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GENETIC ENHANCEMENT OF SEMI-EXOTIC MAIZE GERMPLASM

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ABSTRACT - The characterization of 26 populations with varying levels of exotic germplasm was conducted in two environments representing distinct locations and planting seasons. The whole set was identified by five subsets: ***I*** ≡ local adapted germplasm; ***II*** ≡ exotic derived from tropical germplasm; ***III*** ≡ semi-exotic derived from tropical germplasm; ***IV*** ≡ semi-exotic derived from varying proportion of tropical and temperate germplasm; and ***V*** ≡ semi-exotic derived from temperate germplasm. In the experiment **εI** (Anhembi, SP; three replications) the mean yield (EW - ear weight, t ha^{-1}) for the five sets were 9.49, 8.88, 9.11, 8.68 and 8.51; which are equivalent to 79.5, 74.4, 76.3, 72.7 and 71.3 in percent of the hybrid check. Means for other traits (E10 – weight of ten ears, EL – ear length, ED – ear diameter, and TB – tassel branch number) were also shown. In the experiment **εII** (Piracicaba, SP; no replications), the following traits were evaluated: EW, GW (grain weight), GR (grain yield ratio), MF (days to male flowering), and SW (specific weight). A low correlation (0.220) was observed for EW between environments. In general, the populations under study presented a fairly good potential to be used in breeding programs.

Key words: exotic germplasm, population improvement, *Zea mays*.

SOBRELEVAÇÃO DO VALOR GENÉTICO DE GERMOPLASMA SEMIEXÓTICO DE MILHO

RESUMO - A caracterização de 26 populações com vários níveis de germoplasma exótico foi conduzida em dois ambientes, representando locais e épocas de plantio distintas. O conjunto total foi identificado por cinco subconjuntos: ***I*** ≡ germoplasma local adaptado; ***II*** ≡ exótico derivado de germoplasma tropical; ***III*** ≡ semiexótico derivado de germoplasma tropical; ***IV*** ≡ semiexótico derivado de variadas proporções de germoplasma tropical e temperado; e ***V*** ≡ semiexótico derivado de germoplasma temperado. No experimento **εI** (Anhembi, SP; três repetições), as médias de produção (EW – peso de espigas, t ha^{-1}) para os cinco subconjuntos foram 9,49, 8,88, 9,11, 8,68 e 8,51, que são equivalentes a 79,5%, 74,4%, 76,3%, 72,7% e 71,3% da média da testemunha. As médias de outros caracteres (E10 – peso de 10 espigas, EL – comprimento da espiga, ED – diâmetro da espiga e TB – número de ramificações do pendão) também foram apresentadas. No experimento **εII** (Piracicaba, SP; sem repetição), foram avaliados os caracteres: EW; GW (peso de grãos); GR (rendimento de grãos); MF (dias para florescimento masculino); e SW (peso específico). Uma baixa correlação (0.220) foi observada para EW entre ambientes. As populações avaliadas apresentam bom potencial para serem usadas em programas de melhoramento.

Palavras chave: germoplasma exótico, melhoramento de populações, *Zea mays*.

Although the importance of exotic germplasm for use in maize breeding has long been emphasized by several authors (Brown, 1953; Hallauer, 1978; Duvick, 1981; Oliveira et al., 2015a), its effective proportion is below 3% of the cropped maize in the United States (Goodman, 1985). When considering germplasm all over the world, most commercial hybrids comprise six major racial groups (**1.** Corn Belt Dents; **2.** Northern Flints; **3.** South America Cateto Flints; **4.** Mexican Dents; **5.** Caribbean Flints; and **6.** Tusons). Recently, the global strategy of seed companies for maize breeding programs over the world may increase the interchange of exotic germplasm (Goodman, 2005).

In Brazil, the maize germplasm is characterized by wide variability, including local or indigenous races, adapted populations and exotic or semiexotic germplasm with various levels of adaptation. Collections of inbred lines and other sources used in active breeding programs also are an expressive portion of the potentially useful germplasm (Nass et al., 2001). Extensive maize breeding programs initiated in the decade of 1930 when seeds of the first commercial hybrid were produced (Krug et al., 1943). In sequence, the introduction of exotic germplasm, particularly Tuxpeño and related races of Mexico and Central America, as well as other important germplasm sources from Colombia, Cuba, and Caribbean region greatly contributed for the development of outstanding semi-dent hybrids (Miranda Filho & Viégas, 1987). Brieger et al. (1958) described 52 races from Brazil and adjacent countries and about 3,000 collected samples originated the Brazilian germplasm bank. Other introductions of exotic germplasm were further reported (Môro et al., 1981; Lima et al., 1982; Miranda Filho, 1985; Miranda Filho & Viégas, 1987; Miranda Filho, 1992).

