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Adaptability and stability of conventional and high oleic sunflower genotypes cultivated in Central Brazil

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ABSTRACT

The objective of this study was to evaluate the adaptability and stability of conventional (55 to 65% linoleic acid) and high (greater than 80%) oleic acid sunflower genotypes cultivated in Central Brazil. Grain and oil yield of genotypes were evaluated from 2006 to 2009 under randomly block designs in various locations of the states of Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Rondônia, São Paulo, and Distrito Federal. Genotypes' adaptability and stability were evaluated by the partition of the general mean into means from favourable or unfavourable environments, by the regression coefficients and deviations and the coefficient of determination. The hybrid NTO 3.0 (high oleic genotype) were the only genotype that had superiority in favorable and unfavorable environments, for both traits. Furthermore, this genotype had high stability, high responsiveness to environmental improvement for grain yield and average responsiveness to oil yield.

Key words: genotype by environment interaction, grain yield, *Helianthus annuus*, oil yield.

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INTRODUCTION

Concerns with human health have demanded an increase of agriculture products with high nutritional quality. Sunflower (*Helianthus annuus* L.) is an oilseed crop considered relevant mainly because of the fatty acids found in its oil.

The content of linoleic acid in the oil of sunflower seeds (conventional sunflower) is 55 to 65%. The use of this kind of oil in human diet might reduce cholesterol levels and, consequently decrease the risk of cardiovascular diseases (Miller *et al*., 1987).

Mutant genotypes (high oleic sunflower) having a seed oleic acid content over 80% have been produced (Soldatov, 1976). The presence of this fatty acid in the oil might also bring benefits to health such as the ones provided by the linoleic acid, having the additional advantage of giving the oil a high level of oxidative stability (Miller *et al*., 1987, Grunvald *et al*., 2013).

Besides the oil quality, when compared to most of the species cultivated in Brazil, sunflower presents important agronomic traits, such as tolerance to a dry, cold or hot environment (Castro *et al*., 1997). Because of these characteristics, this crop might be a relevant economic alternative in grain crop rotation and succession systems, mainly in the central region of Brazil. In Central Brazil, a second summer season is common beginning in February or March, taking advantage of the adequate temperature and rainfall conditions. However, to ensure a greater success of the crop, it is necessary to appropriately choose cultivars.

In Brazil, the sunflower genotypes experiment and selection have been carried out by Network of Trial for the Evaluation of Sunflower Genotypes and coordinated by Embrapa. In these field trials, the genotypes selection is made based on the mean performance of grain and oil yield. However, this selection might be difficult when there are different responses because of the environmental variations. The influence of genotypes x environments interaction might be reduced through studies regarding the adaptability and stability. Studies evaluating the grain and oil yield of conventional sunflower cultivars have been performed by Grunvald *et al*. (2008, 2009) and Porto *et al*. (2008, 2009). Evaluations should be performed continuously in order to obtain information from new and more productive genotypes to be provided to farmers. Recently, high oleic cultivars have been analyzed at field trial, however there is no information about the behavior of these genotypes grown in the country yet.

The purpose of this study was to evaluate the adaptability and stability of conventional and high oleic sunflower genotypes cultivated in Central Brazil as for the grains and oil yield from 2007 to 2009.

MATERIALS AND METHODS

Data on grain and oil yield (kg ha^{-1}) resulted from trials carried out from 2007 to 2009 were analyzed in various locations in the states of Goiás (GO), Mato Grosso (MT), Mato Grosso do Sul (MS), Minas Gerais (MG), Rondônia (RO), São Paulo (SP), and Distrito Federal (DF). These trials were part of the Network of Trials for the Evaluation of Sunflower Genotypes, which was coordinated by Embrapa with the participation of several public and private partners. The characteristics of these places and the respective institutions responsible for the trials are described in Table 1.

The cultivars were planted in February or March, in randomized block designs with four replicates. Each plot consisted of four rows 6 m long, spaced from 0.7 to 0.9 m. At harvest, only the two central rows were used for data collection. Plants located until 0.5 m apart from the tip of each central row were also discarded, resulting in a usable area from 7 to 9 m^2 per plot, depending on the space adopted. Fertilization and weeding were made to allow optimum plant development.

