Description of cultivar

Fuertemayo F2016: variety of bread wheat for irrigated sowings in Mexico

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Abstract

In Mexico, the main wheat-producing regions are located in the northwest (Sinaloa, Sonora and Baja California), where 64% of national production is obtained, under irrigation conditions during the autumn-winter cycle. Fuertemayo F2016 is a spring flour wheat, released by the National Institute of Forestry, Agricultural and Livestock Research. It is of intermediate cycle, with average height of 93 cm, presents grain of medium size and white color. The line that gave rise to Fuertemayo F2016 was generated by the International Maize and Wheat Improvement Center and was evaluated by the National Institute of Forestry, Agricultural and Livestock Research in 60 environments of normal and limited irrigation. The yield under normal irrigation was 4 999 kg ha^{-1} and under limited irrigation was 4 576 kg ha^{-1}, surpassing the controls by 3% (Roelfs F2007) up to 28% (Palmerín F2004). Its greatest advantage over the controls is its resistance to leaf and yellow rust, the maximum level of severity was 5 to 20%, respectively. It possesses the resistance genes of pleiotropic effect *Lr46/Yr29/Sr58*, *Sr2/Yr30* and *Lr68*. It is a semi-hard grain variety, with average hectoliter weight of 79 kg hl^{-1} and average protein content in flour of 11.7%. For its W= 350 x 10^{-4} J, it is classified as having strong gluten, suitable for the mechanized baking industry and can be mixed to improve weak dough flours. It is recommended for sowings under normal and limited irrigation during the winter, in early to late dates in the states of Sinaloa, Baja California, Chihuahua, Coahuila, Nuevo León, Tamaulipas, and in early to intermediate dates in the region of El Bajío.

Keywords: quality, resistance, yield.

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Globally, bread wheat (*Triticum aestivum* L.) is the most important cereal after corn, its production is mainly for human consumption (FAO, 2020). In Mexico, the main wheat-producing regions are located in the northwest (Sinaloa, Sonora and Baja California), where 64.2% of the national total is produced, such production is carried out under irrigation conditions during the autumn-winter cycle (SIAP, 2020). A limiting factor in these regions is the availability of water, since approximately 58% of aquifers have a water deficit, while in dams their storage capacity varies from 5.5 to 73.6% (CONAGUA, 2015).

On the other hand, in these same regions during the last years, the incidence of rusts increased considerably (Rodríguez *et al*., 2020) and worldwide (Singh *et al*., 2016), among other causes, due to changes in the environment, mainly the increase in temperature during the crop cycle, which has led to the evolution of pathogenic populations of these fungi to more virulent forms (Ávila-Quezada *et al*., 2018).

In the northwest of the country, the diseases known as rusts are the most economically important of this cereal. Leaf rust caused by *Puccinia triticina* E. is the most important in the north and northwest of the country, this disease is the most distributed and occurs in most irrigated areas where wheat is sown (Huerta-Espino *et al*., 2011; Rodríguez *et al*., 2020). However, yellow rust caused by *P. striiformis* f. sp. *tritici* W. has increased its incidence in recent years. It is therefore necessary to make available to producer's varieties with good yield potential, resistance to diseases and good industrial quality.

Origin

Fuertemayo F2016 is a variety of bread wheat released by the National Institute of Forestry, Agricultural and Livestock Research (INIFAP, for its acronym in Spanish). The experimental line that gave rise to the variety was obtained by the Bread Wheat Program of the International Maize and Wheat Improvement Center (CIMMYT, for its acronym in Spanish). A simple cross was made between the line ND643/2∗WBLL1 and the variety Villa Juárez F2009 and its genealogy is: ND643/2∗WBLL1//VILLA JUAREZ.

The simple cross was made in Obregon City, Sonora, in the autumn-winter cycle (A-W), A-W/2008-2009 (CMSS08Y00233S) and was sown in its F_1 generation in El Batán, Texcoco, State of Mexico, in the S-S/2009 cycle, that population was harvested massively and gave rise to the F_2 generation, which was sown in Obregon City, Sonora, in the A-W/2009-2010 cycle and an indefinite number of selections (099Y) were harvested massively. The F_3 generation was evaluated in Atizapán, State of Mexico, in the spring-summer (S-S) cycle, S-S/2010, also selecting and massively harvesting an indefinite number of selected plants (099M).