In addition, it is appropriate to stress that the use of germplasm with wide genetic base is a primary criterion to assure positive perspectives in the gain from selection (Carena, 2013a). In fact, the evaluation of exotic and semiexotic populations have shown the importance of their use in breeding programs. Mendes et al. (2015) worked in a project for the incorporation of semiexotic germplasm into local and adapted populations and showed good perspectives for the enhancement of the basic germaplasm for the conditions of the Southwest region in the State of Goiás. In the same line, Oliveira et al. (2015a, 2015b) reported on the performance of three semiexotic populations derived from exotic germplasm with potential for *corn stunt* resistance and concluded that the program was based on appropriate strategies for widening the perspectives of breeding programs. The possibility of higher stability of populations derived from exotic germplasm to environments under abiotic stresses also was emphasized by Carena (2013b).

The objective of the present project was the characterization of several populations with varying levels of exotic germplasm, relative to their potential of yield and other traits to be used in other local breeding programs toward the widening of genetic variability and the exploitation of other important traits.

Material and Methods

Along the final three decades of the last century, the maize breeding program at the Department of Genetics (ESALQ/USP) accumulated several sources of germplasm from diverse origins which were used not only as introduction but also for incorporation into local adapted populations (Miranda Filho, 1985; Nass et al., 2001). Recently, 36 populations of that collection were multiplied in isolated blocks under the condition of “safrinha” (second crop) in the region of Jataí, Southwest of the State of Goiás. From

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the collection above mentioned, 26 populations with varying proportions of exotic germplasm were chosen for characterization relative to their potential for breeding purposes. The identification of populations is shown in Table 1.

The 26 populations were evaluated in 2008 (normal season) at Anhembi (SP) in a completely randomized block experiment (**εI**) with three

Table 1. Identification and origin of 26 open-pollinated populations with varying levels of exotic germplasm.

Þ	Identification	Origin
01	Syn RV-01	Recombination of hybrids HG (4, 5, 13, 14) [я]
02	Syn RV-02	Recombination of hybrids HG (6, 7, 9, 10) [я]
03	Syn RV-03	Recombination of hybrids HG (4, 5, 7, 10) [я]
04	Syn RV-04	Recombination of hybrids HG (3, 6, 9, 11) [я]
05	PAQ-1	Introgression of germplasm from Pakistan[Љ] in line L27
06	PAQ-2	Introgression of germplasm from Pakistan[Љ] in line L07
07	PAQ-3	Introgression of germplasm from Pakistan[Љ] in line L29
08	Comp. G3	Intercross: CMS-14C, CMS 28, CMS 39, BR 105, Nitrodente
09	Comp. G4	Intercross: CMS 50, BR 106, Cunha, Sin. Elite, Saracura
10	CUBAEX	Intercross: Cuba 173 x B73, Cuba117 x B73, Cuba 110 x Mo17
11	PAQ-4	Introgression of germplasm from Pakistan[Љ] in line L14
12	GO-SPR	Selection of half-sib family from population Suwan (Ne = 4)[ь]
13	ARGITA	Composite: hybrids from Argentina x local population (ITA)
14	RCE-01	Intercross: [CMS 14C, IAPAR 51, PASCO 014] [a] x P-3041
15	RCE-02	Intercross: [SE 032, BR 105, CMS 24] [a] x P-3041
16	RCE-03	Intercross: [MAYA XVI, MS 007, BA 187, BA 032] [a] x P-3041
17	Comp. TUTU	Intercross: Population BR-106 (Tuxpeño) x Tusón (Cuban)
18	Comp. GO-B	Composite Goiás ≡ bulk selection for white kernel ears
19	Comp. RL	Composite resistant to fall armyworm
20	NAP– *flint* A	bulk selection for yellow kernel ears (flint type endosperm)
21	NAP– *flint* L	bulk selection for orange kernel ears (flint type endosperm)
22	NAP– *dent* B	bulk selection for white kernel ears (dent type endosperm)
23	NAP– *flint* B	bulk selection for white kernel ears (flint type endosperm)
24	NAP– RPM	selection of accesses for resistance to *Phaeosphaeria maydis*
25	Comp. Calor-F	Composite with heat tolerance (flint type pattern)
26	Comp. Calor-D	Composite with heat tolerance (dent type pattern)

Þ – [Number of identification]; [я] [Populations (F_2) derived from commercial hybrids collected in the region of Jataí (GO)]; [Љ] (Germplasm from Pakistan with potential for earliness and heat resistance]; [ь] [selection of one half-sib family for prolificacy]. [a] (Accesses from the germplasm bank selected for resistance to corn stunt complex]. [NAP – Research Project NAP-MILHO (Núcleo de Apoio à Pesquisa do Milho/USP, ESALQ/USP).