The conventional and high oleic sunflower genotypes tested were simple hybrids developed by the companies Advanta, Dow AgroScience, Embrapa Soja, Helianthus do Brasil, Nidera, Sembras, and Seminiun S.A. AGROBEL 960, HELIO 358 and M 734 cultivars (conventional sunflower) were used as controls. Each genotype group was evaluated for two years in the final trials of the first and second years. Fatty acid composition was analyzed by gas chromatography (Grunvald *et al*., 2013).

The analysis of variance was performed on grain and oil yield (kg ha^{-1}) for each year and location (location and year). As the locations of the trials included in the final trials of the first year were not exactly the same ones as those

Table 1 Main characteristics of the locations of Network of Trials for the Evaluation of Sunflower Genotypes and respective research institutions responsible for the trials from 2007 to 2009.

Federal Unit	Location	Crop season	Institution	Latitude	Longitude	Altitude	Soil type
GO	Rio Verde	2008[2]	FESURV	17°47'24"S	50°47140"W	753 m	Dystrophic Red Latosoil
	Porangatu	2009[2]	Agência Rural	13°18'19"S	49°06'27"W	357 m	Red Latosoil
MT	Cáceres	2007[1]	EMPAER	16°13'42"S	57°40'5"W	118 m	Eutrophic argisol
	Campo Verde	2009[2]	UFMT	15°45'12"S	55°22'44"W	740 m	Distrophice Dark-Red Latosoil
	Campos de Julio	2008[2]	AGROPLANT	13°43'43"S	59°15'41"W	660 m	Red Nitosoil
	Sinop	2007[1]	EMPAER	11°50'53"S	50°38'57"W	384 m	Red-Yellow Latosoil
MS	Chapadão do Sul	2008[2], 2009[2]	Fundação Chapadão	18°47'39"S	52°37'22"W	790 m	Dystrophic Red Latosoil
	Dourados	2007[1]	Embrapa Agropecuária Oeste	22°17'08"S	54°48'17"W	375 m	Dystrophic Red Latosoil
MG	Janaúba	2009[2]	EPAMIG	15°01'S	44°03'W	436 m	Red-Yellow Latosoil
	Muzambinho	2008[2] 2009[2]	EAFMUZ	21°22'S	46°31'W	1.048 m	Dystrophic Red Latosoil
	Patrocínio	2009[2]	EPAMIG	18°56'38"S	46°59'33"W	950 m	Dystrophic Red Latosoil
	Patos de Minas	2008[1]	EPAMIG	18°34'44"S	46°31'05"W	832 m	Clayed Red Latosoil
RO	Cerejeiras	2007[1]	Embrapa Rondônia	13°11'S	60°44'W	277 m	Eutrophic Red Latosoil
	Vilhena	2007[1], 2008[1], 2008[2], 2009[2]	Embrapa Rondônia	12°44'26"S	60°08'45"W	600 m	Distrophic Red-Yellow Latosoil
SP	Cravinhos	2008[2], 2009[2]	Dow AgroSciences	21° 17' 57" S	47° 44' 24" W	836 m	Distroferric Red Latosoil
	Jaboticabal	2007[2], 2008[1]	UNESP	21°14'05"S	48°17'09"W	615 m	Eutroferric Red Latosoil
	Manduri	2009[2]	CATI	23°10'S	49°20'W	589 m	Dystrophic Red Latosoil
DF	Planaltina	2007[1], 2008[1], 2008[2], 2009[2]	Embrapa Cerrados	15°35'30"S	47°42'30"W	1007 m	Dystrophic Red Latosoil

[1] Final trial of the first year. [2] Final trial of the second year.

chosen for the final trials of the second year, a joint analysis of environment (specific location and year) for each group of cultivars was carried out. The homogeneity of residual variances obtained in individual analysis was verified. In this test, variances were considered as homogeneous when the ratio between the larger and the smaller residual mean square was smaller than 7.0 (Pimentel Gomes, 1985). The effects of genotypes were considered fixed and the environment, random.

