Description of cultivar

Jade: new variety of oats for the production of grain in rainfed crops in Mexico

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Abstract

The National Institute of Agricultural and Livestock Forestry Research, makes available to producers of oats from Mexico the variety 'Jade', which was obtained by its Genetic Improvement Program located in the Valley of Mexico Experimental Field (CEVAMEX). Jade was obtained through a simple cross between the line 815A-129-72-CI-648/SR-CPX and the Obsidiana variety, and its F_1 that was backcrossed to the variety, in the selection towards homozygosis the gravimetric methods were applied and massive families until obtaining the experimental line that was evaluated in 105 localities in 12 states of the republic in temporary conditions from 2008 to 2012. During this period in JADE there were readings of trace stem rust (TR) at 20 MR, type of resistance reaction that exceeded all the control varieties. Its average grain yield was 3 681 kg ha^{-1} in favorable environments, 2 302 kg ha^{-1} in intermediate environments and 1 382 kg ha^{-1} in critical environments, surpassing the eleven control varieties in each condition. Based on its agronomic behavior and resistance to stem rust, with the Jade planting it can be substituted for the Menonita, Avemex, Papigochi, Chihuahua, Cuauhtemoc and Opalo varieties, which will increase on average 28% the productivity of oats in plantings of temporary. Due to the above, Jade will be part of the genetic mosaic of varieties that INIFAP recommends for rainfed sowing in Mexico.

Keywords: *Avena sativa* L., higher yield, temperate environments, tolerance to stem rust.

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In Mexico during 2017 the area sown with the oat crop (*Avena sativa* L.) was 856 354 ha, being in the fifth place with the largest sown area of the crops in our country. 94% of the production of oats was in temporary conditions, 87% was for the production of forage in green, hay or grain, was sown in 21 entities and stood out for its importance Chihuahua, Durango, Zacatecas, State of Mexico and Hidalgo (SIAP, 2017).

A limiting factor in the production of temporary oats is the loss in yield caused by stem rust disease (*Puccinia graminis* f. sp. *avenae* E. and H), which reaches 70% in susceptible varieties (Leyva *et al*., 2004) and in addition, causes the obtaining of poor quality forage (Espitia *et al*., 2012). Given that its chemical control is expensive due to the number of applications required, the most effective way to reduce these losses is through the planting of varieties that are resistant or tolerant to this disease (Villaseñor *et al*., 2009a). Additionally, drought is a major problem in the cultivation of oats that is increasingly accentuated in rainfed crops in the different producing regions, so that early varieties with good response to water stress is the most appropriate strategy to reduce losses (Villaseñor *et al*., (2009b).

The genetic improvement of oats in Mexico, which has been the responsibility of the program of INIFAP-CEVAMEX (Villaseñor *et al.* (2009b), has focused mainly on the release of varieties that combine precocity and tolerance to drought and stem rust, as well as a higher yield of grain. Result of the process of genetic improvement, INIFAP makes available to the producers of oats from Mexico the new Jade variety, to face the biotic and abiotic problems of the country's oats and increase their productivity. Jade registered in the Catalog of Feasible Varieties of Certification of the National Service of Inspection and Certification of Seeds with the number AVE-020-290514.

Obtaining the variety and characteristics

The variety of Jade oats was obtained by genetic recombination, selection and evaluation by the Oat Genetic Improvement Program of the National Institute of Agricultural and Livestock Forestry Research (INIFAP) based in the Valley of Mexico Experimental Field (CEVAMEX).

The crossing was carried out during the autumn-winter cycle 1998-1999 (A-W/1998-99) in Chapingo, State of Mexico. (CEVAMEX), participating in its crossing as a female parent line experimental 815A-129-72-CI-648/SR-CPX and as a male the Obsidiana variety, in the spring-summer cycle of 1999 (S-S/1999) in the CEVAMEX F_1 was backcrossed with Obsidiana (F_1R). The seed of their F_1R was planted in the cycle A-W/1999-2000 in the CEVAMEX and the population was harvested massively. Generation F_2 was also evaluated in that experimental station of the INIFAP during the S-S/2000 cycle, where population no. 4537 was sown under competition, was harvested massively and later was applied selection by density and grain weight (0C). In the F_3 generation planted in the CEVAMEX in the S-S/2001 cycle, individual plant selection was made (selection of the 5C plant) to derive massive families in the F_4 generation, which was sown in the Bajio Experimental Field (CEBAJ) in Roque, Guanajuato. During the autumn-winter cycle (A-W) of 2001-2002 and the family was harvested massively (0R); this procedure was also practiced in generation F_5 in the CEVAMEX in the spring-summer cycle (S-S)/2002, where the family was also harvested massively (0C).

