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Editors:
Mohamed Mergoum
Associate Professor
North Dakota State University
Fargo, North Dakota, United States of America

and

Helena Gómez-Macpherson
Research Scientist
Instituto de Agricultura Sostenible
Cordoba, Spain

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Triticale in Spain

C. Royo, D. Villegas, L.F. García del Moral

The area devoted to triticale in Spain increased sharply between 1986 and 1989 when it reached 75 500 ha (Figure 1). From 1989 onwards, triticale cultivation declined due to its replacement by other subsidized field crops, mainly durum wheat. At present, triticale covers about 32 000 ha with a total production of 75 000 tonnes, averaging 2.3 tonnes/ha (Figure 2). The export market is minor, while within the country the average price received by farmers for this grain has decreased 16 percent since 1995 to 130 •/tonne in 2000 (Figure 3).

TRITICALE CULTIVATION

In Spain, triticale is generally cultivated under rainfed conditions, mostly in the southern regions of the country: Andalusia (which accounts for about 65 percent of the area) and Extremadura (with about 20 percent). These regions have a Mediterranean climate, with an average annual precipitation of about 450 mm, usually distributed evenly throughout the growing season. Terminal drought stress is the main abiotic constraint to the crop. However, minor cultivation areas are scattered in central-eastern regions (Castilla-La Mancha, 11 percent), the Balearic Islands (3 percent) and northeastern zones (Catalonia, 1 percent). The central and northern regions have a more continental climate, with lower temperatures during winter and spring and very high temperatures and water stress during grainfilling. Rainfall is lower (200 to 300 mm) and less evenly distributed. Hail damage (Plate 1) may occur occasionally. In the wet northern region, grain damage due to sprouting (Plate 2) may occur. Biotic stresses have not limited the cultivation of triticale in the past. However, some varieties have recently become susceptible to foliar diseases, especially leaf rust.

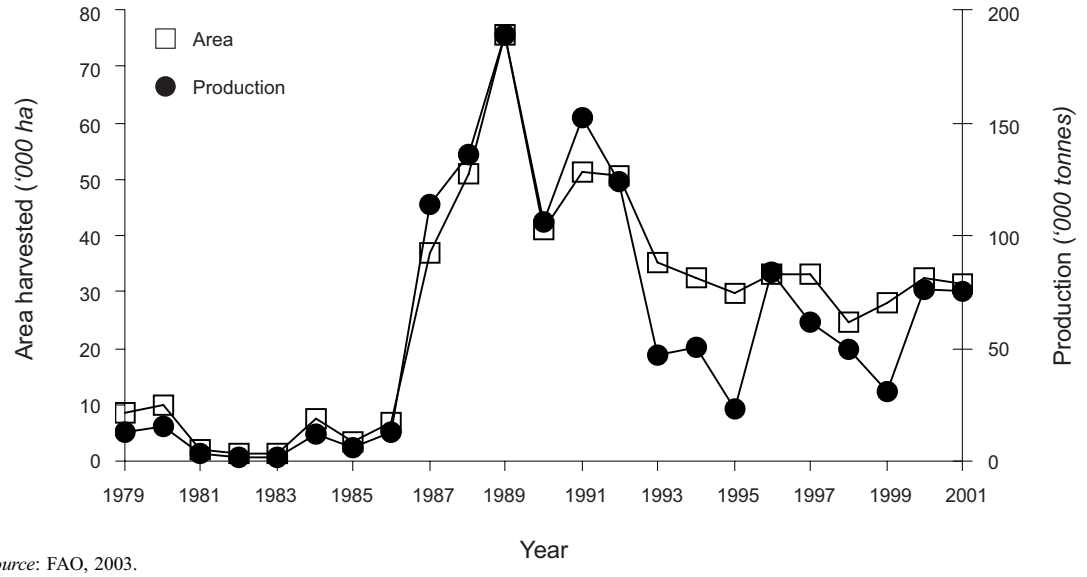
Most of the triticale varieties cultivated in Spain are spring types that admit an alternative sowing, even during autumn. Planting is generally carried out in November. Earlier sowings are not recommended in cool areas to avoid frost damage (Plate 3) to the crop during spring or aphid infestations during autumn (Royo, 1992). The impact of a delayed sowing date and drought on grain growth and morphometry has recently been investigated (Royo *et al.*, 2000). Recommended sowing densities range between 200 and 250 kg/ha. One of the advantages of triticale compared with barley or wheat is its early vigour, which enables a fast crop growth during the first stages of development and a rapid cover of the soil by the crop canopy. Moreover, during its vegetative growth, triticale is much less attractive to rabbits and other rodents than other small-grain cereals.