replications of two-row plots with 4 m long and 20 plants per plot after thinning. Spaces of 0.90 m between rows and 0.20 m between plants were used, thus resulting a population density of 55,555 plants. ha^{-1}. The following traits were analyzed: EW – total ear weight (t. ha^{-1}) adjusted for the variation of the expected number of ears per plot (n=20); E10 – weight of ten ears (t. ha^{-1}) chosen by their regular appearance; EL – ear length (cm); ED – ear diameter (cm); TB – tassel branch number; [for EL, ED and TB the experimental unity for analysis was the mean of 10 plants per plot (5 plants in each row of the whole plot)]. The commercial hybrid DAS 2B710 was used as check, intercalated between ten plots within each replication and at the end of replications. The analysis of variance was performed for each trait and estimates were obtained for the parameters: m_0: overall mean of populations; m_T: check mean, CV%: coefficient of variation. The observed means for each population were also shown.

In the same year the whole set of 26 populations was planted at Piracicaba (SP) in observation block experiment (**εII**) under the condition of second crop ("safrinha", 2009) without replications (Miranda Filho & Reis, 2012). Plots were of 4 m linear rows spaced 0.90 m and the following traits were analyzed: EW – ear weight (t. ha^{-1}), GW– grain weight (t. ha^{-1}), GR – grain yield ratio (GW/EW), MF – days to male flowering, SW – specific weight (weight/volume: kg/200 ml); traits EW and GW were analysed after adjustment to the expected number (20) of ears per plot, that is an approximation of the expected number of plants per plot (55,555 plants/hectare).

Results and Discussion

The analysis of variance referring to five traits of 26 populations evaluated in three replications (Experiment ε**I**) is shown in Table 2. A high significance (F test: $P < 0.01$) for the variation among populations was observed for all traits. On the average, the yield traits (EW and E10) showed means around 9 t ha^{-1} and 10 t ha^{-1}, representing 75.7% and 81.5%, respectively, of the check means; the yield level for EW was similar to the average (~8.5 tha^{-1}, representing ~77% of the check mean) reported by Miranda Filho & Nass (2001) for three semi-exotic populations (ESALQ-PB1 X Cravo). For ear traits (EL and ED) the population means (16.6 cm and 4.72 cm) were smaller than the check mean (18.0 cm and 4.80 cm). The mean tassel size of populations, evaluated by the number of branches (15.3), was

Table 2. Analysis of variance, estimated means and coefficient of variation for five traits in maize populations. [Experiment **εI**].

Source	df	EW[1]	E10[1]	EL[2]	ED[2]	TB
Populations	25	1.6991	2.3663	2.3022	10.406	811.96
Error	50	0.4861	0.9242	1.0542	1.9646	223.08
m_0		9.038	10.225	16.6	4.72	15.3
m_T		11.940	12.543	18.0	4.80	10.7
m_0%		75.7	81.5	92.0	98.2	143.2
CV%		7.7	9.4	6.2	3.0	13.8
F [pop]		3.50**	2.60**	2.18**	5.30**	7.30**

[1] Mean squares (M) in $t.ha^{-1}$; [2] cm. ** Significance of the F test: $P<0.01$.

around 50% higher than the hybrid check (10.7).

A more detailed analysis of the population means is shown in Table 3. The most promising populations for EW were **08** (Composite G3) and **16** (RCE-03). The first was evaluated by Nass & Miranda Filho (1999) and showed a yield level equivalent to 83.5% of the hybrid check (G-85), on the average of nine experiments (450 half-sib families); information on the second population (composite RCE-03) comes from a predicted yield (Basso & Miranda Filho, 2001) which should be equivalent to 95.7% of the hybrid check (P-3041). On the opposite side, the poorest yielding (around 7.7 t ha^{-1} or 67% of the check mean) populations were **11** (PAQ-4) and **21** (NAP– *flint* L); both populations are identified as semi-exotics because the first was obtained by incorporation of germplasm from Pakistan into local and adapted inbred line; and the second was synthesized from accesses of the Brazilian germplasm bank including sources of several regions. Therefore, the lower level of adaptation of those populations was expected at some extent.

For ear length, only three populations [**08**: Composite G-3; **18**: Composite GO-B; **22**: NAP– *dent* B] showed means around 18 cm, very close to the check mean; the lower means (<16 cm) were for populations **06** (PAQ-2), **11** (PAQ-4) and **19** (Composite RL), all developed from incorporation of exotic germplasm. For ear diameter, 10 populations showed to be higher than the check hybrid (4.80cm), and the extremes (4.93, 4.97 and 5.03 cm) were to **03** (Syn RV-03), **04** (Syn RV-04), **06** (PAQ-2) and **07** (PAQ-3). For the trait TB, only three populations (**3, 6 and 11**) showed means lower than the check hybrid (10.7); the higher means were for populations **19** (19.7cm) and **22** (21.2cm), whose origin trace back mostly to tropical exotic germplasm.

