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New high-yielding conventional soybean adapted to the states of Goiás, Minas Gerais and Mato Grosso, Brazil

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ABSTRACT. This paper aims to present the features of the new soybean cultivar UFUS Milionária, which was developed by the Soybean Improvement Program of the Federal University of Uberlândia (UFU) through crossing between IAC-100 and Cristalina RCH cultivars, using the Single Seed Descent (SSD) method. UFUS Milionária is resistant to many diseases caused by the fungus, bacteria, and virus. In addition, it also has been proved well-adapted to many Brazilian states, showing high yield even under water deficit conditions and Asian-rust infection; average yield was 4,451 kg ha^{-1} in 2015/16 growing season.

Keywords: *Glycine max*; cultivar release; soybean Asian-rust; plant breeding.

Introduction

Soybean [*Glycine max* (L.) Merr.] genetic improvement is a procedure regarding the development of variability for desired traits, identification of superior genotypes, and seeds multiplication intending commercial production. The crossing of divergent parents produces the genetic variability of specific features intended to be transferred into new or improved varieties. The progenies from these crosses are then allowed to natural genetic segregation through successive generations of self-fertilization, and new genotypes are thus formed. Various selection methods might be used for identification of those progenies that possess the most useful combinations of the desired features. These include the pedigree method where best-appearance families, in each generation, are visually selected then within each family one or more plants are chosen to advance to the next generation; single-seed descent method which involves advancing one seed, or pod, from each plant to the next generation in order to develop nearly homozygous lines; and bulk breeding method, which a population is advanced in bulk with no artificial selection until later generations, when nearly homozygous lines are selected for yield testing (Miladinović et al., 2011).

In 1997, the Soybean Improvement Program of the Federal University of Uberlândia (UFU) was established. Since then we have obtained soybean genotypes with excellent behavior in States as Minas Gerais (MG), Maranhão (MA), Tocantins (TO), and Mato Grosso (MT), among others. Soybean genetic improvement has been critical to the success of this crop in Brazil, and we have been contributing to this success by developing soy cultivars with genetic resistance to biotic and abiotic factors, which are promoting a profound impact on production and profitability.

UFUS Millionaria is a non-GMO (non-genetically modified organisms) soybean. It is one of first cultivars developed by the team of the Soybean Improvement Program of UFU. It was registered in 08/04/2009 with the Brazilian Cultivars Protection Service - SNPC, reporting to the Ministry of Agriculture and Supplies (MAPA); and protected by the Industrial Property Law and Plant Variety. However, since 2008 we have continued testing UFUS Milionária in many greenhouse and field experiments. We have found that it is a very well adapted soybean cultivar, showing high-yielding even under Asian-rust infection.

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Material and methods

We carried out experiments in the Capim Branco farm of Federal University of Uberlândia, Uberlândia-MG. We have used the Single Seed Descent (SSD) method in order to establish segregating generations; and then over generations we have eliminated most pest and disease-susceptible plants, also those one showing low yielding. The single seed descent method is a modification of bulk method of breeding that allows the equal survival of a segregates. Hybridization methods in soybean breeding are very important to development of cultivars with desired agronomic characteristics. Segregating populations from these crossing must be conducted through successive generations of self-pollination and the appropriate method choice for conduction of these populations increases the efficiency of selection of superior lineages (Da Silva et al., 2017).

We have chosen the breeding and selection methods to development of this new cultivar based on the heritability of the traits being improved and commercial objectives. The hybrid seed (F1) was produced by manual crosses between selected parents (IAC-100 x Cristalina RCH). We have collected only one single seed from each F2 plant then we have bulked those seeds to grow the next F3 generation. We continued this procedure by picking one single seed from each plant until we reach the F5 or F6 generations when the plants became nearly homozygous, then we have selected many single plants from F5 and F6 generations and let grown separately. In F7 and F8 generations, we have selected and tested the superior progenies thus, we have identified the best ones for release. In F5 and F6 generations we have performed VCU trials.

Value for cultivation and use (VCU) are mandatory as part of the application process to register, protect and add a new a new soybean cultivar to the Brazilian national list. VCU tests must be established to assess differences of productivity, biological characteristics, chemical and technological characteristics, resistance to pests and diseases, as well as other commercially important characteristics. We carry out VCU trials by comparing the performance of candidate varieties to varieties already on the national list using a randomized blocks design, with three replications during 2-year period (2006/07); size of plot was equal to 5.0 m2.