END-USES

Triticale was first introduced in Spain as a grain crop. Under the Mediterranean conditions of Spain, triticale grain can provide between 300 kg/ha of crude protein under rainfed conditions to almost 900 kg/ha under irrigation, with a content in essential amino acids (g aa/100 g protein) ranging between: 1.98 and 2.29 for lysine; 0.94 and 2.04 for methionine; 3.02 and 3.44 for phenylalanine; 4.25 and 4.52 for threonine; and 4.83 and 4.98 for leucine (García del Moral *et al.*, 1995; Fernandez-Figares *et al.*, 2000). Although most of the triticale fields have this end-use, farmers familiar with the crop are increasingly focussing on alternative and specific uses. On the other hand, marketing problems are frequent for the growers when trying to sell their triticale grain, and often when they find a purchaser, the prices received are lower than for bread wheat, but similar to those for barley or rye for feed.

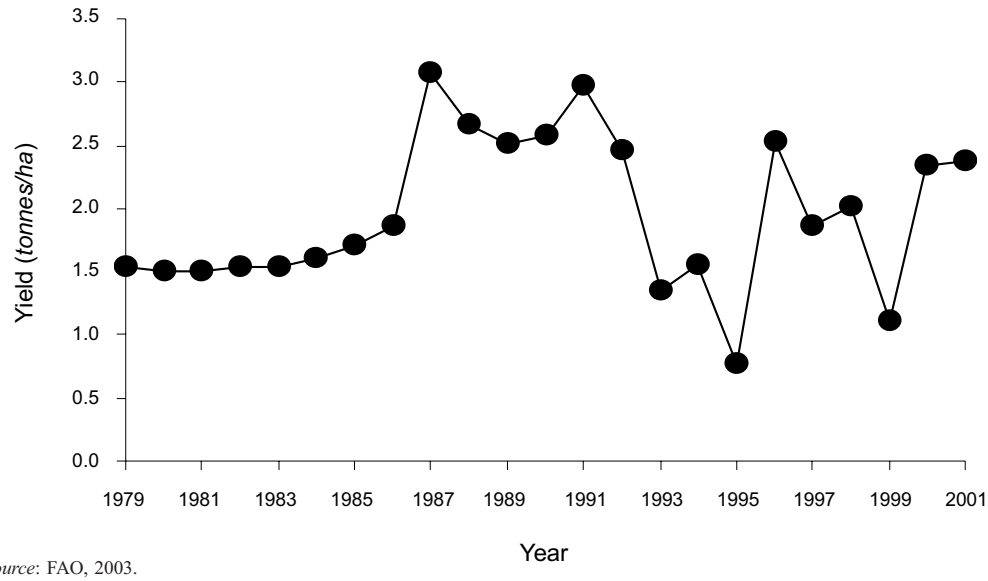
In some meadows of Extremadura and Andalusia, triticale is grown as an intercrop in ilex fields, for pig or sheep grazing, providing green forage or mature spikes. Conversely, in the cereal-producing areas of northeastern Spain, with an average rainfall during the crop season (from November to July) of 500 mm and where sheep and dairy cattle are common, triticale is grown on about 1 500 ha for silage (Plate 4) in rotation with maize. Harvesting takes place about ten days after flowering in order to have enough forage production with acceptable quality (Royo *et al.*, 1998) and to avoid significant yield reductions from delayed sowing of maize, the main crop of the rotation. This practice allows farmers to grow two crops per year. The average composition from 17 analyses of silages from different farms showed 28.8 percent dry matter, 9.4 percent crude protein, 32.6 percent crude fibre, 29.4 percent acid detergent fibre, 58.2 percent neutral detergent fibre and 6.2 percent lignin (Royo and Serra,

FIGURE 1
Evolution of the area devoted to triticale and total production in Spain, 1979-2001



Source: FAO, 2003.

