Like the ME4, a large part of the ME6 crosses is dedicated to resistance to Ug99. However, as opposed to ME4, ME6 Ug99 breeding focuses more on the use of major genes because of the risk of Ug99 spreading in KASIB seems lower than in South Asia, so major genes could bring an acceptable solution at the moment, and because most KASIB cultivars are highly susceptible to stem rust, and breeding with APR would be very difficult in Kenya with photoperiod-sensitive, ME6 material.

KASIB yield data analysis presented at the KASIB meeting held in Pavlodar in August ,2008, showed that there is little 'G x E' in the region, making it possible to find high-yielding lines/cultivars with broad adaptation. These lines will have priority use for crossing. The correlation analysis showed that some sites predict better global performance than others, in particular Omsk in Siberia and Karabalyk in North Kazakhstan. Until 2008, material selected in Mexico was sent only to Shortandy. From 2009, it will be sent to Omsk and to Karabalyk as well. Shuttle materials will be selected from the data and observations collected at these two sites, and then sent to all breeders of the KASIB network.

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Reaction of durum wheats to black point in southern Sonora, Mexico.

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Introduction. More than 100 species of fungi, including *Alternaria*, *Fusarium*, and *Helminthosporium* spp., can be isolated from newly harvested wheat grain. These fungi are most important in humid field environments, where they infect seed when relative humidity exceeds 90% and seed moisture content exceeds 20%. Rainfall during seed maturation favors black point (BP), as well as humid weather prevailing for a few days prior to harvest (Prescott et al. 1986). Expanding green kernels are most susceptible. Premature seed senescence also promotes BP because many of the fungi are saprophytic (Wiese 1987). *Alternaria alternata* and *Bipolaris sorokiniana* are generally considered the primary causal agents of the disease (Mathur and Cunfer 1993). Infected ears may look normal, but there may be elliptical, brown to dark brown lesions on the inner side of the glumes. The disease is more pronounced as brown to dark brown or blackish, localized discolored areas, usually around the embryo end of seeds (Adlakha and Joshi 1974; Hanson and Christensen 1953; Rana and Gupta 1982; cited by Mathur and Cunfer 1993). The discoloration also may occur near the brush, in the crease or any part of the seed and may be light or dark or with a distinct margin. Severe infection causes discoloration and shriveling of the whole seed (Adlakha and Joshi 1974). In southern Sonora, Mexico, black point is an endemic disease of durum and bread wheat, although incidence is variable from year to year. Wheat-breeding programs select for disease resistance during seed evaluation after harvest, however, there is not a formal project on BP in Sonora. The objectives of this work were to evaluate the reaction of durum wheat elite advanced lines, pre- and candidate lines for commercial release, and commercial cultivars to BP after harvest in year 2008.

Materials and methods. The materials evaluated consisted of various nurseries. The evaluation was by visual inspection taking in to consideration the relative amount of affected grains in the sample, but without considering the area or the percentage of affected area. The rating scale was as follows: 0 = healthy grains, 1 = low incidence of black point, 2 = moderate, and 3 = high incidence. The following nurseries were evaluated: a) Advanced Yield Trial consisting of 171 entries planted on 15 November, 2007, in block 810, in a clay soil with pH 7.5; 100 g per entry were analyzed; b) pre-candidate lines for commercial release consisting of 62 entries, planted on 27 December, 2007, in block 910, in a heavy sandy clay loam soil, pH 7.5; grains from five spikes were evaluated; c1) commercial cultivars, four groups with five replications (four spikes each) of Altar C84 and Júpare C2001 planted on 22 November, 2007, in block 710, in a clay soil with pH 7.8; c2) commercial cultivars Altar C84, Nacori C97, Rafi C97, Atil C2000, Júpare C2001, Samayoa C2004, and Banamichi C2004, planted on 15 November, 2007, in block 810, 100 g were evaluated; c3) commercial cultivars Júpare

C2001, Samayoa C2004, Banamichi C2004, and Platinum planted on 8 and 21 November and 10 December, 2007, in block 710, under overhead irrigation, grains from ten spikes per date were evaluated; d) 17 candidates for commercial release with origin in wheat season 2006–07 and another group from 2007–08 planted on 8 and 21 November and 10 December, 2007, in block 710, under overhead irrigation, grains from ten spikes per date were evaluated; e) a group of 25 elite advanced lines with origin in wheat season 2006–07, planted on 8 and 21 November and 10 December, 2007, in block 710, under overhead irrigation, grains from ten spikes per date were evaluated; and f) 72 progenies derived from single spikes of 23 genotypes, planted on 27 December, 2007, in block 910, the product of three spikes was evaluated (total number of spikes = 4,968).

Results and discussion. *Advanced Yield Trial*. One hundred and two lines did not show any infected grain, 63 had level 1, and six were level 2. Ten lines out of the 102 which did not show infected grains are shown in Table 1.

Table 1. Ten lines from the Advanced Yield Trial that did not show black point-infected grains in the field at one planting date during the crop season autumn–winter 2007–08, in the Yaqui Valley, Sonora, Mexico.

Line	Pedigree and selection history
1	AINZEN_1//PLATA_6/GREEN_17 CDSS99B00315S-0M-0Y-66Y-0M-0Y-2M-0Y
2	ALTAR 84/BINTEPE 85/3/ALTAR 84/STINT//SILVER_45/4/LHNKE/ RASCON//CONA-D CDSS99B01265T-0TOPY-0M-0Y-12Y-0M-0Y-1M-0Y
3	SOMAT_3/PHAX_1//TILO_1/LOTUS_4/3/SOOTY_9/RASCON_37 CDSS01B00473S-17M-0M-0Y-0Y
4	SOOTY_9/RASCON_37//CAMAYO CGSS02Y00004S-2F1-6Y-0B-1Y-0B
5	MINIMUS/COMB DUCK_2//CHAM_3/3/FICHE_6/4/MOJO/AIRON/5/ SOMAT_3.1 CDSS02Y00233S-0Y-0M-9Y-0Y
6	LABUD/NIGRIS_3//GAN/3/AJAIA_13/YAZI/4/SORA/2*PLATA_12// SOMAT_3 CDSS02Y00358S-0Y-0M-21Y-0Y
7	CF4-JS 21//RASCON_39/TILO_1 CDSS02Y00439S-0Y-0M-3Y-0Y
8	CBC 509 CHILE/5/2*AJAIA_16//HORA/JRO/3/GAN/4/ZAR CDSS02Y01222T-0TOPB-0Y-0M-5Y-0Y
9	SOOTY_9/RASCON_37//CAMAYO CGSS02Y00004S-2F1-6Y-0B-1Y-0B
10	SOOTY_9/RASCON_37//GUAYACAN INIA CGSS02Y00011S-2F1-5Y-0B-2Y-0B-2Y-0B

Precandidate lines for commercial release. Twenty-five lines did not show any infected grain, 31 had level 1, and six with level 2. The ten lines out of the 25 that did not show infected grains are shown in Table 2 (p. 130).

Commercial cultivars. In the c1 nursery, no infected grains with black point were detected in any of the replications of the four groups of commercial cultivars Altar C84 and Júpare C2001. In the c2 nursery, commercial cultivars showed differences in disease incidence; Altar C84 and Júpare C2001 did not show any infected grains, whereas Samayoa C2004 showed the highest disease incidence (Table 3, p. 130). In nursery c3, commercial cultivars showed differences in disease incidence; Júpare C2001 and Platinum showed a disease range of 0–3, Samayoa C2004 from 1–3, and Banamichi C2004 from 0–1 (Table 4, p. 130). The results from the last two groups of commercial cultivars clearly show that Samayoa C2004 had the highest black point incidence with and without the overhead irrigation, whereas Júpare C2001 and Platinum reached the highest incidence in some of the evaluations under overhead irrigation.

Candidates for commercial release. Lines originating in 2006–07 that did not show infected grain in all planting dates were SOOTY_9/RASCON_37//STORLOM (CGSS02Y00006S-2F1-21Y-0B-10Y-0B) and SOOTY_9/RASCON_37//LLARETA INIA (CGSS02Y00010S-2F1-15Y-0B-5Y-0B), whereas line 1A.1D5+10-6/3*MOJO//RCOL/4/ARMENT//SRN_3/NIGRIS_4/3/CANELO_9.1 (CDSS02Y00408S-0Y-0M-6Y-0Y) showed the highest disease incidence. Lines originating in 2007–08 that did not show infected grains in all planting dates were ARTICO/AJAIA_3//HUALITA/3/FULVOUS_1/ MFOWL_13/4/RASCON_39/TILO_1 (CDSS02Y01178T-0TOPB-0Y-0M-4Y-0Y) and LHNKE/HCN//

Table 2. Ten precandidate lines for commercial release that did not show black point-infected grains in the field at one planting date during the crop season autumn–winter 2007–08, in the Yaqui Valley, Sonora, Mexico.

Line	Pedigree and selection history
1	RCOL/POHO_1/3/DIPPER_2/BUSHEN_3//SNITAN CDSS02B00782T-0TOPB-0Y-0M-1Y-3M-04Y-0B
2	PLATA_6/GREEN_17//RCOL/3/SNITAN/SOMAT_3//FULVOUS_1/MFOWL_13 CDSS02B00199S-0M-9Y-06Y-2M-1Y
3	PLATA_6/GREEN_17//SNITAN/4/ARMENT//SRN_3/NIGRIS_4/3/CANELO_9.1 CDSS02B00200S-0M-18Y-06Y-4M-1Y
4	SOOTY_9/RASCON_37//TILO_1/LOTUS_4/3/SOMAT_3/PHAX_1// TILO_1/LOTUS_4 CDSS02B00385S-0M-20Y-06Y-1M-1Y
5	CMH74A.630/SX//TSI/3/GUANAY/4/2*D86135/ACO89//PORRON_4/5/SOOTY_9/RASCON_37/3/ SOOTY_9/TARRO_1//AJAIA_2 CDSS02B00713S-0M-16Y-06Y-1M-1Y
6	STORLOM/3/RASCON_37/TARRO_2//RASCON_37/4/D00003A CDWS02FM00018S-0M-2Y-06Y-3M-1Y
7	STOT//ALTAR 84/ALD/3/AUK/GUIL//GREEN/4/GODRIN/GUTROS//DUKEM/3/THKNEE_11 CDSS04Y00283S-30Y-0M-06Y-3M-1Y
8	NUS/SULA//5*NUS/4/SULA/RBCE_2/3/HUI//CIT71/CII*2/5/ARMENT//SRN_3/NIGRIS_4/3/CANE-LO_9.1 CDSS04Y00888T-0TOPB-26Y-0M-06Y-2M-1Y
9	KOFA/8/GEDIZ/FGO//GTA/3/SRN_1/4/TOTUS/5/ENTE/MEXI_2//UI/3/YAV_1/GEDIZ/6/SOMBRA_20/7/ STOT//ALTAR 84/ALD CDSS04SH00003S-26Y-5M-6Y-4M-1Y
10	MOHAWK/10/PLATA_10/6/MQUE/4/USDA573//QFN/AA_7/3/ALBA-D/5/AVO/HUI/7/PLATA_13/8/ THKNEE_11/9/CHEN/ALTAR/3/HUI/POC//BUB/RUFO/4/FNFOOT CDSS04SH00022S-22Y-2M-1Y-2M-1Y

Table 3. Black point incidence in commercial durum wheat cultivars planted on 15 November, 2007 in block 810 during the crop season autumn–winter 2007–08, in the Yaqui valley, Sonora, Mexico.