To select the genotype according to the grain and oil yield, a stability and adaptability study was carried out by using the methodology presented by Porto *et al*. (2007). In this study, there is a partition of the general mean into means from favorable (FE) or unfavorable environments (UE). A favorable environment was defined as the one with a mean greater than the trial general mean and the unfavorable was defined as the one with a mean lower than the general mean (Verma *et al*., 1978). When a genotype had a superior mean only in favorable environments, it was indicated to this type of environment and the same for unfavorable environments. When the mean was superior for both environments, it would be assigned as environments in general.

The genotypes superiority, in different environments, was verified using Duncan's test at the probability level of 10%. This level was adopted, because significant differences using mean tests were not usually observed among the sunflower genotypes (Grunvald *et al*., 2009; Porto *et al*., 2007; Porto *et al*.,2008). Additionally, the regression coefficient (β_{1i}), deviation from regression (δ^2_d) and the determination coefficient (R^2) were calculated according to Eberhart and Russell (1966). In this study, when $\beta_{1i} > 1$, the genotype showed a high responsiveness to improved environmental conditions and when $\beta_{1i} < 1$, the genotype showed low responsiveness. The parameters δ^2_d and R^2 were associated to genotypes stability or predictability. The analysis of variance and mean tests were carried out by using SAS (SAS Institute, 1999) software program. Regression and determination coefficients and deviation from regression by using Genes software (Cruz, 2006).

RESULTS AND DISCUSSION

In the joint analysis of variance, significant differences among the genotypes were found for grain and oil yield (Table 2). The coefficient of variation (C.V.) for these traits ranged from 12.79% to 15.26%, values classified as average showing a good experimental accuracy, according to Pimentel-Gomes (1985) and Carvalho *et al*. (2003).

When using Duncan's test at the probability level of 10%, the genotypes that showed the greater general means for grain yield, between 2007 and 2009, were BRSGIRA 23, BRSGIRA 20, BRSGIRA 18, NEON and NTO 3.0 (high oleic genotype) (Table 3). As for oil yield, the hybrids with the best performance were HLA 863, BRSGIRA 20, NTO 3.0, PARAISO 20, TRITONMAX, HLT 5004, BRSGIRA 26, PARAISO 33 and NEON (Table 4). Only BRSGIRA 20, NEON and NTO 3.0 were superior to both characteristics evaluated in the study. For these characteristics, the last two hybrids showed a better performance than the other three controls. According to Oliveira *et al*. (2005), when a genotype is superior in relation to only one of the evaluated traits, the farmer should choose the best hybrid based on the current marketing policy of the sunflower seeds crushing plants. Currently, the plants provide bonus for genotypes which oil content is over 40%. When there is a bonus, the preference for hybrids presenting a better oil yield due to the grain yield will also increase.

Besides the genotypes, significant differences were found in the genotype x environment interaction (G x E) for the analyzed characteristics (Table 2), showing there was a change in the genotypes production performance in the several environments evaluated. The interaction (G x E) in sunflower cultivar yield trials was also verified in other sunflower genotypes evaluation studies in Central (Grunvald *et al*., 2008; Porto *et al*., 2008) and South of Brazil (Grunvald *et al*., 2009; Porto *et al*. 2009). This presence justifies the genotypes adaptability and stability study to detect those with good performance in specific or environments in general.

In the adaptability and stability study, based on the method by Porto *et al*. (2007) and considering the 2008 cropping season, it was found that grain yield for BRSGIRA 23,

Table 2 Joint analysis of variance for grains and oil field (kg ha^{-1}) of sunflower genotypes evaluated at Network of Trials, coordinated by Embrapa, from 2007 to 2009.

Variable	Cropping season	
	2008[(1)]	2009
Grain yield		
QMG[(2)]	1,545,773.72**	1,895,748.46**
QMGA[(3)]	282,667.80**	310,073.03**
C.V. (%)[(4)]	12.79	1.63
Mean[(5)]	2777	2311
Oil yield		
QMG	227,229.46**	475,969.74**
QMGA	63,700.03**	73,129.58**
C.V. (%)	13.21	15.26
Mean	1018	1023

** Significant at a level of probability of 1% using F test. [(1)]Evaluations made in 2008 included experimental data from the final trial of the first year (2007) and final trial of the second year (2008), with similar procedure for 2009. [(2)]QMG: Genotype mean square. [(3)]QMGA: genotype by environment interaction mean square. [(4)]C.V.: Experimental coefficient of variation in %.[(5)]General mean in kg ha^{-1}.