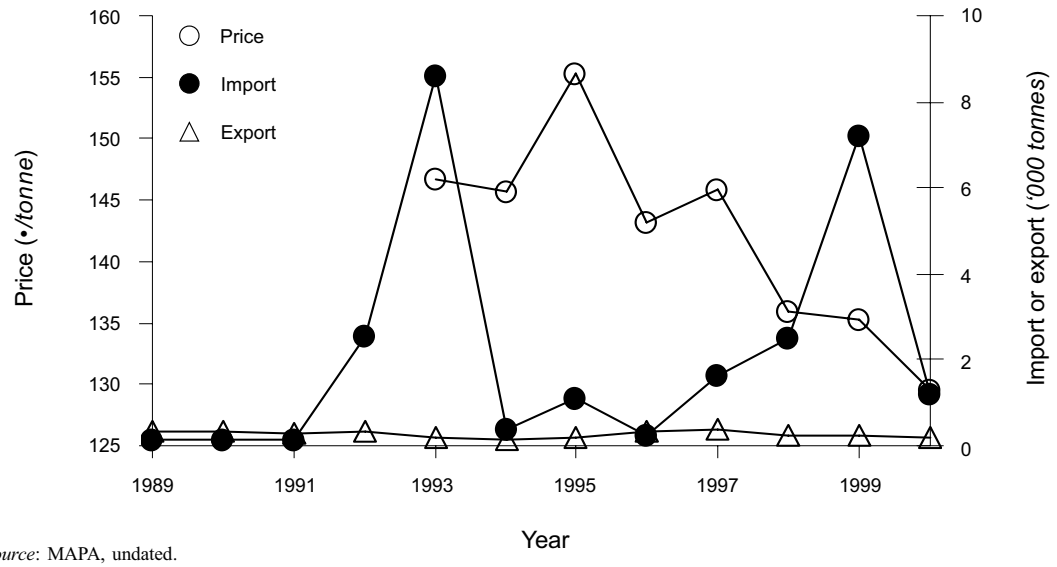
FIGURE 2
Average yield of triticale in Spain, 1979-2001



Source: FAO, 2003.

1993). Farmers agree that the advantages of triticale in rotation with maize in these areas include: (i) guaranteed forage supply during winter (triticale is grown from November to May and maize in the remaining months); (ii) higher productivity than other cereals, such as wheat or barley; (iii) less lodging and fewer diseases than barley; (iv) earlier flowering than wheat; and (v) lower water consumption than ryegrass (Royo and Aragay, 1994). Different studies conducted in the region have concluded that when triticale is the only crop grown during the year,

FIGURE 3
Price received by farmers for triticale and import and export of triticale in Spain, 1989-2000



Source: MAPA, undated.

forage has to be harvested at the late-milk/early-dough stage, because the low quality at this stage compared with earlier ones is offset by higher dry-matter yields.

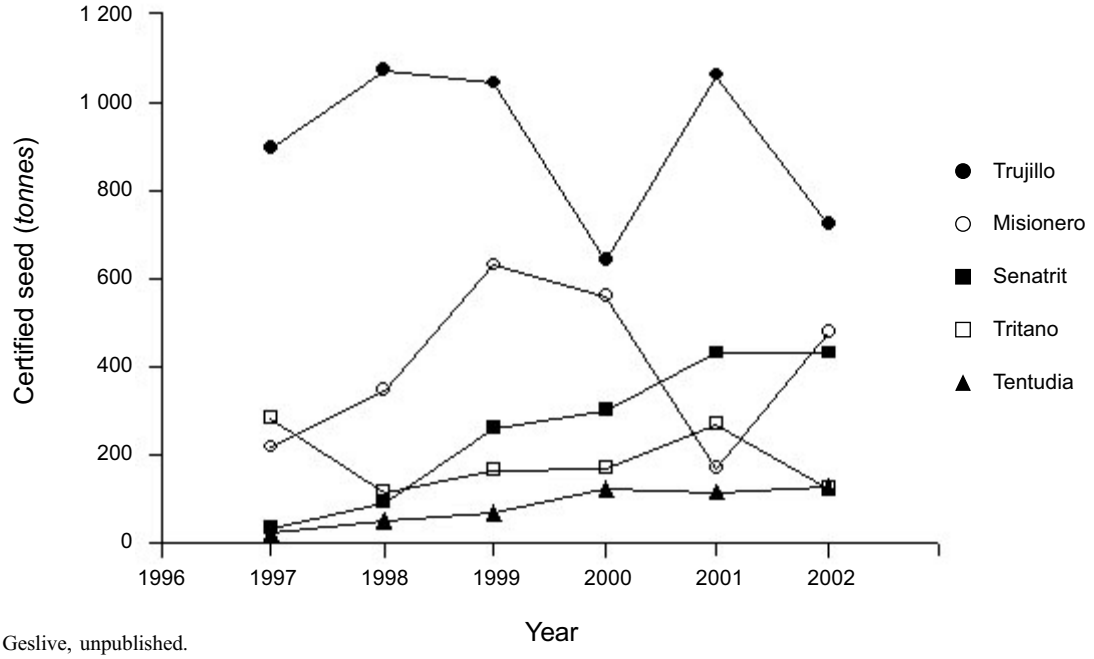
The use of triticale for dual purpose (forage and grain production in the same crop season) has been widely investigated in Spain (Royo, 1997; Royo and Tribó, 1997). This end-use is recommended when forage is needed during winter but the main objective of the field is grain production. In several experiments throughout Spain, the crude protein in the forage varied from 29.6 to 31.2 percent (showing a trend to diminish with late cuttings), the digestible crude protein varied from 24.9 to 26.3 percent and the acid detergent fibre from 17.2 to 19.8 percent (tending to increase with late cuttings) (Royo *et al.*, 1994). Early sowing is recommended when forage and grain are to be harvested in the same cropping season. To avoid drastic grain yield reductions, forage should be cut no later than the beginning of jointing, leaving intact the apical dome (Plate 5) (Royo *et al.*, 1997). Winter triticales appear to be better adapted for forage production, but the combined output of both forage and grain makes spring types seem better suited to the Mediterranean climate and to late-autumn sowing (Royo and Parés, 1996; Royo and Romagosa, 1996).