Cultivar	Disease incidence (range)
Altar C84	0
Nacori C97	1
Rafi C97	0–1
Atil C2000	0–1
Júpare C2001	0
Samayoa C2004	0–2
Banamichi C2004	0–1

Table 4. Black point incidence in commercial durum wheat cultivars planted on 8 and 21 November and 10 December, 2007, in block 710 under mist irrigation during the crop season autumn–winter 2007–08, in the Yaqui valley, Sonora, Mexico.

Cultivar	Disease incidence (range)
Júpare C2001	0–3
Samayoa C2004	1–3
Banamichi C2004	0–1
Platinum	0–3
Banamichi C2004	0–1

PATA_2/3/ CAMAYO/5/ CREX//BOY/YAV_1/3/ PLATA_6/4/PORRON_11 (CDSS02Y01197T-0TOPB-0Y-0M-7Y-0Y). Lines with the highest disease incidence were MUSK_1// ACO89/FNFOOT_2/4/ MUSK_4/3/ PLATA_3// CREX/ALLA/5/OLUS*2/ ILBOR//PATKA_7/YAZI_1 (CDSS02Y00786T-0TOPB-0Y-0M-2Y-0Y), 1A.1D 5+10-6/3*MOJO//RCOL/4/ ARMENT//SRN_3/NI-GRIS_4/3/CANELO_9.1 (CDSS02Y00408S-0Y-0M-4Y-0Y), TADIZ/3/ SOMAT_3/ PHAX_1//TILO_1/LOTUS_4 (CDSS02B00456S-0Y-0M-7Y-1M-04Y-0B), and CNDO/PRIMADUR//HAI-OU_17/3/ SNITAN/4/STOT//ALTAR 84/ALD/5/CNDO/ PRIMADUR// HAI-OU_17/3/SNITAN (CDSS02Y01208T-0TOPB-0Y-0M-22Y-0Y).

Elite advanced lines. Lines that did not show infected grains in all planting dates were ADAMAR_15//ALBIA_1/AL-TAR84/3/SNITAN/9/USDA595/3/ D67.3/RABI//CRA/4/ALO/5/HUI/YAV_1/6/ARDENTE/7/HUI/YAV79/8/POD_9 (CDSS02Y00214S-0Y-0M-5Y-0Y), GREEN_2/HIMAN_12//SHIP_1/7/ECO/ CMH76A.722//YAV/3/ALTAR84/4/ AJAIA_2/5/KJOVE_1/6/MALMUK_1/ SERRATOR_1 (CDSS02Y00287S-0Y-0M-10Y-0Y), MUSK_1//ACO89/ FNFOOT_2/4/ MUSK_4/3/PLATA_3//CREX/ALLA/5/OLUS*2/ILBOR//PATKA_7/YAZI_1 (CDSS02Y00786T-0TOPB-0Y-0M-2Y-0Y), AINZEN_1/3/SN TURK MI83-84 503/LOTUS_4//MUSK_4/6/CMH82A.1062/3/GGOVZ394//

SBA81/PLC/4/AAZ_1/ CREX/5/HUI//CIT71/CII (CDSS00B00307T-0TOPY-0B-33Y-0M-0Y-1B-0Y), and ZHONGZUO/2*GREEN_3//SORA/2*PLATA_12/10/PLATA_10/6/MQUE/4/ USDA573//QFN/AA_7/3/ALBA-D/5/ AVO/HUI/7/PLATA_13/8/THKNEE_11/9/CHEN/ ALTAR 84/3/HUI/POC//BUB/RUFO/4/FNFOOT (CDSS02Y00213S-0Y-0M-30Y-0Y).

Lines with highest level of disease incidence were RASCON_22/RASCON_21// MOJO_2/3/GUANAY/4/ RCOL/5/SORA/2*PLATA_12//SOMAT_3 (CDSS01B00292S-0Y-0M-11Y-0Y), PLATA_6/GREEN_17//RCOL/3/ RYPS27_3/SKARV_3 (CDSS02Y00371S-0Y-0M-1Y-0Y), BRAK_2/AJAIA_2// SOLGA_8/3/CANELO_8// SORA/2*PLATA_12/4/YAZI_1/AKAKI_4//SOMAT_3/3/AUK/GUIL//GREEN (CDSS02Y00763T-0TOPB-0Y-0M-4Y-0Y), and RCOL/GUANAY *2//SOMAT_3/ GREEN_22 (CDSS02Y01193T-0TOPB-0Y-0M-19Y-0Y).

Progenies derived from single spikes. Genotypes that did not show infected grains with black point in any of the progenies were SOMAT_4/INTER_8//BCRCH_1/3/ SOOTY_9/RASCON_37 (CDSS02Y01276T-0TOPB-0Y-0M-17Y-0Y), and TGBB/ CANDEF//LALA/GUIL/3/BONVAL/4/TILO_1/LOTUS_4/5/TILO_1/LOTUS_4 (CDSS02B01344T-0TOPB-0Y-0M-2Y-2M-04Y-0B). Five genotypes showed a disease incidence of level 2 in one of their progenies, and none showed level 3.

With the exception of the commercial cultivar Samayoa C2004, none of the lines reached the highest disease incidence (level 3) when grown without the overhead irrigation, and despite of the various planting dates influenced by different weather conditions (Figs. 1 and 2). During the last two weeks of January, the average temperature range was 10.4–18.6°C and 56.2–89.6% relative humidity. In February, the average temperature range was 11.9–20.3°C and 54.0–76.3% relative humidity. In March, the average temperature range was 11.7–18.9°C and 47.5–70.4% relative humidity. During the first two weeks of April, the average temperature range was 17.7–21.8°C and 49.5–69.2% relative humidity. The wheat crop season was quite dry; only 6.2 mm on rain were recorded on 24 January and 1 mm on 17 March.

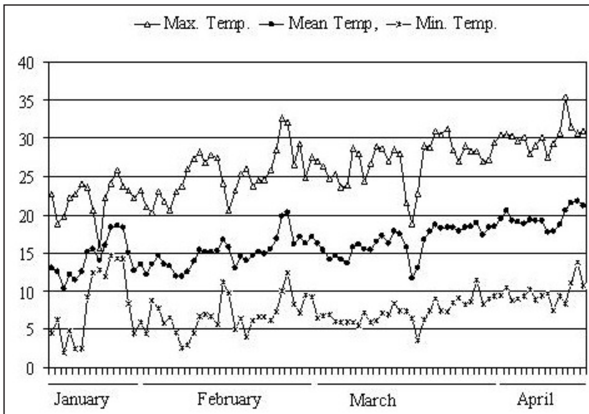

Fig. 1. Daily maximum, minimum, and mean temperature (°C) during 16 January–15 April, 2008, in blocks 710–910 in the Yaqui Valley, Sonora, Mexico.

Commercial cultivars Júpare C2001 and Platinum, some candidates for commercial release, and some elite advance lines showed the highest disease incidence (level 3) when subjected to the overhead irrigation during anthesis–first stage of kernel formation (Zadoks et al. 1974; stages 60 to 69–71). Further testing of some lines and cultivars would be necessary to corroborate their reaction so that they can serve as sources of resistance to black point. Because overhead irrigation is used to evaluate wheats for Karnal bunt resistance in the field (Fuentes-Davila and Rajaram 1994; Fuentes-Dávila and Trethowan 2007), the system also could be used to evaluate wheat germ plasm for resistance to black point.

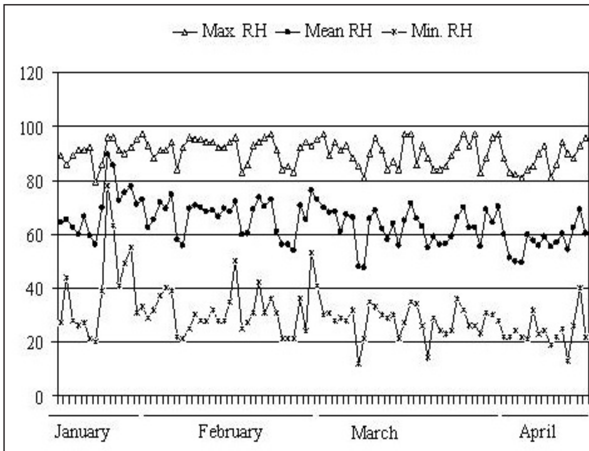

Fig. 2. Daily maximum, minimum, and mean humidity (%) during 16 January–15 April, 2008, in blocks 710–910 in the Yaqui Valley, Sonora, Mexico.

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Effect of yellow berry on wheat seed emergence at three sowing depths.

Teresa de Jesús Ruiz-Vega, Juan Manuel Cortés-Jiménez, and Guillermo Fuentes-Dávila.

Summary. The effect of yellow berry and sowing depth on seed germination were studied in the durum wheat cultivar Banamichi C2004. Seedling emergence decreased significantly as the sowing depth increased. Yellow berry affects neither seed germination nor its interaction with sowing depth.

Introduction. In southern Sonora, Mexico, wheat occupies up to 220,000 ha. Considering that a common practice is to use 120 kg of seed/ha, the demand for the region is in the order of 26,400 ton. For wheat export, regulations establish a limit of 10% of grain affected by yellow berry, a characteristic that has a negative correlation with protein content in the grain. According to Ottman and Doerge (1994), nitrogen is the factor with the highest impact on grain protein content, so application of nitrogen during heading is recommended in order to avoid yellow berry (Miezan et al. 1977; Linquist et al. 1992). Currently, the price of nitrogen has increased more than 100%. Reduced production costs in fields used for seed multiplication and not destined for export could be realized if the application of 50 nitrogen units recommended to avoid yellow berry is eliminated. An economic impact of approximately $321,428 USD could be generated considering a cost of $1.43 USD per unit of nitrogen of urea and an area of 4,500 ha used for seed production in the region. However, determining the effect of yellow berry upon wheat seed germination and seedling initial vigor, the objectives of this study, is nececcary.