We carry out initial breeding in greenhouse experiments in 1990. In 2000, we proceed first field tests in order to select best progenies. We have started local level testing in cities of Uberlândia, Guarda-Mor, Ituiutába, Irai de Minas, in the 2003/04 season; and regional tests in the 2006/07 season, in the states of Goiás (GO), Mato Groso (MT), Piauí (PI), Maranhão (MA), Bahia (BA), and Tocantins (TO).

Results and discussion

We have tested UFUS Milionária in compliance with requirements of Value for Cultivation and Use (VCU) as recommended by the Ministry of Agriculture and Supplies (MAPA). Results of the comparative tests regarding growth habit, cycle, morphological descriptors, the rate of lodging, grain yield and others, are presented in the Tables 1 and 2. UFUS Milionária have shown good yielding, 3,772 kg ha^{-1} in 2010/2011 season in the Coqueiros farm (GO); and excellent results, 5,268 kg ha^{-1} in the 2011/2012 season, in Palmeiras de Goiás town (GO), regarding other genotypes under study. It shows that was UFUS Milionária was able to take benefic advantages of local variations.

Table 1. Results of the comparative test of conventional soybean genotypes, in the 2010/2011 season. Location BR 364- km 306, Coqueiros farm, Mineiros, Goiás State (GO), Brazil.

Genotypes	[a] G. H.	[b] Pub.	[c] Cycle	[d] Rated lodging	Grain Yield kg ha^{-1}
UFUS Milionária	d	b	138	1.0	3,772
UFUS Impacta	d	b	135	1.0	3,771
UFUS Xavante	d	g	142	2.0	3,770

BRSGO 7760	u	b	116	1.0	3,554
Riqueza	d	b	130	1.0	3,409

[a] G. H.: Growth Habit, d = determined, u = undetermined. [b] Pub.: Pubescence, b = brown, g = gray. [c] Cycle: Number of days of the cycle. Rated lodging on a scale of 1 to 5 as follows, 1.0 = almost all plants erect, 2.0 = either all plants leaning slightly or a few plants down, 3.0 = either all plants leaning moderately (45º angle) or 25-50% down, 4.0 = either all plants leaning considerably or 50-80% down, 5.0 = all plants down.

Table 2. Results of the comparative test of conventional soybean genotypes, in the 2011/2012 season. Palmeiras de Goiás, Goiás State (GO), Brazil. Latitude 16°47'22.26'' S; Longitude 49°55'57, 55''W; Altitude 2,066 Feet.

Genotypes	[a] Color			[b] Cycle	[c] Height			Nº of Nodes	Nº Grains/pod	Grain Yield
	Hil.	*Flo.*	*Pub.*		*Flow.*	*Mat.*	*Ins.*			kg ha^{-1}
UFUS 501	b	w	lb	136	49	55	12	25	3	4,878
UFUS 523	b	w	b	129	50	70	16	27	3	4,830
UFUS 508	b	w	b	115	48	69	13	27	2	5,124
UFUS 518	b	p	lb	133	57	63	13	27	3	5,085
UFUS Impacta	b	p	b	133	43	69	9	32	3	4,326
UFUS Xavante	b	p	b	136	44	72	15	24	3	4,074
UFUS Milionária	b	w	b	139	34	54	6	23	3	5,268
UFUS Impacta	b	p	b	136	59	71	12	-	-	4,671

[a]Color: Hil. = hilum, Flo. = flower, Pub. = pubescence, b = brown, lb = light brown; [b] Cycle: number of days of the cycle; [c] Height: Flow. = flowering, Mat. = maturity, Ins. = height (cm) of insertion of first pod.; (-): lost data.

UFUS Milionária presents determined growth habit and it has shown rate of lodging as low as 1.0, what means almost all plants erect (Table 1). Excessive vegetative growth might lead to lodging that reduces yields by causing increased harvest losses and inefficient use of sunlight by the plant. Lodging percentage showed significant negative correlations with grain yield (Buzzello et al., 2013), root weight, stem diameter, and stem strength (Chen et al., 2017); and significant positive correlations with branch number, internode length, number of nodes, plant height (Chen et al., 2017; Lee, Jun, Michel, & Mian, 2015).

We have asked farmer's opinion about the performance of UFUS Milionária cropping held in three farms located in the state of Piauí, 2011/2012 season. The feedback regarding the new cultivar was satisfactory; farmers got very good results by cropping UFUS Milionária, which has shown superior grain yield in all 3 locations (Table 3).

Table 3. Farmer's opinion regarding UFUS soy cultivars cropping in three farms located in the state of Piauí (PI), Brazil, in the 2011/2012 season.