VARIETY DEVELOPMENT

In 1947, Sánchez-Monge started the first triticale breeding programme in Spain (Sánchez-Monge, 1996). He also determined that the hexaploid ploidy level of triticale was the optimal level for vigour and productivity. Cachirulo, the first Spanish triticale variety, was developed by this programme and released for production in 1969. Since then, about 50 new varieties have been released in the country, but only a few of them have reached the farmers. Germplasm from the International Maize and Wheat Improvement Center (CIMMYT) has had a strong impact on the development of new triticale varieties in Spain. Manigero and Fascal, two substituted types (rye chromosome 2R replaced by chromosome 2D of wheat), were the most cultivated varieties in the 1980s. Afterwards, a new generation of complete types (having all seven rye chromosomes), more productive and stress tolerant, was introduced. Presently, several public and private breeding programmes continue (Plate 6), and the best performing varieties are selected for demonstration trials (Plate 7) visited by farmers during field days.

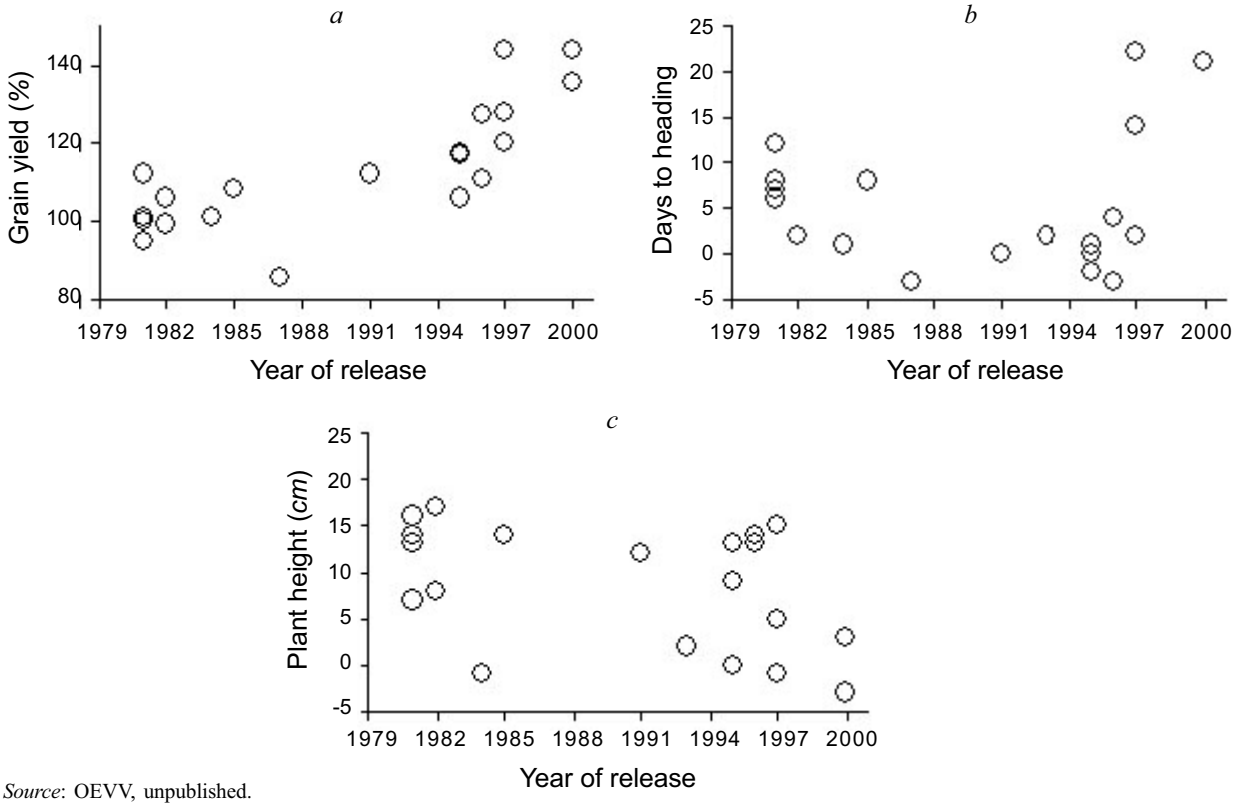
A map of the current variety structure in Spain can be determined by looking at the amount of certified seed used for each variety. The five most cultivated varieties at present are Trujillo, Misionero, Senatrit, Tritano and Tentudia (Figure 4). However, low amounts of Trijan, Galgo, Activo, Noe, Abaco, Camarma and Medellin seed were also certified in 2002. The total amount of triticale seed certified in Spain during the 2001/02 crop season was 2 553 tonnes, representing only 0.8 percent of the total certified seed of small-grain cereals.