Materials and methods. Seed of the durum wheat cultivar Banamichi C2004 was used in this study, which was conducted under laboratory conditions. One seed lot had 100% yellow berry incidence and the other only healthy seed. Seeds were sown in plastic pots (1.3-kg capacity, 20 seeds/pot) with clay soil, pH 8.2, at 1-, 2-, 3-, and 4-cm depths. The soil was previously sieved (2.0 mm) and water applied until reaching soil capacity, which was determined by the saturation value. Water conductivity was 0.45 dS/m. A factorial experimental design with six replications was used. Counts of seedling emergence were made daily. The pots also were weighed every 3 days in order to supply the water lost by evaporation.

Results and discussion. Highly significant differences were found between the sowing depth treatments. Yellow berry did not affect seedling emergence, and no interaction between these two factors was detected (Table 5). Greater sowing depth correlated with less seedling emergence with differences up to 20% (Fig. 3). In a parallel experiment, we observed that the percentage of germinated seed that was able to emerge was 76.45% and the total seed germinated was 76.97%, indicating that less emergence at greater depth is not due to germination failure but rather due to a lack of vigor to emerge. On average, a difference of 0.83% was observed in favor of seed with yellow berry when

Table 5. Percent seedling emergence of the durum wheat cultivar Banamichi C2004 as a function of sowing depth and yellow berry (Tuckey, p = 0.01, 16.86).

Depth (cm)	Yellow berry		
	Without	With	Average
1	82.50	83.33	82.92 a
2	85.00	85.83	85.42 a
3	75.00	72.50	73.75 ac
4	67.50	62.50	65.00 bc
Average	77.50 a	76.04 a	

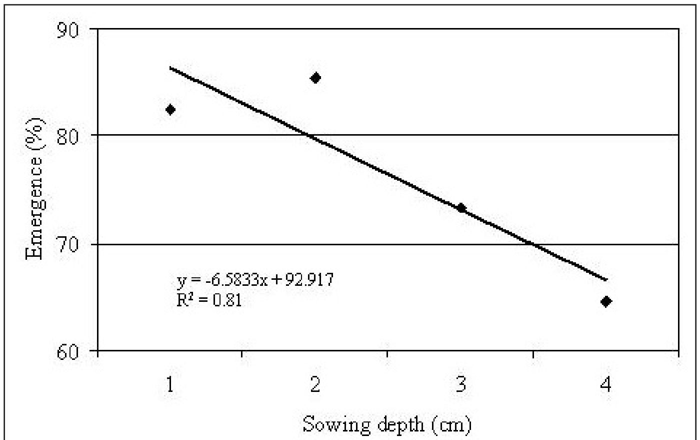

Fig. 3. The relationship between percent seedling emergencs and sowing depth of the durum wheat cultivar Banamichi C2004 *in vitro*.

germination was evaluated, even when seedlings had not emerged (data not shown). Similarly, 1.46% more seed with yellow berry emerged when considering only those that emerged independently of those that germinated. The observed less emergence at 1-cm depth than at 2 was attributed to more unfavorable humidity conditions, because the seed is closer to the surface and the soil cracked, however, there was no statistical difference. Seed affected with yellow berry had 96.67 and 90% germination when incubated in Petri plates and plastic Gerber-type bottles, respectively (Ruiz-Vega et al. 2009), without interaction with the soil. Seed germination reached 76.97% when seed was sown in plastic pots with soil, even at low sowing depths.

Conclusions. Yellow berry does not affect the process of germination and emergence of wheat seed, sowing depth does not affect seed germination but does reduce emergence of seedlings, and no interaction between yellow berry and sowing depth occurs.

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Effect of containers on wheat seed germination affected with yellow berry.

Teresa de Jesús Ruiz-Vega, Juan Manuel Cortés-Jiménez, and Guillermo Fuentes-Dávila.

Summary. The effect of two types of containers and three levels of yellow berry incidence on germination was evaluated using seed of the wheat cultivar Banamichi C2004. The highest percent germination was obtained with the Gerber-type bottle. Yellow berry did not affect germination, and there was no interaction between both factors.

Introduction. The occurrence of yellow berry is a common problem in wheat grown in southern Sonora, Mexico. Grain affected with yellow berry is characterized by low nitrogen content, which might be corrected by application of this element during heading of the wheat plant (Miezan et al. 1977). Wheat farmers are interested in the effect of yellow berry on seed germination; therefore, determining the interaction between these factors, and at the same time, evaluating laboratory techniques that are cheap, simple, fast, and that could be implemented by wheat producers is necessary. Seed germination by laboratory analysis is defined as the emergence and development of the esential structures that indicate for each class of seed analyzed its hability to become a normal plant under favorable conditions (Samaniego 2008). The importance of this process for the seed is vital, because no germination produces no plants and no harvest. Our objective was to evaluate the effect of two types of containers and three levels of yellow berry incidence upon seed germination and the initial hypocotyl growth in durum wheat seed.

Materials and methods. Two experiments were performed to assess seed germination of the durum wheat cultivar Banamichi C2004 using healthy seed and seed lots with 50 and 100% yellow berry incidence. The first experiment used 8.5-cm Petri plates and plastic Gerber-type bottles (6.5 cm in diameter). Ten seeds per treatment were placed on porous filter paper of the same diameter as the container. Four mL of distilled water were added to the container at planting; thereafter, 2 mL were added every 24 h for three days. Containers were kept open. A factorial experimental design with three replications was used. For the second experiment, only Gerber-type plastic bottles were used, adding a total of 8 mL of distilled water over a period of 11 days, and the bottles were kept closed.

Table 6. Percent seed germination of commercial durum wheat cultivar Banamichi C2004, in seed lots with different incidence of yellow berry incubated in two different type of containers.

Yellow berry incidence (%)	Petri plate	Plastic Gerber-type bottle	Average
0	66.67	100.00	83.33 a
50	63.33	96.66	80.03 a
100	96.67	90.00	93.33 a
Average	75.55 a	95.55 b	

Results and discussion. The occurrence of yellow berry did not affect wheat seed germination statistically (Table 6, p. 133). Significant differences were observed in germination in the two containers used, which agrees with the report of Román (2000); there was no interaction between both factors. Average seed germination in the bottle was 20% higher than that in the Petri plate, with the exception of the 100% yellow berry treatment, where seed germination was 6.67% higher in the Petri plate than in the bottle. Results from the first experiment indicated that there was a tendency to lower percent seed germination in bottles as yellow berry increased, however, this could not be corroborated in the second experiment. Figure 4 shows seed germination in both types of containers. In the second experiment, after 11 days of incubation in plastic bottles, more than 50% of the seeds with yellow berry and those without yellow berry, reached more than 8.3 cm in height (Table 7). We noticed that seed lot with 50% incidence of yellow berry had 70% of seeds that reached more than 8.3 cm in height; 13.3% more than healthy seed.

Fig. 4. Seed germination test of the durum wheat cultivar Banamichi C2004 in Petri plates and plastic, Gerber-type bottles.

Table 7. Percent seed germination of commercial durum wheat cultivar Banamichi C2004, in seed lots with different incidence of yellow berry incubated in plastic Gerber-type bottles.

Yellow berry (%)	≥ 8.3 cm	3 cm	1 cm	< 1 cm	Total (%)
0	56.66	26.66	10.00	6.66	100.00
50	70.00	23.33	6.66	0.00	100.00
100	53.33	30.00	13.33	3.33	100.00

Conclusions. Significant differences were observed between the containers evaluated; Gerber-type bottles with closed caps are better. The presence of yellow berry on wheat seed does not affect seed germination.

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Evaluation of Larrea tridentata dichloromethanic extract for control of karnal bunt in the field.

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Introduction. Karnal bunt or partial bunt of wheat was reported in Mexico in 1972 by Durán. This disease has become an important problem for wheat growers and certified seed producers in northwestern Mexico due to export restrictions (Fuentes-Dávila et al. 1996). In mature grains, the disease appears as sori enclosing a black powdery teliospore mass. Infection of wheat florets by wind-borne sporidia occurs after heading. The disease has a minor effect on yield, but may affect wheat quality if the level of infected grain is greater than 3%. Several fungicides for seed and foliar treatment have been shown to be useful in management of the disease (Krishna and Singh 1982; Singh and Singh 1985; Smilanick et al. 1987; Warham et al. 1989; Salazar-Huerta et al. 1997; Figueroa-López and Álvarez-Zamorano 2000; Fuentes-Dávila et al. 2005; Fuentes-Dávila 2007); however, they are not 100% effective and in some cases not economically profitable. Plants produce a wide variety of natural compounds that possess antifungal activity (Hoffmann et al. 1983). The use of natural bioactive substances for control of fungi has gained attention due to problems associated with chemical agents; these include resistance of pathogens to chemicals, toxicity to users, detection of residues in export commodities for human consumption, contamination of the environment, and adverse effects on beneficial organisms (Guerrero-Rodríguez et al. 2007; Suárez-Jiménez et al. 2007). Vallejo-Cohen et al. (1999) reported that *in vitro* tests of eight plant extracts caused 85 to 97% mycelial growth inhibition of *T. indica* and one showed 100% control. Rivera-Castañeda et al. (2001) reported that dichloromethane (DCM) extracts from *Chenopodium ambrosiodes* and *Encelia farinosa* reduced the radial mycelial growth of *T. indica*, but total inhibition occurred with 500 mg/mL of the DCM extract from *Larrea tridentata in vitro*. Therefore, our objective was to evaluate the ability of such extract from *L. tridentata* on control of Karnal bunt in the field.

Materials and methods. Leaves and stems from *L. tridentata* were collected from native populations in the Sonoran desert and sun-dried for several weeks. Both leaves and stems (500 g) were extracted with DCM (1,000 mL) using a Soxhlet apparatus. The plant extract was then evaporated under reduced pressure in a rotary evaporator at 40°C and 700 mmHg. The DCM extract was dissolved in 100 mL acetone or 100 mL distilled water at a concentration of 1 g/L and used for the field tests with commercial bread wheat cultivar Bacanora T88, susceptible to Karnal bunt, which was sown on 16 November, 2005, on 20 beds with two 20-m rows. Inoculum was prepared using one-year-old teliospores that were disinfected with sodium hypochlorite 0.5% while centrifuging at 3,000 rpm for 2 min (Fuentes-Dávila and Rajaram 1994). After two rinses with sterile distilled water, they were plated on 1.5% water-agar and incubated at room temperature (20–22°C). Upon germination, pieces of agar with the growing fungus were transferred to potato-dextrose-agar (PDA) for multiplication. To obtain allantoid sporidia, pieces of PDA with the fungus were inverted onto the lids of sterile glass Petri plates containing a small amount of water. Sporidia were collected daily, counted with a haemacytometer, and adjusted to a concentration of 10,000 sporidia/mL for inoculations. Treatments used in this experiment were the following: 1) inoculation of the extract into the boot (Zadoks 48-49) (1 mL) and inoculum injection (1 mL) the following day, 2) inoculation with the fungus (1 mL) and extract injection (1 mL) the following day, 3) inoculation with the fungus (1 mL) and application of extract spray, 4) inoculation with the fungus (0.5 mL) and injection of extract (0.5 mL), and 5) injection of extract (0.5 mL) and inoculation with the fungus (0.5 mL). Harvest was carried out manually and the evaluation and counting of healthy and infected kernels was by visual inspection. The experiment was repeated twice. The first round of inoculations were made on 27 February, 2006, and the second on 1 March, 2006. Forty heads were used for each treatment and date.