The F_4 was established in Kenya at the Njoro Experiment Station to be evaluated for resistance to the stem rust race *Ug99* in the S-S/2011 cycle and an indefinite number of selections (099NJ) were harvested massively. The F_5 generation was sown in Obregon City, Sonora, in the A-W/2011-2012 cycle, where plant 27 was selected and harvested individually, which, due to its white grain, was assigned WGY (WG= white grain 27WGY).

The seed of that plant was sown in its F_6 generation in El Batán, Texcoco, State of Mexico, in the S-S/2012 cycle, where the experimental line (0B) was massively harvested, which was recognized with the pedigree: CMSS08Y00233S-099Y-099M-099NJ-27WGY-0B.

From the A-W/2013-2014 cycle, the experimental line was evaluated at INIFAP in the national yield trials of irrigated bread wheats in nine states nationwide and in 60 different production conditions, as well as in the disease evaluation nurseries established in the region of the High Valleys of Mexico in the states of Puebla, Tlaxcala and State of Mexico in cycles S-S/2014 to S-S/2016. During four years of evaluation, the Fuertemayo F2016 variety stood out with respect to the control varieties for its greater resistance to diseases and grain yield and for its good baking quality.

Fuertemayo F2016 is of spring habit, of intermediate cycle (days to maturity of 121 days on average), with absent or very weak anthocyanin pigmentation of the coleoptile and its plant size is medium (average height of 93 cm). It has an average frequency of plants with recurved flag leaf and its heading is uniform. Its spikes have parallel edges, with medium serosity during grain filling, white at maturity and slightly curved position. Its grain is medium-sized, white, with semi-hard consistency and medium coloration to the reaction to phenol.

Grain yield

Table 1 shows the comparison of grain yield of Fuertemayo F2016 and control varieties tested in 60 different experiments in the states of Sinaloa, Sonora, Baja California, Coahuila, Nuevo León, Tamaulipas and Guanajuato under conditions of normal irrigation and limited irrigation, where it is observed that this variety exceeded the overall yield of all varieties by 3% (Roelfs F2007) up to 26% (Palmerín F2004), showing better behavior under limited irrigation conditions.

Table 1. Grain yield of Fuertemayo F2016 and varieties in 60 environments under conditions of normal irrigation and limited irrigation and percentage with respect to control varieties.

Variety	Overall* (60)		Normal irrigation (34)		Limited irrigation (26)	
	(kg ha^{-1})	(%)	(kg ha^{-1})	(%)	(kg ha^{-1})	(%)
Fuertemayo F2016	4 809		4 999		4 576	
Roelfs F2007	4 667	-3	4 889	-2	4 401	-4
Onavas F2009	4 600	-4	4 827	-3	4 327	-5
Villa Juárez F2009	4 591	-5	4 803	-4	4 451	-3
Norteña F2007	4 568	-5	4 774	-4	4 428	-3
Kronstad F2004	4 525	-6	4 794	-4	4 194	-8
Tacupeto F2001	4 366	-9	4 560	-9	4 132	-10
Urbina S2007	4 239	-12	4 465	-11	3 981	-13
Palmerín F2004	3 573	-26	3 804	-24	3 294	-28

*= yield includes evaluations of Sinaloa, Sonora, Baja California, Coahuila, Nuevo León, Tamaulipas and Guanajuato (complete irrigation and limited irrigation); %= percentage with respect to Fuertemayo F2016.

Reaction to diseases

Table 2 shows the reaction to leaf rust and yellow rust in the foliage and spike of the Fuertemayo F2016 variety and control varieties evaluated from 2013 to 2016 under irrigation conditions in the autumn-winter cycles and under rainfed conditions in the spring-summer cycles, where it was observed that this new variety showed resistance to the two rusts. For leaf rust caused by *P. triticina*, it is moderately resistant, with readings of 0 to 5% severity; its resistance is based on the effects of specific race genes Lr1, Lr2a, Lr2c, Lr17 and Lr23 that give resistance at all stages of growth, in adult plant that resistance is due to the effect of genes Lr46 and Lr68, presence that was determined with the markers *csLV46G22* (Lan *et al*., 2019), 7BLNRR, CSGS and CSSCL68 (Herrera-Foessel *et al*., 2012), respectively.