FIGURE 4
Use of certified triticale seed in Spain, 1997-2002



Source: Geslive, unpublished.

FIGURE 5
Average yearly values for official multilocational trials of triticale genotypes released as varieties for grain yield (a), days to heading (b) and plant height (c) in relation to the check variety Manigero, 1981-2000



Source: OEVV, unpublished.

Genotype candidates to be released for cultivation must be submitted by breeders to the Oficina Española de Variedades Vegetales (OEVV), the office responsible for determining whether the candidate varieties meet the requirements to be released. The candidates are tested for two crop seasons in multilocation trials around the country. A committee evaluates annually the performance of candidates in the cooperative test network and either recommends or rejects the registration of the proposed lines. Progress in yield may be assessed by comparing the yield of the varieties released each year with the main yield of the check variety Manigero that remains stable over different crop seasons. Yield has risen mostly from 1995 onwards (Figure 5a) at an overall mean rate of 1.68 percent/year. The latest yield increases may be associated with the late-heading varieties (Figure 5b). On the other hand, recently released triticales are also shorter in height than their predecessors (Figure 5c). Important improvements have also been achieved among the released lines in 1 000 kernel weight (average gain of 2.5 percent/year), in specific grain weight (gain of 1.44 percent/year) and in protein content (gain of 1.92 percent/year).

CONCLUDING REMARKS

Triticale has a place in Spanish agriculture. However, until now its spread has been restricted by causes other than the intrinsic value of the crop. The lack of expansion of the crop, due mainly to political and commercial reasons, has compelled some Spanish institutions that traditionally conducted breeding programmes and research projects on triticale to dedicate their efforts to crops with greater market demand. Good varieties for grain production are available at present, but future efforts should concentrate on the development of triticale varieties for forage production.