Results. Spikes inoculated with the extract showed conspicuous damage with yellowing and wrinkle plant tissue. Treatment 1, which consisted in injection of 1 mL of the extract and of inoculum the following day, caused the greatest number of unemerged spikes (Table 8, p. 136). Treatment 2 (injection of inoculum and the extract the following day) caused the greatest number of spikes halfway emerged without grain. These two treatments had three (1) and four (2) emerged spikes with grains and only one spike in each treatment had infected grains (42.62 and 39.22% infection, respectively). In addition to damaging plant tissue, the extract did not affect the fungus because Karnal bunt infection was high.

Treatments four and five, which were similar to one and two but with 0.5 mL less inoculum and 0.5 mL less extract, were more benign on inoculated plants. With these treatments, spikes formed without emerging, spikes emerged with and without grains, and spikes halfway emerged without grains. For spikes emerged with grains, treatment four in February had ten with a range of infection 0.00–62.50%, but the 18 spikes from March did not have any infected grain. Treatment five in February had 19 with a range of infection 0.00–50.00%, whereas on 22 March the range was 0.00–32.61%. As in treatments one and two, the extract did not affect the fungus.

Treatment 3,, which consisted in spraying the extract on the inoculated heads, caused the highest infection levels. All spikes emerged normally, and the infection range was 0.00–96.46 for February and 0.00–78.23 for March. The percentage of infection reached in some inoculated heads indicated that the extract at the concentration used in this study was stimulatory for the fungus, because the mean of the three highest infection levels in the susceptible check bread wheat cultivar WL-711 used in other experiments during the 2005–06 season was 78.63% and under overhead mist irrigation. Because the *L. tridentata* DCM extract at 500 ppm was fungitoxic to *T. indica in vitro*, showing a complete inhibition of teliospore germination after 21 days, trying different concentrations for field testing is worthwhile.

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Table 8. Results of application of dichloromethane extract from *Larrea tridentata* for control of *Tilletia indica* in artificially field-inoculated, bread wheat cultivar Bacanora T88.

Spike formed, without grains	Spike formed, emerged with grains	Spike formed, halfway emerged without grains
Treatment 1 [27 February, 2006]		
34	2 spike 1 healthy grains = 35 infected grains = 26 % infection = 42.62 spike 2 healthy grains = 35 infected grains = 0 % infection = 0.00	4
Treatment 1 [1 March, 2006]		
20	1 spike 1 healthy grains = 67 infected grains = 0 % infection = 0.00	19
Treatment 2 [27 February, 2006]		
5	3 spike 1 healthy grains = 52 infected grains = 0 % infection = 0.00 spike 2 healthy grains = 54 infected grains = 0 % infection = 0.00 spike 3 healthy grains = 7 infected grains = 0 % infection = 0.00	32
Treatment 2 [1 March, 2006]		
2	1 spike 1 healthy grains = 31 infected grains = 20 % infection = 39.22	27
Treatment 3 [27 February, 2006]		
	40 Range of infection 0.00–96.46	
Treatment 3 [1 March, 2006]		
	40 Range of infection 0.00–78.23	
Treatment 4 [27 February, 2006]		
19	10 Range of infection 0–62.50 Emerged without grains – 11	
Treatment 4 [1 March, 2006]		
	18 Range of infection 0.00 Emerged without grains – 12	10
Treatment 5, February 27, 2006		
5	19 Range of infection 0 Emerged without grains 9	7
Treatment 5 [1 March, 2006]		
7	22 Range of infection 0.00–32.61 Emerged without grains – 4	7

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Evaluation of elite triticale advanced lines for resistance to Karnal bunt under artificial field inoculation in the Yaqui valley, Sonora, Mexico, during the crop season 2007–08.

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Introduction. Karnal bunt occurs naturally on bread wheat (Mitra 1931), durum wheat, and triticale (Agarwal et al. 1977). Affected kernels usually are partially infected and completely infected ones are rare (Mitra 1935; Bedi et al. 1949; Chona et al. 1961). Since the early 1980s, Meeta et al. (1980) and Fuentes-Davila et al. (1992) have reported about the resistance and inmunity shown by triticale cultivars and experimental advanced lines under artificial inoculations; however, maintaining the monitoring new lines for their reaction to *T. indica* is important, especially for those lines intended for commercial use. Our objective was to evaluate 20 elite, triticale advanced lines for resistance to Karnal bunt.

Materials and methods. Twenty elite, triticale advanced lines were evaluated for Karnal bunt resistance during the crop season 2007–08 in block 710 in a clay soil with a pH 7.8. Planting dates were 8 and 21 November and 6 December, 2007 using approximately 10 g of seed for a bed with two 1-m rows. A mist-irrigation system was used 3–5 times/day (15 min each time) to provide a humid environment in the experimental area. Inoculation was by injection during the boot stage applying 1 mL of an allantoid sporidial suspension (10,000/mL) to ten heads/genotype. Harvest was carried out manually, and the evaluation and counting of healthy and infected grains was by visual inspection. Tested genotypes included several advanced lines generated by the collaborative project between The International Maize and Wheat Improvement Center (CIMMYT) and The National Institute for Forestry, Agriculture and Livestock Research in Mexico (INIFAP) (Table 9, p. 138).

Table 9. Elite triticale advanced lines artificially inoculated with Karnal bunt (*Tilletia indica*) in three planting dates during the crop season 2007–08 in the Yaqui valley, Sonora, Mexico.

Line	Pedigree and selection history
1	POLLMER_2.1.1 CTY88.547-22RES-1M-0Y-2M-1Y-0M-1B-0Y
2	DAHBI_6/3/ARDI_1/TOPO 1419//ERIZO_9/4/SONNI_3 CTSS99Y00115S-1Y-0M-0Y-8B-1Y-0B
3	BAT*2/BCN//CAAL/3/ERIZO_7/BAGAL_2//FARAS_1 CTSS99Y00246S-1Y-0M-0Y-5B-1Y-0B
4	LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/BULL_10/MANATI_1/7/ARDI_1/TOPO 1419//ERIZO_9/3/2*KETTU_1 CTSS01Y00040S-1M-3Y-3Y-4M-0Y
5	PRESTO//2*TESMO_1/MUSX 603/4/ARDI_1/TOPO 1419//ERIZO_9/3/ SUSI_2/5/AR/SNP6//TARASCA 87_2/C,S10/3/POR-SAS_4-1/4/CHACAL_3-2 CTSS01Y00150S-4Y-010M-1Y-10M-0Y
6	AR/SNP6//TARASCA 87_3/C,S10/3/URON_5/TATU_1/4/BULL_10/ MANATI_1/3/ELK 54/BUF_2//NIMIR_3/5/DAHBI_6/3/ARDI_1/TOPO 1419//ERIZO_9 CTSS02B00002T-25Y-4M-4Y-1M-1Y-0M
7	CHEN/CENT.ELVON/7/LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/ BULL_10/MANATI_1/8/PRESTO//2*TESMO_1/MUSX 603/4/ARDI_1/TOPO 1419//ERIZO_9/3/SUSI_2 CTSS02B00073T-10Y-3M-3Y-2M-1Y-0M
8	CMH73A.497/3*MEXI75//CENT.BRAZIL/5/ERIZO_12/2*NIMIR_3/3/Z9/ZEBRA 31//ASAD/4/FOCA_2-1/6/PRESTO//2*TESMO_1/MUSX 603/4/ARDI_1/TOPO 1419//ERIZO_9/3/SUSI_2 CTSS02B00083T-2Y-4M-4Y-4M-1Y-0M
9	HUI/TUB//CENT.TURKEY/3/CAAL/7/LIRON_2/5/DIS B5/3/SPHD/PVN// YOGUI_6/4/KER_3/6/BULL_10/MANATI_1 CTSS02B00107T-19Y-1M-3Y-4M-1Y-0M
10	1715/CENT.DOUKALA/7/LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/ 4/KER_3/6/BULL_10/MANATI_1/8/FAHAD_8-2*2//PTR/PND-T/3/GAUR_3/ ANOAS_2//BANT_1/4/HARE_7265/YOGUI_1//BULL_2 CTSS02B00134T-20Y-5M-1Y-4M-2Y-0M
11	BW32-1/CENT.SARDEV/7/LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/ BULL_10/MANATI_1/8/MERINO/JLO//REH/3/HARE_267/4/ARDI_4/5/PTR/CSTO//BGLT/3/RHINO_4-1/4/HARE_7265/YOGUI_3/6/BULL_10/MANATI_1 CTSS02B00149T-28Y-1M-1Y-4M-1Y-0M
12	PAVON/CENT.SARDEV/6/CMH77A.1024/2*YOGUI_1//CIVET#2/3/JLO 97/CIVET/4/MANATI_1/5/ERIZO_11/YOGUI_3/7/PRESTO//2*TESMO_1/MUSX 603/4/ARDI_1/TOPO 1419//ERIZO_9/3/SUSI_2 CTSS02B00167T-8Y-6M-1Y-1M-2Y-0M
13	SN64/EER/3/ERIZO_15/FAHAD_3//POLLMER_2.1/5/PRESTO//2*TESMO_1/MUSX 603/4/ARDI_1/TOPO 1419//ERIZO_9/3/SUSI_2 CTSS02B00172T-21Y-1M-1Y-4M-1Y-0M
14	STAR/CENT.CHINA/5/ARDI_1/TOPO 1419//ERIZO_9/3/LIRON_1-1/4/FAHAD_4/FARAS_1/6/YOGUI_3/ERIZO_11//ONA_2/POSS_1-2 CTSS02B00178T-23Y-5M-3Y-1M-2Y-0M
15	TURACO/CENT.SARDEV/7/LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/ 4/KER_3/6/BULL_10/MANATI_1/8/LIRON_2/5/DIS B5/3/SPHD/PVN// YOGUI_6/4/KER_3/6/BULL_10/MANATI_1 CTSS02B00186T-8Y-3M-3Y-4M-1Y-0M
16	CMH82.1082/ZEBRA 31/7/LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/4/ KER_3/6/BULL_10/MANATI_1/8/LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/4/ KER_3/6/BULL_10/MANATI_1 CTSS02B00268T-53Y-5M-1Y-1M-2Y-0M
17	CAAL/3/T1494_WG//ERIZO_10/2*BULL_1-1 CTSS02B00380S-11Y-1M-4Y-2M-2Y-0M
18	LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/BULL_10/MANATI_1/7/ DAHBI_6/3/ARDI_1/TOPO 1419//ERIZO_9 CTSS02B00413S-22Y-2M-3Y-2M-1Y-0M
19	TICKIT/4/DAHBI_6/3/ARDI_1/TOPO 1419//ERIZO_9 CTSS03SH00006S-1Y-3M-2Y-4M-2Y-0M
20	HX87-244/HX87-255/5/PRESTO//2*TESMO_1/MUSX 603/4/ARDI_1/TOPO 1419//ERIZO_9/3/SUSI_2 CTSS03SH00028S-23Y-4M-3Y-2M-2Y-0M

