulated experience, in an area where the soil is already contaminated with teliospores of *T. indica*, the use of infected seed for sowing, in this particular case ranging from 5 to 5,000 seeds/kg, does not influence a greater incidence of Karnal bunt.

Conclusions. Results of the experiments conducted during crop seasons 1989-90 to 1994-95, showed that using infected seed with karnal bunt for sowing, at rates ranging from 5 to 5000/kg, do not influence an increase on the incidence of the disease.

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ITEMS FROM PAKISTAN

NATIONAL AGRICULTURAL RESEARCH CENTER (NARC), ISLAMABAD
Wheat Wide Crosses and cytogenetics

ATTA-UR-RAHMAN SCHOOL OF APPLIED BIOSCIENCES (ASAB),
NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY (NUST)
Islamabad, Pakistan.

Germplasm conservation prebreeding value addition for yield enhancement as a conduit to national food security for combating climate change and the 2050 vision.

A. Mujeeb-Kazi and Alvina Gul Kazi.

The importance of wheat as a food cereal is paramount, and the need to be on secure production grounds a national priority. Changing international scenarios around wheat production in light of productivity constraints and new sophisticated technologies necessitate that our researchers move with time and be proactive. This involves swift research program restructuring that generates outputs efficiently, is unique, and targets threats due to climate change that will impact food security issues in 2050, when a population surge touching 9.2 billion approximately 230 million of which will be Pakistan's share.

National wheat yields currently are 2.6 t/ha with annual productivity approaching 25 x 10^6 tones. Our 2015 goal is 30 x 10^6 tonnes and about 33 x 10^6 tones for 2030. Maximizing yields is a tall order, because a huge yield gap exists and the full varietal productivity potential near 9.0 t/ha is too distant. Despite cultivar releases that are high yielding, national yield levels remain stagnant, between 25–30 maunds/acre (2.5–3.0 t/ha) when the upper limit touchs about 8.4 t/ha, and close to 5 t/ha in irrigated and rainfed areas by progressive farmers. Policy setting and management play a vital role to counter this poor performance but, on the research horizon, stress constraints are a huge concern. The fear of seeing the migration of stem rust Ug99 in to Pakistan is one factor, another is the breakdown of yellow rust resistance that has occurred, and finally, the emergence of spot blotch in scattered locations in 2009 go hand in hand to motivate proresearchers to find solutions that can curb these new dangers. Exploiting genetic resources is a viable option and this taps the abundant genomic diversity of the annual and perennial Triticeae members across all three wheat gene pools.

Our Wide Cross Program is an offshoot of the CIMMYT program as Mujeeb-Kazi, who was the architect of the CIMMYT program and led it from 1979 until late 2004, has provided that program's basic outputs under the devolution concept that allowed CIMMYT to focus on their special tasks with our efforts to compliment the remaining wide cross activities. Over the years at CIMMYT, seed maintenance, viability, and distribution of stocks that earlier were major