BRSGIRA 20 and BRSGIRA 18 was superior in favorable and unfavorable environments, being assigned for environments in general. Hybrid HLA 863 showed to be superior only in favorable environments (Table 3). For oil yield, the hybrids BRSGIRA 20, HLA 863, BRSGIRA 23, BRSGIRA 19, BRSGIRA 12, BRSGIRA 13, BRSGIRA 04, BRSGIRA18 and V50386 (high oleic genotype) were superior only in favorable environments. No genotype from 2008 cropping season evaluated was indicated for environments in general regarding oil yield (Table 4). In relation to the controls performance of the characteristics evaluated, when considering the set of genotypes tested, only hybrid AGROBEL 960 was indicated for environments in general.

In the 2009 cropping season, for grain yield, genotypes NEON and NTO 3.0 were indicated for environment in general and hybrids BRSGIRA 26, PARAISO 20, TRITONMAX and BRSGIRA 06 were indicated for unfavorable environments. For oil yield, genotypes NTO 3.0, PARAISO 20 and PARAISO 33 were indicated for environments in general and hybrids TRITONMAX, HLT 5004, BRSGIRA 26, NEON, EXP 1450 (high oleic genotype), BRSGIRA 06 were indicated for unfavorable environment. Only genotype NTO 3.0 (high oleic genotype) was assigned for environment in general for two characteristics. Different from the 2008 cropping season, none of the controls had this indication. Because in each crop a set of distinct genotypes are evaluated and the comparison in performance is made for each set, a genotype might be assigned for specific or general environments in a cropping season, but have a different indication when another group of genotypes is selected.

By using the method of Porto *et al*. (2007) genotypes that were not selected based on the general mean were identified, but they showed a good performance in specific environments, such as EXP 1450 and BRSGIRA 06 (2009 cropping season) in the selection for oil yield. These genotypes had a good performance in unfavorable environments, even not having superiority on the general mean. On the other side, some genotypes were indicated based on the general average, but were superior only in one type of environment. This might be verified in the 2008 cropping season for all genotypes selected based on the general average for oil yield, but that were assigned for favorable environments (Table 4). These results evidence the importance and need to carry out adaptability and stability studies of genotypes in order to select them, according of the general average analysis.

To contribute with additional information to the genotypes in respect to different environments, analysis of the regression coefficient (β_{1i}), deviation from regression (δ^2_d) and determination coefficient (R^2) were made (Tables 3 e 4). According to Porto *et al*. (2007), genotypes might have a good performance in favorable and unfavorable environments, being recommended for both environment, but present differences in their response (β_{1i}) to the improved environmental conditions (more fertilization, proper planting date, better sanitary control).

In the present study, these differences might be observed for BRSGIRA 20 and BRSGIRA 23 for the grain yield evaluated during the 2008 cropping season. These two hybrids might be cultivated in favorable and unfavorable environments, but the first hybrid showed $\beta_{1i} > 1$ (high responsiveness) and the second, $\beta_{1i} = 1$ (average responsiveness). Namely, the hybrids BRSGIRA 20 and BRSGIRA 23 have performed well, but the hybrid BRSGIRA 20 responds more favorably to improvement in the environmental conditions, than BRSGIRA 23. In the 2009 cropping season, similar results were found for NTO 3.0 ($\beta_{1i} = 1$) and PARAISO 20 ($\beta_{1i} > 1$) in terms of oil yield.

As for the genotypes stability or predictability, the regression deviations (δ^2_d) were, in general, significant. However, the determination coefficients (R^2) were high (over 80%) indicating the high stability and predictability (Tables 3 and 4), as suggested by Cruz and Regazzi (2003).