Table 2. Reaction of Fuertemayo F2016 to rusts and control varieties.

Variety	Leaf rust	Yellow rust in leaf	Yellow rust in spike (%)
Fuertemayo F2016	0 to 5MR	0 to 20MR	0 to 10
Palmerín F2004	0 to 10R	0 to 40MS	0 to 15
Villa Juárez F2009	0 to 20MR	0 to 40MS	0 to 20
Ónavas F2009	5R to 20MR	5R to 60MS	5 to 30
Roelfs F2007	10MR to 40MS	5R to 60MS	10 to 40
Norteña F2007	10MR to 60MS	10MR to 60MS	5 to 40
Urbina S2007	10MR to 60MS	0 to 60MS	0 to 30
Kronstad F2003	40MS to 70S	0 to 60MS	0 to 30
Tacupeto F2001	20MR to 80S	30MS to 90S	20 to 70

R= resistant; MR= moderately resistant; MS= moderately susceptible; S= susceptible.

For yellow rust caused by *P. striiformis* f. sp. *tritici*, its resistance is due, in part, to the non-specific race resistance gene Yr29, linked to leaf tip necrosis (*Ltn*), morphological trait corroborated with the csLV46G22 marker (Lan *et al*., 2019) and the Yr30 gene by the gwm533 marker (Randhawa *et al*., 2018).

Industrial quality

Fuertemayo F2016 had average hectoliter weight values of 79.2 kg hl^{-1}, higher than the control varieties (Table 3), which will allow it to obtain high flour yields. It is of semi-hard grain, with an average content of protein in flour of 11.7%, similar to the control variety with the highest content (Kronstad F2004). Its dough presented an average value of W= 350 x 10^{-4} J in its strength, being classified as a variety of strong gluten and in its tenacity-extensibility ratio, it presented a value of PL= 1.1, being classified as a variety of balanced gluten, its strong-balanced dough allowed it to obtain bread volume values greater than 850 ml, surpassing all control varieties (Table 3). Fuertemayo F2016 is suitable for the mechanized baking industry and can be used to improve weak and tenacious dough flours.

Table 3. Industrial quality characteristics of Fuertemayo F2016 and control varieties in irrigation conditions.

Genotype	HLW	GH	PF	W	PL	BV
Fuertemayo F2016	79.2	50	11.7	350	1.1	865
Borlaug 100 F2014	78.7	46	10.7	334	1	840
Villa Juárez F2009	77	42	10.4	342	1.3	734
Roelfs F2007	76.8	45	10.5	364	1	787
Kronstad F2004	75.5	40	11.7	426	1	827

HLW= hectoliter weight; GH= grain hardness (%); PF= protein in flour (%); W= strength of dough (10-4J); PL= tenacity-extensibility ratio; BV= bread volume (ml).

Scope of recommendation

The Fuertemayo F2016 variety is recommended for cultivation under conditions of normal irrigation and limited irrigation during the autumn-winter cycle for the states of Sinaloa, Baja California, Chihuahua, Coahuila, Nuevo León, Tamaulipas, Guanajuato and Michoacán, in order to obtain the best results with the sowing of this variety. For the northwestern, northern and northeastern states, Fuertemayo F2016 is recommended on early to late sowing dates, while for the states that make up El Bajío, it is recommended for early to intermediate sowings.

This new variety has the registration TRI-180-090318 in the National Catalog of Plant Varieties of the National Service of Inspection and Certification of Seeds and Breeder's Title No. 1930. The wheat program of INIFAP-CEVAMEX protects and makes available to interested parties the seed in its basic category.

Conclusions

Fuertemayo F2016 is a variety released by the Wheat Program of INIFAP, recommended for sowings under normal irrigation and limited irrigation in the Northwest, North, Northeast and El Bajío. It is resistant to rusts and meets the quality demanded by the baking industry. Its sowing will allow enriching the genetic mosaic of varieties recommended by INIFAP, to avoid the appearance of new physiological races of rusts in Mexico.

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