Generation F_6 was evaluated again in the CEVAMEX in the cycle S-S/2003, where individual plant selection was made (selection of the 2C plant) to derive lines in the F_7 generation, seed that was sown in the CEBAJ in the cycle A-W/2003-04 and the line was massively harvested (0R). In the cycle S-S/2010 in the town of Coatepec, municipality of Ixtapaluca, State of Mexico, segregation was observed in the experimental line, so it was proceeded to make individual selection of 50 panicles, which were sown in the CEBAJ during the cycle A-W/2010-11, and where the advanced line number 18 (18COAT-0R) that gave rise to Jade was massively selected, which was identified with the following genealogy and pedigree: 815A-129-72-CI-648/SR-CPX)/2∗OBSI-4537-0C-5C-0R-0C-2C-0R-18COAT-0R.

The line in 2006 was part of the third oat selection nursery (3rd VISAVENA) and from 2007 to 2012 it was part of the seventh to the twelfth national uniform oatmeal trial (7th EUAVENA to 12th EUAVENA). The previous, allowed to evaluate it in 105 localities that were located in 12 states of the republic that included Oaxaca, Puebla, Tlaxcala, Hidalgo, State of Mexico, Guanajuato, Michoacán, Jalisco, Aguascalientes, Zacatecas, Durango and Chihuahua. The new variety Jade is of habit of spring, of intermediate vegetative cycle (107 days average to physiological maturity), with a height of average plant (100 cm average), tolerant to the acame and responds favorably in any type of environment of production under temporary.

Reaction to diseases

During its evaluation period, the Jade variety was resistant to moderately resistant to stem rust (*Puccinia graminis* f. sp. *avenae*), resistant to rust from the crown or leaf (*P. coronata*) and tolerant to the complex of foliar diseases caused by *Helminthosporium avenae* (leaf spot), *Septoria avenae* f. sp. *avenae* (leaf spot) and *Colletotrichum graminicola* (anthracnose).

Table 1 shows the reaction to Jade diseases and the control varieties evaluated from 2008 to 2012 under rainfed conditions. Jade recorded stem rust readings for traces of resistance (TR) at 20% infection of moderate resistance (20MR), type of reaction that exceeded all control varieties; Mariscal *et al*. (2011) report the evaluation to 24 different races of stem rust of eight of the control varieties against which Jade was tested and according to their results, it is indicated that Jade resistance to stem rust may be due to the action joint of 2 to 3 genes of additive effects.

For the case of crown or leaf rust, the new variety was also the genotype with the highest resistance, showing incidences of traces of resistance (TR) at 10% resistance infection (10R), higher than the Turquesa and Karma control varieties, which presented incidences of up to 50% susceptibility. The new Jade variety equated tolerance to the foliar disease complex of most of the control varieties and showed greater resistance to these pathogens than the susceptible varieties Papigochi and Menonita.

The highest incidence of foliar disease complex occurred in localities with rainfall greater than 600 mm, considered temporary as rainy environments for the cultivation of oats. Due to their tolerance to these diseases, Jade is a good option to be recommended in these types of environments, together with Turquesa and Obsidiana, mainly.

Table 1. Agronomic and phytopathological characteristics of the new Jade variety and control varieties in rainfed environments from 2008 to 2013.

Variety	DAM	AP (cm)	Acame	RT	RC	Foliares
Jade	107	100	MR	TR to 20MR	TR to 10R	6/40 (T)
Turquesa	107	97	MR	5MR to 40MS	10R to 30MS	6/40 (T)
Obsidiana	108	97	MR	10MS to 60S	20MS to 70S	5/20 (T)
Karma	107	95	R	10MS to 50S	10R to 50S	6/40 (T)
Avemex	108	111	MS	20MS to 80S	20MS to 70S	6/40 (T)
Menonita	103	93	R	10MS to 80S	20MS to 70S	7/60 (MS)
Papigochi	106	92	MR	5MR to 70S	20MR to 70S	7/60 (MS)
Chihuahua	111	98	S	60S to 100S	50S to 100S	6/40 (T)
Cuauhtemoc	112	100	S	70S to 100S	30MS to 80S	6/40 (T)
Ópalo	115	107	S	70S to 100S	60S to 100S	6/30 (T)

DAM= days to maturity; AP= plant height; RT= stem rust; RC= crown rust; TR= resistance traces; R= resistant; S= susceptible; MR= moderately resistant; MS= moderately susceptible; T= tolerant.