Most of the hybrids selected for grain and/or oil yield, between 2007 and 2009, are conventional sunflower genotypes (55% - 65% linoleic acid). This result might be explained by the greater number of conventional hybrids selected and longer period of genetic improving. Similar to oil content, even when high oleic genotypes present a poor performance, the farmer might choose them, in cases where the industries grant a bonus for cultivars with a good oil quality. The higher the bonus, the bigger will the preference for high oleic hybrids. Even with a reduced number of high oleic genotypes been evaluated, hybrid NTO 3.0 (high oleic) was the only genotype that had general indication for grain yield as well as oil yield (Table 3 and 4). Besides the high stability (R^2 over 80%), this hybrid also showed a high responsiveness ($\beta_{1i} > 1$) for grains yield and mean responsiveness ($\beta_{1i} = 1$) for oil yield. Despite recent researches, these results show that genetic improvement programs have been able to develop high oleic genotypes with yields similar to the conventional, which is facilitated by the non-complex heritage in the expression of this characteristic (Miller *et al*., 1987).

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Table 3 General mean and adaptability and stability parameters obtained by using the method by Porto et al. (2007), for grains yield (kg ha^{-1}) of sunflower genotypes evaluated at Network of Trials, coordinated by Embrapa from 2007 to 2009.

	MG(1)	MF(2)	MD(3)	β_{1i}(4)	δ^2_d(5)	R^2(6)
Safra 2008(7)						
BRSGIRA 23 (LIN)(8)	2536 a(10)	3270 a	2047 ab	1.09 ns	10.135.24 ns	95.43
BRSGIRA 20 (LIN)	2518 a	3222 ab	2049 ab	1.15#	20.057.87*	94.64
AGROBEL 960 (LIN)(9)	2433 ab	3006 abcd	2051 ab	0.74##	45.010.86**	81.85
M 734 (LIN)(9)	2429 ab	2839 cdef	2155 a	1.05 ns	174.288.77**	75.41
BRSGIRA 18 (LIN)	2407 abc	3025 abc	1994 abc	1.09 ns	476.82 ns	96.92
HELIO 358 (LIN)(9)	2381 abcd	3023 abc	1954 bcd	1.02 ns	1.306.74 ns	96.65
BRSGIRA 19 (LIN)	2298 bcde	2894 bcdef	1901 bcd	0.88#	13.995.50 ns	92.40
HLA 863 (LIN)	2281 bcde	2941 abcde	1841 cde	1.07 ns	37.849.47**	91.43
BRSGIRA 13 (LIN)	2244 cdef	2885 bcdef	1817 cde	1.01 ns	28.145.16**	91.84
BRSGIRA 12 (LIN)	2234 cdef	2898 bcdef	1792 de	1.11#	21.765.76*	94.06
BRSGIRA 22 (LIN)	2215 defg	2791 cdef	1832 cde	0.86#	115.289.11**	74.85
V 50386 (OL)	2135 efg	2641 def	1797 cde	1.04 ns	102.087.54**	82.83
BRSGIRA 07 (LIN)	2096 fg	2561 f	1787 de	0.73##	39.75 ns	93.30
BRSGIRA 14 (LIN)	2093 fg	2737 cdef	1664 e	1.05 ns	46.297.45**	89.88
BRSGIRA 04 (LIN)	2088 fg	2749 cdef	1648 e	1.08 ns	16.424.29*	94.41
BRSGIRA 16 (LIN)	2039 g	2606 ef	1662 e	0.94ns	37.408.41**	89.15
MG	2277	2881	1874	-	-	-
MT(11)	2415	2956	2053	-	-	-
Safra 2009						
NEON (LIN)	2692 a	3676 a	2200 a	1.12#	124.525.90**	80.64
NTO 3.0 (OL)	2562 ab	3649 a	2018 ab	1.26##	9.495.52ns	95.47
M 734 (LIN)(9)	2472 bc	3302 ab	2057 ab	1.02ns	10.842.58ns	92.98
BRSGIRA 26 (LIN)	2442 bc	3177 bc	2075 ab	1.02 ns	47.016.12**	87.51
PARAISO 20 (LIN)	2429 bc	3253 b	2017 ab	1.07 ns	15.563.54ns	92.90
TRITONMAX (LIN)	2424 bc	3189 bc	2041 ab	0.92 ns	49.691.22**	84.44
PARAISO 33 (LIN)	2340 cd	3245 b	1888 bcd	1.09 ns	47.416.10**	88.79
HLT 5004 (LIN)	2333 cd	3085 bcd	1957 bc	0.90 ns	- 3.931.85ns	94.34
BRSGIRA 06 (LIN)	2305 cde	2874 bcd	2021 ab	0.92 ns	156.117.29**	69.70
V 20041 (LIN)	2280 cde	2921 bcd	1959 bc	0.70##	70.388.75**	71.72
HELIO 358 (LIN)(9)	2205 de	3018 bcd	1798 cde	1.01 ns	30.296.48*	89.69
EXP 1450 (OL)	2191 def	3033 bcd	1770 cde	1.02 ns	21.377.98*	91.29
SRM 822 (OL)	2179 def	3074 bcd	1732 de	1.07 ns	-120.09ns	95.32
HLS 07 (LIN)	2168 def	2986 bcd	1759 cde	1.02 ns	53.738.29**	86.54
AGROBEL 960 (LIN)(9)	2135 ef	2975 bcd	1715 de	0.93 ns	22.750.33*	89.61
HLE 15 (LIN)	2125 ef	2767 cd	1804 cde	0.90 ns	20.518.62ns	89.28
ZENIT (LIN)	2001 f	2726 d	1638 e	0.96 ns	57.816.33**	84.31
MG	2311	3115	1909	-	-	-
MT	2270	3098	1856	-	-	-