Results. Although the overhead mist irrigation is important for obtaining infection by artificial inoculation, especially when seasons are dry and warm (Apodaca-Millán 1998), weather conditions play an important role in the outcome of the inoculation. During the last two weeks of January, 2008, the average temperature range was 10.4–18.6°C and 56.2–89.6% relative humidity (AGROSON 2009). In February, the average temperature range was 11.9–20.3°C and 54–76.3% relative humidity. In March, the average temperature range was 11.7–18.9°C and 47.5–70.4% relative humidity. During the first two weeks of April, the average temperature range was 17.7–21.8°C and 49.5–69.2% relative humidity. The wheat crop season was quite dry; the only rain was 6.2 mm on 24 January and 1 mm on 17 March. The range of infection for the first planting date was 0.00–1.69% with a mean of 0.25; 13 lines did not have any infected grain (Fig. 5). The range of infection for the second planting date was 0.00–7.95%, with a mean of 0.66; 15 lines did not have any infected grain. For the third planting date, the range of infection was 0.00–2.89 with a mean of 0.34; 16 lines did not show any infected grain. The difference between the mean percent infection of the first, second, and third planting dates and the mean of the three highest levels of infection of the suceptible check KBSUS 1 (95%) was 94.75, 94.34, and 94.66%, respectively. The frequency of lines in the different infection categories are shown in Fig. 6. In the overall results, nine lines did not show infected grain, eight fell within the 0.1–2.5 infection category, two were in the 2.6–5.0 category, and one was in the 5.1–10 infection category (Table 10). Lines with less than 5% infection are considered resistant (Fuentes-Dávila and Rajaram 1994). Salazar et al. (1990) reported that pubescence in glumes of some wheats conferred a mechanical barrier to penetration by the fungus, which also may operate in triticale. Rye may be a source of morphological resistance for triticale to this disease (Warhan 1988). These results indicate that although the high level of resistance to Karnal bunt in triticale has been maintained in the new, elite germ plasm coming out of the CIMMYT program, collaborative efforts between INIFAP and CIMMYT must continue in order to detect lines that

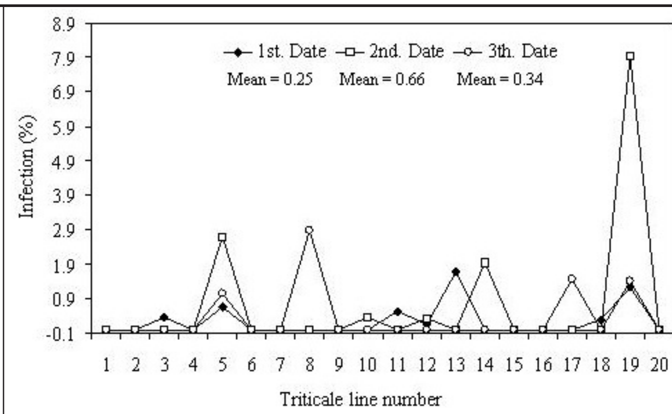

Fig. 5. Percentage of infection with Karnal bunt (*Tilletia indica*) of 20 elite triticale (*XTriticosecale*) advanced lines artificially inoculated in the field during the 2007–08 crop season on three dates in the Yaqui Valley, Sonora, Mexico.

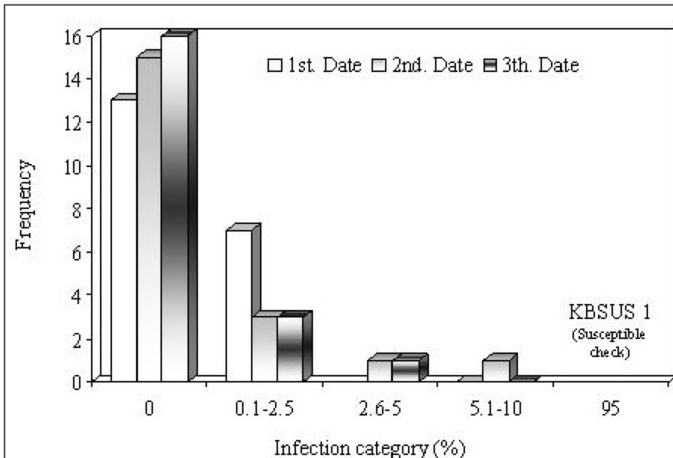

Fig. 6. Results of artificial field inoculation on three dates with Karnal bunt (*Tilletia indica*) of 20 elite triticale (*XTriticosecale*) advanced lines in the Yaqui Valley, Sonora, Mexico, during the 2007–08 crop season. The level of infection of KBSUS 1 is the mean of the three highest infection scores.

Table 10. Elite triticale advanced lines artificially inoculated with Karnal bunt (*Tilletia indica*) in three planting dates during the crop season 2007–08 in the Yaqui valley, Sonora, Mexico, which showed infection levels greater than 2.5%.

Line	Pedigree and selection history
	Infection level 2.6–5.0%
5	PRESTO//2*TESMO_1/MUSX 603/4/ARDI_1/TOPO 1419//ERIZO_9/3/ SUSI_2/5/AR/SNP6//TARASCA 87_2/C,S10/3/ PORSAS_4-1/4/CHACAL_3-2 CTSS01Y00150S-4Y-010M-1Y-10M-0Y
8	CMH73A.497/3*MEXI75//CENT.BRAZIL/5/ERIZO_12/2*NIMIR_3/3/Z9/ZEBRA 31//ASAD/4/FOCA_2-1/6/ PRESTO//2*TESMO_1/MUSX 603/4/ARDI_1/TOPO 1419//ERIZO_9/3/SUSI_2 CTSS02B00083T-2Y-4M-4Y-4M-1Y-0M
	Infection level 5.1–10.0%
19	TICKIT/4/DAHBI_6/3/ARDI_1/TOPO 1419//ERIZO_9 CTSS03SH00006S-1Y-3M-2Y-4M-2Y-0M

might be susceptible to Karnal bunt in order to ensure adequate levels of resistance in materials released for commercial cultivation in Mexico and elsewhere.

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Agronomic characteristics of four commercial bread wheat cultivars and six advanced lines in trials carried out in the Yaqui valley, Sonora, Mexico.

Pedro Figueroa-López, Víctor Valenzuela-Herrera, and Guillermo Fuentes-Dávila.

Introduction. In northwest Mexico, wheat is the crop that occupies most of the cultivated area. In southern Sonora alone, it covers more than 300,000 ha. Durum wheat is cultivated in 74% of the area, whereas 80,247 ha are used for bread wheat. The average yield in the 2007–08 crop season was 6.18 ton/ha with a total production of 1.8 x 10^6 ton. Bread wheat production in the region since the late 1900s has been reduced drastically, because it is not competitive nationally and the production costs. These two factors are strongly affected by the national production system, which involves methods of irrigation, pest and disease control, fertilization, and high cost of fuel, among other factors. The collaborative wheat program between the National Institute for Forestry, Agriculture and Livestock Research in Mexico (INIFAP) and the International Maize and Wheat Improvement Center (CIMMYT) has generated cultivars and elite lines of bread wheat with good yield potential and other outstanding characteristics that make this species a competitive crop in northwest Mexico. Our objective was to compare four commercial bread wheat cultivars and six elite advanced lines in yields trials in different planting dates.

Establishment of the trial. The study was carried out at the Experimental Station in the Yaqui valley, which belongs to the Northwest Regional Research Center of INIFAP, during the autumn–winter crop seasons of 2006–07 and 2007–08. The nursery consisted of 10 bread wheat genotypes, including four commercial cultivars released by INIFAP and six elite advanced lines from the wheat-breeding programs of CIMMYT. Planting dates were 15 and 30 November, 17 December, and 2 January, using 100 kg of seed/ha in beds 4 x 0.80 m with two rows. The experimental design was a factorial with completely randomized blocks and three replications. Fertilization consisted of 300 kg of urea/ha before sowing and 100 kg of urea/ha and 130 kg/ha of monoamonic phosphate during the first irrigation. Thirty-five days after sowing, the herbicide Situi xl was applied at the rate of 25 g of commercial product/ha. The trial was provided with a total of four furrow irrigations.

Results. The analysis of variance showed significant differences in yield of genotypes at the different planting dates. The cultivar Navojoa M-2007 showed the highest average yield during both crop seasons. All genotypes had a height smaller than 105 cm with the exception of cultivar Tacupeto F-2001, which is preferred by the wheat growers in northwest Mexico. Grain yield, plant height, and days to physiological maturity are presented in Table 11.

Table 11. Agronomic characteristics of the four commercial bread wheat cultivars and six advanced lines in trials carried out in the Yaqui Valley, Sonora, Mexico, during the crop seasons 2006–07 and 2007–08.

Cultivar or line [and selection history]	Grain yield (kg/ha)	Days-to-physiological maturity	Plant height (cm)
Tacupeto F-2001	6,585 b	116	105
Kronstad F-2004	6,325 c	116	103
Roelfs F-2007	6,490 bc	114	104
Navojoa M-2007	7,027 a	115	104
Toba97/Pastor [CMSS97M05756S-040M-020Y-030M-015Y-3M-1Y-3M-0Y]	6,265 bcd	116	103
Chen/*Ae. tauschii*//2*Opata/3/Babax/4/Jaru [CMSS99Y03521T-040M-040Y-040M-040SY-040M-5Y-010M]	5,950 e	118	104
Sunco/2*Pastor [CMSS99Y05530T-10M-040Y-040M-040SY-040M-14Y-010M]	6,446 bcd	114	99
Pfau/Weaver//Kiritati [CGSS01Y00155S-099Y-099M-099M-50Y-0B]	6,263 bcd	114	99
D67.2/P66.270//*Ae. tauschii* (320)/3/CUNNINGHAM [CMSS99M02230S-040M-040SY-6M-3Y-0M-10Y]	6,233 bcd	115	104
Wbll1*2/Brambling [CGSS01B00062T-099Y-099M-099M-099Y-099M-60Y-0B]	6,279 bcd	108	102
LSD (0.05) = 220			

The lines and cultivars evaluated in this trial stand out for their yield stability under constrasting crop conditions, which could be observed at all four planting dates, where the most recently released cultivar Navojoa M-2007 showed an interesting response under restricted irrigation, maintaining its yield superiority. The production of better bread wheat cultivars will bring about greater interest in their cultivation by farmers in southern Sonora. Therefore, in addition to yield trials, other studies on industrial quality and resistance to diseases have been conducted. Navojoa M-2007 and other outstanding lines showed resistance to yellow rust, a disease that has become more relevant in this part of Mexico during the last three years. Disease resistance to the most important diseases is an important aspect that will help to promote a mosaic of cultivars in southern Sonora.