Potential for yield

Table 2 shows the comparison of grain yield, as well as the percentage of decrease of the control varieties with respect to Jade. This new average variety of the 105 evaluations presented higher average grain yield, with 2241 kg ha^{-1}, surpassing the control varieties from 4% (Turquesa) to 45% (Ópalo).

Table 2. Grain yield and percentage of decrease of the control varieties with respect to the new Jade variety in different rainfed environments from 2007 to 2012.

Variety	General (105)		AF (21)		AI (43)		AC (41)	
	(kg ha^{-1})	(%/J)	(kg ha^{-1})	(%/J)	(kg ha^{-1})	(%/J)	(kg ha^{-1})	(%/J)
Jade	2 241		3 681		2402		1 337	
Turquesa	2 144	-4	3 652	-1	2 203	-8	1 312	-2
Teporaca	2 036	-9	3 384	-8	2 138	-11	1 239	-7
Obsidiana	2 028	-10	3 332	-9	2 141	-11	1 242	-7
Karma	1 914	-15	3 205	-13	1 993	-17	1 171	-12
Menonita	1 804	-20	2 784	-24	1 925	-20	1 176	-12
Chihuahua	1 780	-21	2 706	-26	1 886	-21	1 196	-11
Papigochi	1 682	-25	2 746	-25	1 631	-32	1 191	-11
Diamante	1 658	-26	2 615	-29	1 700	-29	1 126	-16
Cuauhtemoc	1 554	-31	2 486	-32	1 621	-33	1 008	-25
Avemex	1 516	-32	2 450	-33	1 515	-37	1 041	-22
Ópalo	1 224	-45	2 057	-44	1 143	-52	883	-34
Tukey (α= 0.05)	473	-22	908	-21	566	-25	390	-14

AF= favorable environments; AI= intermediate environments; AC= critical environments; %/J= percentage of decrease with respect to the Jade variety.

The production environments where it was evaluated were classified as critical with an approximate rainfall of less than 300 mm during the production cycle, in intermediates with an approximate rainfall of 300 to 500 mm and in favorable conditions with an approximate rainfall greater than 500 mm. Based on this environmental classification, Jade showed yields of 36 81 kg ha^{-1}, 2 402 kg ha^{-1} and 1 337 kg ha^{-1} in favorable, intermediate and critical environments, respectively, surpassing the 11 control varieties in each of the indicated production conditions.

The average yield per type of production environment with respect to the average of the 11 controls in each one, indicates that Jade in favorable environments exceeded 21%, in intermediate environments in 25% and in critical environments in 14%, which in at this time, it would be indicative that Jade, due to its greater resistance to stem rust, has more advantages over the control varieties in intermediate and favorable environments, where conditions suitable for the incidence of the disease prevail. In critical environments drought conditions generally prevailed, where Jade also showed better response than most control.

It is important to indicate that in general, Jade productivity was considerably higher than that of the Menonita (20%), Chihuahua (21%), Papigochi (25%), Diamante (26%), Cuauhtémoc (31%), Avemex (32%) and Ópalo (45%), so that by replacing such varieties with the new Jade variety, the productivity of oats in rainfed crops will be increased 28% on average, with greater impact in environments where there is a higher incidence of stem rust.

Areas of recommendation of production

The new variety Jade is recommended for planting in critical, intermediate and favorable production environments in the areas of weather where oats are produced during the spring-summer agricultural cycle in the states of Oaxaca, Puebla, Tlaxcala, Hidalgo, State of Mexico, Queretaro, Guanajuato, Michoacan, Jalisco, Aguascalientes, Zacatecas, Durango and Chihuahua.

In general it is recommended as the best option, together with the Turquesa variety, in any production environment; it is important to recommend varieties with different genetic backgrounds to form genetic mosaics that do not allow the dynamic evolution of the races of stem rust, so that, together with Jade and Turquesa, also Teporaca varieties, Obsidiana and Karma are recommended. Jade is also recommended, along with Turquesa and Obsidiana, for autumn-winter plantings, in the states where this cereal is produced.

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