1/MG = General mean. (2)MF = favorable environment mean. (3)MD = unfavorable environment mean. (4)β_{1i}= regression coefficient. (5)δ^2_d= deviation from regression. (6)R^2=e o determination coefficient. (7) Evaluations in 2008 included experimental data obtained during the first trial of first year (2007) and final trial of the second year (2008), with procedures similar to 2009. (8)LIN = linoleic genotype; OL = high oleic genotype. (9)Trial controls.(10) The means followed by the same letter, in the column, do not significantly differ from each other by using Duncan's test at a probability level of 10%. * and ** significant at a level of probability of 1 and 5%, respectively, by using the T test., # and ## significant at a level of probability of 1 and 5%, respectively, by using the F test. ns not significant. (11)MT = control mean.

Table 4 General mean and adaptability and stability parameters obtained by using the method by Porto et al. (2007), for oil yield (kg ha^{-1}) of sunflower genotypes evaluated at Network of Trials, coordinated by Embrapa from 2007 to 2009.

[1/]MG = General mean. [(2)]MF = favorable environment mean. [(3)]MD = unfavorable environment mean. [(4)]β_{1i}= regression coefficient. [(5)]δ^2_d= deviation

	MG[(1)]	MF[(2)]	MD[(3)]	β_{1i}[(4)]	δ^2_d[(5)]	$R^{2(6)}$
2008 cropping season[(7)]						
AGROBEL 960 (LIN)[(8)(9)]	1.134 a[(10)]	1.405 ab	953 a	0.79$^{\#\#}$	13.149.03**	80.40
HELIO 358 (LIN)[(9)]	1.121 ab	1.447 a	904 ab	1.13$^{\#}$	1.076.19^{ns}	96.35
HLA 863 (LIN)	1.054 abc	1.365 abc	848 bcd	1.03^{ns}	11.559.46**	88.40
BRSGIRA 20 (LIN)	1.054 abc	1.359 abc	850 bcd	1.08^{ns}	2.197.20^{ns}	95.25
BRSGIRA 23 (LIN)	1.041 bcd	1.357 abc	830 bcd	1.04^{ns}	1.956.95^{ns}	95.09
BRSGIRA 19 (LIN)	1.040 bcd	1.334 abcd	844 bcd	0.92^{ns}	3.156.04^{ns}	92.74
BRSGIRA 12 (LIN)	1.035 bcd	1.341 abc	832 bcd	1.09^{ns}	3.056.89^{ns}	94.80
BRSGIRA 13 (LIN)	1.029 cde	1.337 abc	823 bcd	1.05^{ns}	5.925.56**	92.43
BRSGIRA 04 (LIN)	1.021 cde	1.359 abc	796 cde	1.17$^{\#}$	6.975.05**	93.20
BRSGIRA 18 (LIN)	1.012 cde	1.300 abcd	820 bcd	1.02^{ns}	1.421.30^{ns}	97.52
V 50386 (OL)	1.010 cde	1.264 abcd	840 bcd	1.07^{ns}	27911.64**	80.52
M 734 (LIN)[9/]	986 cdef	1.156 d	873 abc	0.94^{ns}	34.652.43**	72.59
BRSGIRA 16 (LIN)	953 def	1.224 bcd	772 de	0.96^{ns}	10.125.11**	87.94