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Reaction of elite bread wheat lines and cultivars to Karnal bunt artificially inoculated during the 2007–08 crop season in the Yaqui Valley, Sonora, Mexico.

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Introduction. The most susceptible plant species to Karnal bunt is *T. aestivum*. Under artificial inoculation, some lines may show more than 50% infeted grain (Fuentes-Dávila et al. 1992; 1993). The causal agent of this disease is the fungus *Tilletia indica* (Mitra 1931; syn. *Neovossia indica*). Although *T. indica* may affect durum wheat (*T. turgidum* subsp. *durum*) and triticale (X*Triticosecale*; Agarwal et al. 1977), the level of infected grain generally is very low. Control of this pathogen is difficult because teliospores are resistant to physical and chemical factors (Krishna and Singh 1982; Zhang et al. 1984; Smilanick et al. 1988). Chemical control can be accomplished by applying fungicides during flowering (Fuentes-Dávila et al. 2005); however, this measure is not feasible when quarantines do not allow tolerance levels for seed production. Resistant wheat cultivars are the best mean to control this disease. The objective of this work was to evaluate 18 elite advanced bread wheat lines and two commercial cultivars for resistance to Karnal bunt.

Materials and methods. Eighteen elite, advanced bread wheats and the cultivars Tacupeto F2001 and Kronstad F2004 were evaluated for Karnal bunt resistance during the autumn-winter in 2007–08 crop season in block 710 in a clay soil (pH 7.8), in the Yaqui Valley, Sonora, Mexico (Table 12). Planting dates were 8 and 21 November and 10 December,

Table 12. Elite bread wheat lines and commercial cultivars artificially inoculated with karnal bunt (*Tilletia indica*) in the field in three planting dates, during the crop season fall-winter 2007-2008, in the Yaqui valley, Sonora, Mexico.

Entry	Pedigree	Selection history
1	TACUPETO F2001	CGSS95B00016F-099Y-099B-099Y-099B-15Y-0B
2	KRONSTAD F2004	CMSS92Y01425T-16Y-010M-010Y-010Y-1M-0Y-50EY-0Y
3	KAMB1*2/KUKUNA	CGSS00B00169T-099TOPY-099M-099Y-099M-9CEL-0B
4	ATTILA/PASTOR	CMSS97Y04045S-040Y-050M-040SY-030M-14SY-010M-0Y
5	TOBA97/PASTOR	CMSS97M05756S-040M-020Y-030M-015Y-3M-1Y-3M-0Y
6	CHEN/AE.SQ//2*OPATA/3/BABAX/4/JARU	CMSS99Y03521T-040M-040Y-040M-040SY-040M-5Y-010M
7	SUNCO/2*PASTOR	CMSS99Y05530T-10M-040Y-040M-040SY-040M-14Y-010M
8	PFAU/WEAVER//KIRITATI	CGSS01Y00155S-099Y-099M-099M-50Y-0B
9	D67.2/P66.270//*Ae. tauschii* (320)/3/CUNNINGHAM	CMSS99M02230S-040M-040SY-6M-3Y-0M-10Y
10	WBLL1*2/BRAMBLING	CGSS01B00062T-099Y-099M-099M-099Y-099M-60Y-0B
11	WBLL1*2/BRAMBLING	CGSS01B00062T-099Y-099M-099M-099Y-099M-12Y-0B
12	WBLL1*2/BRAMBLING	CGSS01B00062T-099Y-099M-099M-099Y-099M-73Y-0B
13	KAMB1*2/KIRITATI	CGSS01B00070T-099Y-099M-099M-099Y-099M-23Y-0B
14	KIRITATI/WBLL1	CGSS02Y00138S-099M-099Y-099M-12Y-0B
15	THELIN/2*WBLL1	CGSS02Y00079T-099B-099B-099Y-099M-6Y-0B
16	KAMB1*2/BRAMBLING	CGSS01B00069T-099Y-099M-099M-099Y-099M-20Y-0B
17	TOB/ERA//TOB/CNO67/3/PLO/4/VEE#5/5/KAUZ/6/FRET2	CMSA00Y00582S-0P0Y-040M-040SY-030M-1ZLM-0ZTY
18	PASTOR/WBLL1	CMSA00Y00587S-0P0Y-040M-040SY-030M-26ZLM-0ZTY
19	T.DICOCCON PI225332/*Ae. tauschii* (895)//WBLL1/3/2*WBLL1	CMSA01M00336T-040Y-14M-010Y-6ZLM
20	BETTY/3/CHEN/*Ae. tauschii*//2*OPATA	CMSW00WM00150S-040M-040Y-030M-030ZLM-3ZTY-0M

2007, using a 1-m bed with two rows. Inoculations were carried out by injecting 1 mL of an allantoid sporidial suspension (10,000/mL) (Fig. 7) during the boot stage (Fig. 8) in ten heads from each line and cultivar. An overhead, mist-irrigation system was used to provide high relative humidity in the experimental area. Harvest was done manually, and the counting of healthy and infected grains was done visually to determine the percentage of infection. Evaluated lines originated from the collaborative project between the International Maize and Wheat Improvement Center (CIMMYT) and the National Institute for Forestry, Agriculture and Livestock Research in Mexico (INIFAP).

Fig. 7. Allantoid secondary sporidia of *Tilletia indica*.

Fig. 8. Artificial inoculation by boot injection.

Results and discussion. The range of infection for the first planting date was 0.00–22.42%, with a mean of 6.70; three lines did not have any infected grains (Fig. 9). The range of infection for the second planting date was 1.71–20.16%, with a mean of 8.48. For the third planting date, the range of infection was 0.62–11.35 with a mean of 5.31. Figure 10 shows the frequency of lines in the different infection categories in the three dates. The suceptible check KBSUS 1 had 95% infection. In the overall results, five lines fell within the 2.6–5.0 infection category, three in the 5.1–10.0 category, and twelve in the 10.1–30 infection category (Fig. 11, p. 144). Lines with less than 5% infection are considered resistant (Fuentes-Dávila and Rajaram 1994).

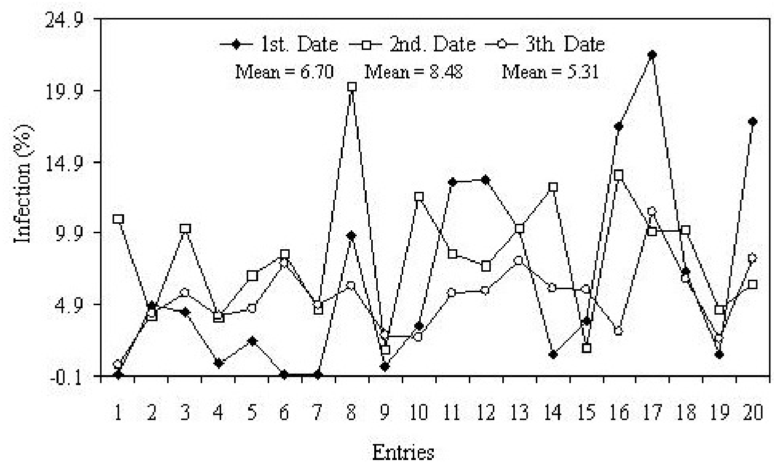

Fig. 9. Percent infection with Karnal bunt (*Tilletia indica*) of 18 elite, advanced bread wheat lines and two cultivars artificially inoculated in the field on three dates with in the Yaqui Valley, Sonora, Mexico, during the 2007–08 crop season.

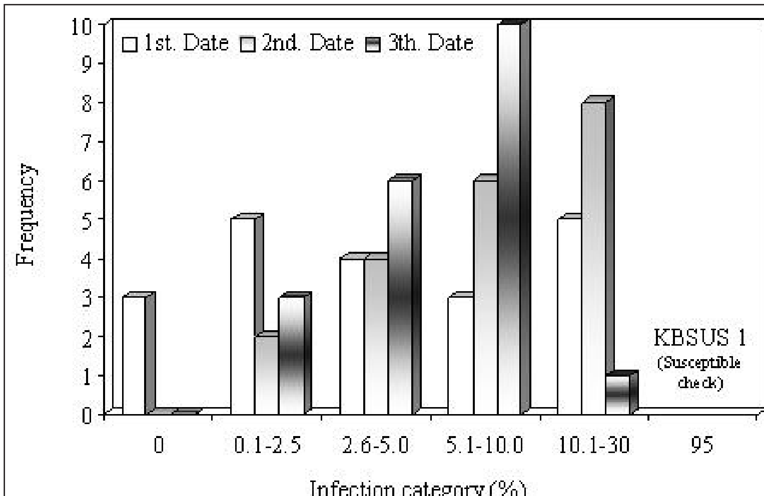

Fig. 10. Results of artificial field inoculation with Karnal bunt (*Tilletia indica*) on three dates of 18 elite, advanced bread wheat lines and two cultivars in the Yaqui Valley, Sonora, Mexico, during the 2007–08 crop season. The level of infection of KBSUS 1 is the mean of the three highest infection scores

Sixty percent of the entries were moderatly susceptible to susceptible, including cultivar Tacupeto F2001 and the line KAMB1*2/KUKUNA. Tacupeto did not show greater infection levels than 10.89% probably due to escape, because it did not have infected grains at the first planting date and 0.62% infection at the third date. This cultivar is one of the two leading bread wheats in southern Sonora because of preference by the milling industry. Susceptibility to Karnal bunt and to stripe rust, however, makes it necessary to apply fungicides; therefore, it is important to look for other cultivars that have been released by INIFAP. Kronstad F2004 and four lines (ATTILA/PASTOR, SUNCO/2*PASTOR, D67.2/P66.270//*Ae. tauschii* (320)/3/CUNNINGHAM, and T.DICOCCON PI225332/*Ae. tauschii* (895)//WBLL1/3/2*WBLL1) showed infection levels between 2.6 to 5.0%, so they are considered resistant and good prospects for commercial release.