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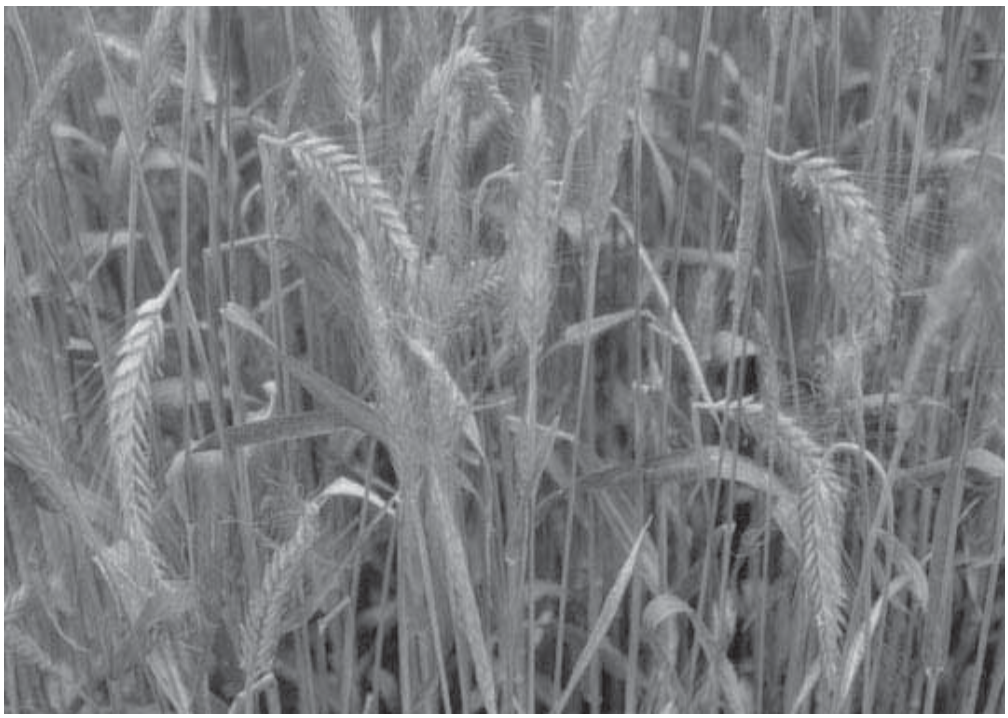
PLATE 1
Damaged triticale stems after a hail storm in Lérida, Spain
C. Royo



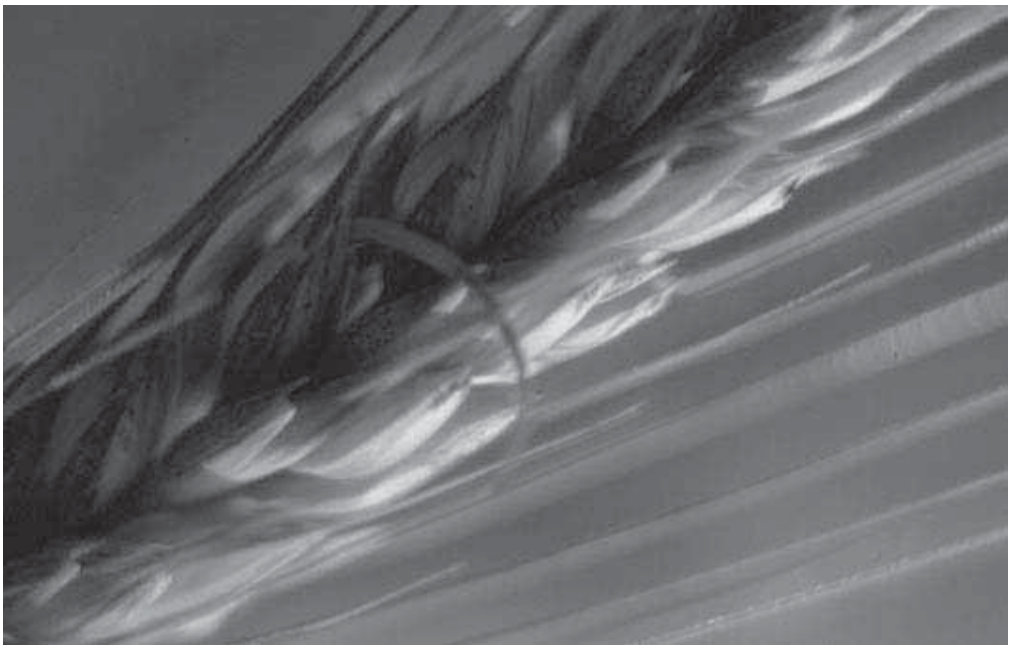


PLATE 2
Sprouting in a triticale spike due to wet conditions during grainfilling in Lérida, Spain
C. Royo

PLATE 3
Frost damage to triticale in Granada, Spain
C. Royo

PLATE 4
Triticale silo in the Alt Empordà region, Gerona, Spain
C. Royo

PLATE 5
Study conducted on the double use of triticale and barley; shorter plants have been cut and have regrown in El Palau d'Anglesola, Lérida, Spain
C. Royo

PLATE 6
F_8 lines at an IRTA triticale breeding programme in which barley rows have been used for isolation in El Palau d'Angesola, Lérida, Spain
C. Royo

PLATE 7
Triticale and wheat variety demonstration trial at IRTA Fundación Mas Badía, Gerona, Spain
C. Royo