BRSGIRA 22 (LIN)	944 ef	1.222 bcd	758 de	0.85^{ns}	18.662.54**	78.25
BRSGIRA 07 (LIN)	942 ef	1.182 cd	782 cde	0.73$^{\#\#}$	4.114.83*	87.93
BRSGIRA 14 (LIN)	908 f	1.181 cd	726 e	1.05^{ns}	16.175.35**	86.14
MG	1.018	1.302	828	-	-	-
MT[(11)]	1.081	1.336	910	-	-	-
Safra 2009						
NTO 3.0 (OL)	1.159 a	1.706 a	885 abcd	0.91^{ns}	15.919.68**	80.24
PARAISO 20 (LIN)	1.145 a	1.583 ab	925 ab	1.33$^{\#\#}$	5.865.23*	94.06
TRITONMAX (LIN)	1.124 ab	1.527 bc	923 ab	1.03^{ns}	10.469.59**	87.40
HLT 5004 (LIN)	1.094 abc	1.501 bc	891 abc	1.00^{ns}	1.427.89^{ns}	93.44
BRSGIRA 26 (LIN)	1.088 abc	1.409 bcdef	928 a	1.09^{ns}	4.717.67*	92.20
PARAISO 33 (LIN)	1.082 abc	1.539 abc	854 abcd	1.18$^{\#\#}$	15.282.59**	87.46
NEON (LIN)	1.076 abc	1.447 bcde	890 abc	1.14$^{\#}$	-147.23^{ns}	95.92
EXP 1450 (OL)	1.039 bcd	1.454 bcd	831 abcd	1.20$^{\#\#}$	6.363.66*	92.55
SRM 822 (OL)	1.017 cdef	1.472 bcd	789 cdef	1.04^{ns}	7.740.69**	89.35
HELIO 358 (LIN)[(9)]	1.014 cdef	1.412 bcdef	815 cd	0.97^{ns}	11.691.61**	85.21
V 20041 (LIN)	984 def	1.306 defgh	823 bcd	0.75$^{\#\#}$	17.348.68**	72.37
AGROBEL 960 (LIN)[(9)]	978 def	1.368 cdefg	784 def	0.94^{ns}	4.706.74*	89.87
BRSGIRA 06 (LIN)	976 def	1.268 efgh	830 abcd	0.92^{ns}	32.075.23**	70.34
M 734 (LIN)[(9)]	953 def	1.245 fgh	807 cd	0.80$^{\#\#}$	3.218.21^{ns}	88.15
HLE 15 (LIN)	929 efg	1.196 gh	795 cde	0.81$^{\#\#}$	11.986.28**	79.70
HLS 07 (LIN)	885 fg	1.246 fgh	704 ef	0.95^{ns}	7.470.26**	87.87
ZENIT (LIN)	853 g	1.163 h	698 f	0.86$^{\#}$	13.971.77**	79.87
MG	1.023	1.402	834	-	-	-
MT	982	1.341	802	-	-	-

from regression. [(6)]R^2=e determination coefficient. [(7)]Evaluations in 2008 included experimental data obtained during the first trial of first year (2007) and final trial of the second year (2008), with procedures similar to 2009. [(8)]LIN = linoleic genotype; OL = high oleic genotype. [(9)]Trial control.[(10)]The means followed by the same letter, in the column, do not significantly differ from each other by using Duncan's test at a probability level of 10%. * and ** significant at a level of probability of 1 and 5%, respectively, by using the T test., $^{\#}$ and $^{\#\#}$ significant at a level of probability of 1 and 5%, respectively, by the F test. ^{ns} not significant. [(11)]MT = control mean.