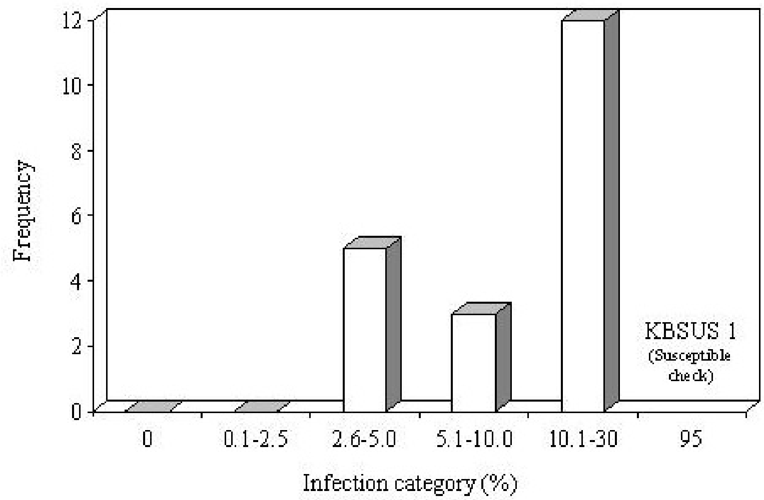

Fig. 11. Overall rating of 18 elite advanced bread wheat lines and two cultivars artificially inoculated in the fiels on three dates with Karnal bunt (Tilletia indica) in the Yaqui Valley, Sonora, Mexico, during the 2007–08 crop season. The level of infection of KBSUS 1 is the mean of the three highest infections scores

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Use of climatology for temperature risk analysis for cultivation of wheat and other agricultural crops in Southern Sonora, Mexico.

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Introduction. The concept of climatic change has become relevant recently and can defined as the deviation of the average expected meteorological time for a given location and during a specific period of time of the year (IPCC 2001). Although there have always been changes and cycles of climatic stability as part of the natural rearrangements on the earth, the climatic system of the planet has changed in an important fashion during the last few years, which with no doubt has been caused by industrial activities, forestry, agriculture, and livestock. Gases that cause the greenhouse effect play an important role in the natural warming, an estimated significant temperature increment (0.6 ± 0.2ºC), of the earth during the twentieth century (IPCC 2001). In Mexico, livestock and agriculture are the sectors with greater contribution (50%) of methane emissions, therefore, this sector is taking into consideration the climatic change as a component of development, eliminating risky practices for the environment within the corresponding production system (INE and SEMARNAP 1999).

Every year, variations in yield recorded in agricultural production systems are induced by diseases, pests, weeds, technological management (irrigation or sowing method), soil type, fertilization, cultivar, an others not less important such as climate, which has great influence on agricultural activities. The state of Sonora is located in a region of the country where anomalies in climatic behavior have been detected in previous years, mainly in rainfall and temperature (Jáuregui 2004). The availability and transfer of climatic analyses is important for the study of environmental phenomena, which are in continuous evolution on the planet, therefore, it is reasonable to widen and strategically systematize the climatic information of the national network. This information will be important for adjusting or establishing new management strategies for forestry, agriculture, and livestock production systems in the near future.

Progress in adaptation to new climatic conditions or to a posible climatic change in the most important agricultural regions of Mexico, will be a function of the technology available, institutional agreements, financing, and education of the population (Chapela 2004). The Yaqui and Mayo Walleys, located in southern Sonora, are an important agricultural region, therefore, studying the climate to understand its impact in this sector, which will allow us to develop an efficient production system, is necessary.

Climate and the agricultural activities; critical temperatures for plants: thermal threshold (TT). In the agricultural sector, temperature influences the development of some crops and affects their yield (Vargas et al. 2001). Besides water, temperature is the bioclimatic element that promotes or limits the increase of the vegetative plant biomass. The optimum temperature limits for plant growth is a topic that regained importance in the 1970s. Because there are temperature limits or thermic thresholds (Fig. 12) in each specific crop, temperature could be optimum, or in an extreme case, as vital as the maximum and minimum temperature, where both thermic conditions could lead the plant to a resting or latent stage, including death depending if they are winter crops or the summer exceeds their TT (Table 13). Similarly, when temperature exceeds the bearable TT in some crops, damage could be gradual in relation to exposure time as the lethal limits approach. However, deterioration magnifies as the thermic oscillation (TO) becomes greater during the day or night (Gastiazoro 2003; Muñoz 2003). Most plant species have a maximum pollen viability between 18 and 20ºC (Escaich et al. 1997). Castilla (1992) reported that temperatures below 10–12°C for several days affect the productivity of vegetable crops; similarly, summer crops are affected when temperatures are greater than 30°C. The plant requires thermal continuity for optimal development, that is, heat accumulation (thermal hours) or cold (cold hours) in the case of summer crops (cotton, vegetables) or winter crops (wheat, oat, maize) respectively, which determine germination, growth, flowering, reproduction, and fruit development.

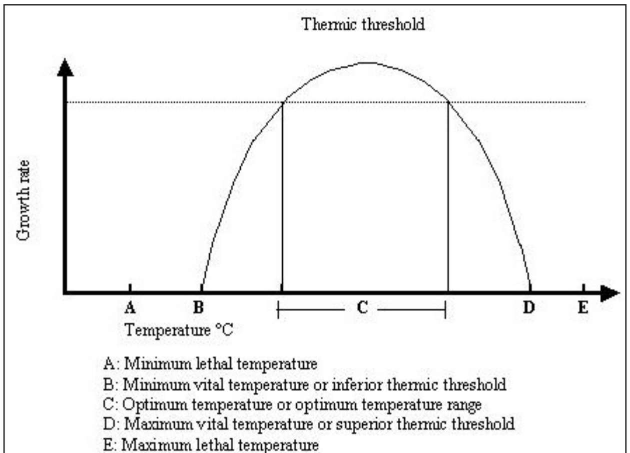

Fig. 12. Graphic representation of the location of the plant thermal limits.

Table 13. Optimum thermal (°C) requirements for different crops in southern Sonora, Mexico.

Crop	Biological minimum	Optimum day	Optimum night	Optimum RH (%)	Source
Wheat	2–6	15–20	16–18	60–70	Del Pozo et al. 1987
Tomato	10–12	21–24	15–20	50–60	Benacchio 1982
Pepper	10–12	20–28	16–20	50–70	Muñoz 2003
Cucumber	12–14	17–22	18–21	70–90	Castilla 1992
Melon	12–14	24–30	18–21	70–90	Nisen 1990
Watermelon	10–13	24–30	20–25	85–90	De la Torre 1999
Cauliflower	3–5	17–20	12–15	65–70	Nisen et al. 1990
Asparagus	6–8	20–25	18–25	60	Yuste 1997

Furthering our knowledge about climate has allowed for many applications in agriculture, where a relationship between climate and yield has been found. A good example is the yield predictive model in crops based on climatic analysis and field data. These models might help to make decisions on agrifoodstuff activity and commercialization stronger in the short to medium term. However, the use of climate data as substitute for other field data might provide a reliable forecast for wheat yield (Banayan et al. 2003), as well as for maturity of cotton (Ryan et al. 2005). At the same time, climate influences population dynamics of pests such as white fly (*Trialeurodes vaporariorum*), because temperature affects duration of the immature stages and the flying capacity of adults (Liu et al. 1994), causing fast development of pests at 10–30ºC. Sánchez et al. (2002) found that an accumulation of 35ºC/day is necessary for the appearance of immature stages of the pest and indicated that starting from this threshold, the white fly population tripled for each grade of increase.

Materials and methods. The climatic data analyzed corresponded to the period January 2002 to December 2006 collected from 35 weather stations located in southern Sonora, which comprises the irrigation districts of the Yaqui and Mayo Valleys. Eight stations belong to the National Water Commission (CNA, 2007). Data from 19 of the other 27 stations is updated constantly and available on the internet: (http://clima.inifap.gob.mx, http://www.agroson.org.mx; In Spanish).

Based on data from several researchers (Table 13, p. 145), we analyzed the thermal thresholds (TT). The number of days with maximum and minimum daily temperature (MXT and MIT) were taken into consideration in order to determine the frequency of days with temperature equal or below 12ºC (Fx12) and a temperature equal or greater than 30ºC (Fx30). Thermal oscillation (TO) during the day and night was analyzed from each month of the year. The difference between the average MXT and the maximum MXT recorded in a given month was used to determine the superior TO (STO). Similarly, the inferior thermal oscillation (ITO) was calculated by the difference between the average MIT and the minimum value of MIT recorded in a given month (Table 14). The digital outline of Fx12 and Fx30 of each weather station were captured and interpolated in an ArcView platform in order to analyze its annual shift (Figs. 13 and 14, p. 147). The same maps were used to locate areas thermically homogeneous since they show the average temperature during the winter and summer (Fig. 15, p. 147).

Table 14. Thermal oscilation in the agricultural area of Southern Sonora (MXT, maximum daily temperature; MIT, minimum daily temperature; MXTO, maximum thermal oscillation; MITO, minimum thermal oscillation). Daily average temperature (ºC) from 2002 to 2006.

Month	Yaqui Valley				Mayo Valley			
	MXT mean	MXTO (°C)	MITO mean	MITO (°C)	MXT mean	MXTO (°C)	MITO mean	MITO (°C)
January	25	+6	7	–5	24	+5	8	–5
February	26	+6	8	–5	25	+5	8	–5
March	28	+7	8	–4	27	+6	8	–4
April	31	+6	11	–4	30	+5	11	–5
May	35	+5	14	–5	34	+4	14	–5
June	37	+4	21	–6	36	+4	20	–6
July	37	+5	24	–4	37	+6	25	–3
August	38	+5	25	–3	37	+3	25	–3
September	37	+7	24	–5	36	+6	24	–4
October	34	+7	18	–6	34	+6	18	–6
November	30	+7	12	–6	30	+7	12	–6
December	26	+6	7	–5	25	+6	7	–6

Results and discussion. The maximum average temperature indicates that the agricultural area of the Yaqui valley is 1ºC warmer from December to September with respect to the agricultural area of the Mayo valley (Table 14). On the other hand, the minimum temperature is similar with the exception of the month of January, where there is a differential of 1ºC less in the Yaqui Valley. The maximum temperature registered during the day within an urban area is 1–3ºC greater with respect to an agricultural valley and minimum temperatures are 2–3ºC greater. This temperature differential makes the urban area a true heat center with respect to the agricultural area. In relation to MXT (Table 14), we observed that in the Yaqui Valley, MXTO can reach 30ºC in the cold months (December to February), whereas the MITO may reach 2ºC in the Yaqui Valley and 3ºC in the Mayo Valley. Because Table 13 (p. 145) and Table 14 are related, you can observe that the TO that occurs in the agricultural area of the Yaqui Valley exceeds the minimum temperature limits and the biological maximum that these species require for optimum growth, especially for cucumber and melon. Muñoz (2003) mentioned that when the maximum day temperature greatly differs from the minimum night temperature imbalances in growth are