Farms	Genotypes	Farmer's opinion	Grain Yield kg ha^{-1}
Três Irmãos	UFUS Milionária	Good	3,240
	UFUS Impacta	Good	3,282
	UFUS Xavante	Medium	2,880
	Msoy 9350	Good	3,420
	P99R01	Good	3,360
Santo Antônio	UFUS Milionária	Good	3,540
	UFUS Impacta	Bad	2,304
	UFUS Xavante	Bad	2,130
	M9144RR	Excellent	3,720
Dona Helena	UFUS Milionária	Excellent	2,880
	UFUS Impacta	Good	2,760
	UFUS Xavante	Good	2,700
	Msoy 9350	Good	2,760

In the test conducted by the SLC Agrícola (Schneider Logemann & Cia) research team, in 2011/12, UFUS Milionária presented moderate resistance against the diseases leaf spot (*Corynespora cassiicola*), Asian rust (*Phakopsora pachyrhizi*) and anthracnose. In addition, the cultivar also showed excellent grain yielding results (Table 4). The SLC is one of the largest soybean producer in Brazil with an area equal to 270,000 ha of planted soybean. Founded in 1977 by the SLC Group its research has been focusing mainly on cotton, soybean and corn.

By performing the VCU trials we have found UFUS Milionária resistant to stem canker (*Diaporthe phaseolorum* f. sp. *meridionalis*), frogeye leaf spot (*Cercospora sojina*), bacterial pustule (*Xanthomonas axonopodis* pv. *Glycines*), downy mildew (*Peronospora manshurica*); moderately resistant to powdery mildew (*Microsphaera diffusa*), southern root-knot nematode (*Meloidogyne incognita*), leaf spot (*Corynespora*

cassiicola) and anthracnose. This soy cultivar was also found well adapted under Asian-rust (*Phakopsora pachyrhizi*) infection, showing high-yielding even under such conditions. UFUS Milionária presents determined growth habit and low rate of lodging.

Table 4. Results of in competition trials conducted by the SLC research regarding yielding and agronomic characteristics of soybean cultivars. Paiaguás Farm, Diamantino, Mato Grosso (MT), Brazil, in the 2011/12 season.

Genotype	[a] Stand	Cycle	Height		[b] Rl	[c] Diseases			Grain Yield
			Plant	*1st Pod*		*Ls*	*Ar*	*Ant*	kg ha^{-1}
UFUS 7910	157,037	139	102.0	11.3	2.5	1.7	1.0	1.3	4,451
Ufus Milionaria	154,074	144	69.7	8.7	1.0	1.7	1.3	1.0	4,201
Ufus Xavante	120,000	140	83.7	8.7	3.0	1.3	1.0	1.3	3,760
Average	213,395	132	76.6	9.2	1.4	1.7	1.1	1.4	4,371
CV (%)									3.64

[a] Stand: total number of plants harvested within the four rows of each plot. [b] Rated lodging on a scale of 1 to 5 as follows: 1.0 = almost all plants erect, 2.0 = either all plants leaning slightly or a few plants down, 3.0 = either all plants leaning moderately (45° angle) or 25-50% down, 4.0 = either all plants leaning considerably or 50-80% down, 5.0 = all plants down. [c] Diseases (Notes 1 to 5): 1 = very light symptoms; 2 = light symptoms; 3 = medium symptoms; 4 = severe symptoms and 5 = very severe symptoms. *Lf* = leaf spot (*Corynespora cassiicola*); Ar = Asian rust (*Phakopsora pachyrhizi*); Ant: anthracnose.

Descriptor detailing: maturity group 8.8; green color hypocotyl; white flowers; brown pubescence; brown pod; seeds presents a flattened sphere shape; medium brightness seed; yellow tegument color; low density of pubescence; light brown hilum; positive reaction to peroxidase; protein and oils levels, 18% and 38%, respectively.

Seed production has begun in 2010 in compliance with the regulations of MAPA. Seed storage and marketing are made by the Federal University of Uberlândia (UFU), which is located at Avenida João Naves de Ávila, nº 2121 Block 3P, CEP: 38408-100, Uberlândia, Minas Gerais , Brazil.

Conclusion

In addition to states of adaptation registered in the MAPA until 12/31/2011, which are Goías, Minas Gerais and Mato Grosso, in our latest tests, UFUS Milionária also have proved well-adapted to Piauí, Tocantis and Bahia states, showing high-yielding even under Asian-rust infection. Recommended cropping between October 20 to December 10 growing seasons; depending on agro climatic zone. Ideal population density is 210 to 230 thousand plants per hectare.

Acknowledgements

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