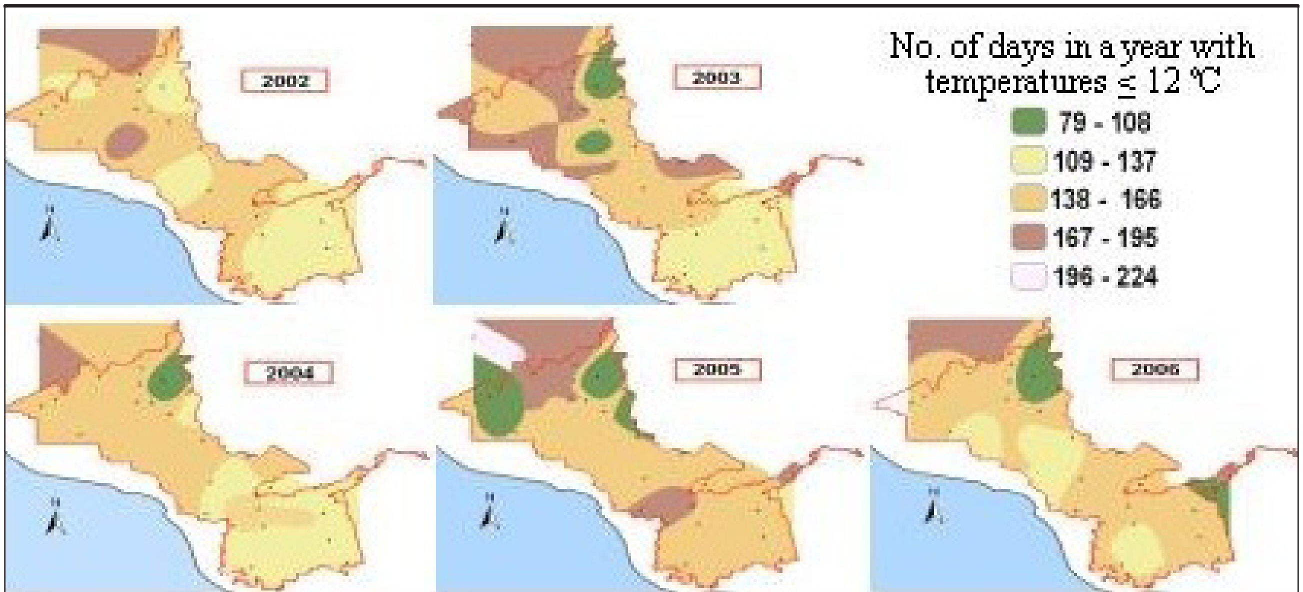

Fig. 13. Spatial shift of the inferior thermal threshold in the agricultural area of southern Sonora during 2002–06.

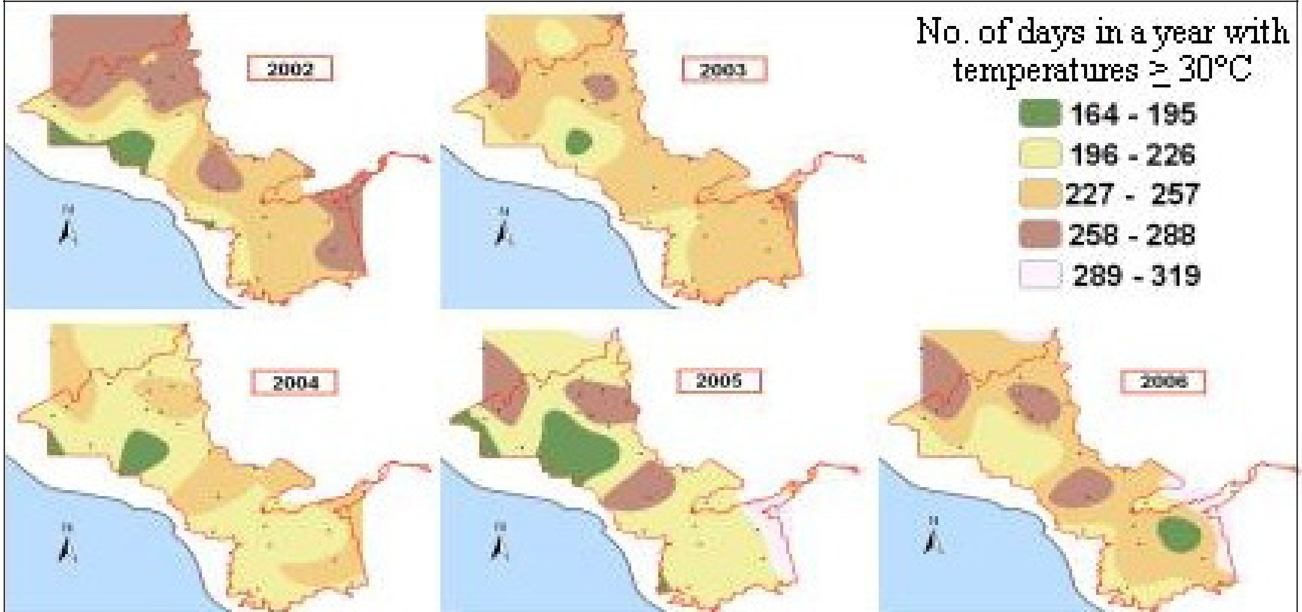

Fig. 14. Spatial shift of the superior thermal threshold in the agricultural area of southern Sonora during 2002–06.

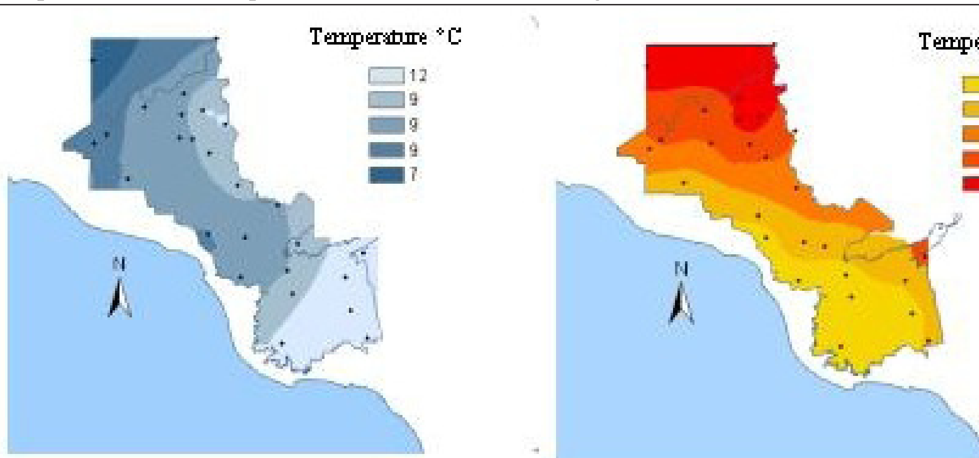

Fig. 15. Behavior of the minimum and maximum daily temperatures in southern Sonora based on the homogeneous characterization of temperature.

caused. A large part of the explanation regarding yield variation in the region is due to the fact that crops established during the autumn and winter get a heat stress produced by the high frequency of days with thermal oscillation that exceed the tolerable limits and cause cummulative damage.

The inferior thermic threshold (ITT) during December to March (Fig. 13, p. 147) was 21.6% (79 d) with respect to the year and 53.4% (195 d) in the Fx12 depending on the zone and year, showing a greater occurrence in year 2003 (three regions) and 2005 (two regions). These zones are the most at risk for frosts, with a tendency to show a Fx12 with a slightly less ocurrence (109–137) mainly in the northern part of the Yaqui Valley. The occurrence of a superior thermic threshold (STT) (Fig. 14, p. 147) in southern Sonora covered most of the agricultural area during 2002 in the Yaqui Valley even when an Fx30 occurred with greater frequency the same year in an area of the Mayo Valley.

Fx12 and Fx30 occur annually with shifts of different magnitude in the entire agricultural area, occurring more frequently in the northern parts. In contrast, these variables show a lesser tendency to occur both toward the southern zone. For the central part of the territory, both thresholds occur with a frequency of days between 109 to 166 for Fx12 and days 196 to 257 for Fx30. Years 2005 and 2006 registered an increment of Fx12 towards the southern part of the agricultural area and Fx30 towards the southwest. In both years, three areas with 258–288 days with Fx30 were observed. Finally, in the south of the agricultural area, which mainly comprises the Mayo Valley, indicates a moderate frequency of Fx30 for 2006 (Fig. 15, p. 147). The threshold temperature analyzed through spatial distribution and sketched by year (Figs. 14 and 15, p. 147) indicates that ITT and STT vary in distribution every year following the annual shift of precipitation influenced by the presence of climatologic phenomena and the dominant crop cover, showing some uncertainty in its distribution in each sowing cycle. The map sequence in Fig. 14 (p. 147) shows that the northern part of the agricultural area registers the highest frequencies of Fx12, which means that these are the areas where crops receive a frequency between 47–54% days of the year with greater stress from minimum temperatures. These show potential for a good accumulation of cold hours for autumn–winter seasons (wheat and maize), whereas those zones that tend to be warmer are risky because the superior thermal oscillation may limit good development of some cereals, mainly at the end of physiological maturity (from flowering to grain filling), which compromises yield in relation to climatic variation during the season.

For temperature homogenization or isothermal (Fig. 15, p. 147), the northwest zone shows characteristics of low temperature (7ºC) during the winter months, however, the central zone shows temperaturas of 9ºC to the southeast where the average IMT is 12ºC (Fig. 15, p. 147) and the average MXT might be from 34–37ºC. The northeast zone of the cuadricula of the valley appears to be the warmest, has the most thernal extremes, and shows the lowest IMT average. The analysis by season shows that its thermal properties are related with specific factors that annually make these zones cold, hot, moderate, or extreme. They are areas closer to the ocean, whereas both Buayseacobe and Tesia have the close presence of the typical shrub plant cover, climatologically characterizing this agricultural portion. This analysis does not takesrelative humidity into consideration. However, relative humidity is an important climatic variable in the equation used to estimate the temperature–humidity index (THI), which complements the humidity effect upon temperature severity. A new index recently is being developed that will include solar radiation and wind speed in addition to ambient temperature and relative humidity.

Conclusions. The annual and monthly temperature variation analyzed, points out to the northern and central regions in the agricultural area of the Yaqui valley, as the zone with the highest risk for production. The highest frequency of damaging thermic thresholds are registered in this area during the winter and summer months, although their effect occurs with different magnitude every year; it is noticeable only when damage by frost or heat occur in autumn and winter crops.

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ITEMS FROM PAKISTAN

NATIONAL AGRICULTURAL RESEARCH CENTER (NARC), ISLAMABAD
Wheat Wide Crosses, NARC, Islamabad, Pakistan.

The development of a wide-cross program in wheat in Pakistan.

A. Mujeeb-Kazi, Alvina G. Kazi, and Iqbal Ayub Khan.

The unequivocal status of wheat importance as a food cereal is paramount and the need to be on secure production grounds a national priority. A national coördination program exists that has alliances with all professionals involved in wheat improvement across the country with international linkages. However, the changing international scenarios