In the experiment **εII** (late planting), shown in Table 4, seven out of 26 populations yielded above 10 t ha^{-1} (ear weight) but the three most promising were **08** (Composite G3), **09** (Composite G4) and **10** (CUBAEX) with means above 11 t ha^{-1}; populations **08** and **10** also were among the three most promising for grain weight (>9.5 t ha^{-1}) but population **12** (GO-SPR) also were in that group with 9.0 t/ha. The poorest yielding populations were **11**, **06**, **14** and **21** for both ear weight (EW) and grain weight (GW); populations **11** and **21** also were the less yielding in the experiment **εI**. Populations **15** (RCE-02), **20** (NAP– *flint* A) and **25** (Composite *Calor-F*) also were outstanding for yield potential. A high correlation (0.962) was observed between EW and GW. However, the correlation between means of the two experiments (**εI** and **εII**) for EW was low (0.220) indicating expressive interaction between the two environments (Anhembi, normal season; Piracicaba, off-season); in fact, the lack of correlation of population means between environments is the main cause of the genotype by environment interaction (Cockerham, 1963).

The grain yield ratio (GR) varied from 0.793 (**09**: Composite G4) to 0.913 (**18**: Composite GO-B); values above 0.9 were shown by populations **02** (Syn RV-02), **13** (ARGITA), **14** (RCE-01), **17** (Composite TUTU) and **18** (Composite GO-B). The trait MF (days to male flowering) varied from 62 (**07**: PAQ-3) to 72 (**16**: RCE-03); other two earlier populations were **06** (PAQ-2) and **14** (RCE-01). Actually, the populations labeled as PAQ were obtained from incorporation of germplasm from Pakistan, which showed to be very early in the Brazilian condition, so that the first attempt to make the interpopulation cross was lost for failure of flowering coincidence. On the other hand, the population RCE-03 was developed by

Table 3. Observed means of five traits in populations of maize with varying levels of exotic germplasm. [Experiment **εI**].

Population	Traits[a]						
	EW	EW%	E10	E10%	EL	ED	TB
01	9.549	80.0	10.380	82.7	16.2	4.83	13.3
02	9.536	79.9	11.667	93.0	16.8	4.90	11.6
03	9.971	83.5	11.398	90.9	16.7	5.03	10.6
04	9.830	82.3	11.065	88.2	17.0	4.97	12.0
05	8.570	71.8	9.685	77.2	16.8	4.83	11.8
06	8.696	72.8	9.639	76.8	15.1	5.03	9.8
07	9.030	75.6	10.556	84.1	16.1	4.93	11.9
08	10.634	89.1	10.981	87.6	17.9	4.73	18.4
09	8.924	74.7	9.704	77.4	16.3	4.53	14.8
10	8.910	74.6	9.796	78.1	16.7	4.57	18.4
11	7.731	64.7	8.333	66.4	14.8	4.80	9.0
12	9.652	80.8	11.713	93.4	17.1	4.87	14.0
13	8.117	68.0	9.463	75.4	17.1	4.53	15.6
14	9.777	81.9	10.231	81.6	16.3	4.83	16.8
15	8.480	71.0	9.769	77.9	16.0	4.53	15.0
16	10.266	86.0	11.704	93.3	17.0	4.90	13.3
17	8.111	67.9	9.065	72.3	16.1	4.70	18.7
18	8.557	71.7	10.648	84.9	18.0	4.57	18.2
19	9.106	76.3	9.713	77.4	14.4	4.60	19.7
20	8.698	72.8	10.037	80.0	17.7	4.57	15.9
21	7.714	64.6	8.991	71.7	16.6	4.40	17.4
22	9.377	78.5	11.019	87.8	17.8	4.63	21.2
23	8.216	68.8	9.269	73.9	16.6	4.43	17.5
24	9.401	78.7	10.324	82.3	17.4	4.50	18.9
25	8.899	74.5	10.167	81.0	16.4	4.70	16.8
26	9.224	77.3	10.528	83.9	16.8	4.67	15.9
m_P	9.038	75.7	10.225	81.5	16.6	4.72	15.3
m_H	10.634	89.1	11.713	93.4	18.0	5.03	21.2
m_L	7.714	64.6	8.333	66.4	14.4	4.40	9.0
m_C	11.940	100.0	12.543	100.0	18.04	4.80	10.7

[a] See text for symbology. m_o: population mean and its range m_H (higher) and m_L (lower); m_C: hybrid check mean.

Table 4. Observed data for five traits and kernel type in populations of maize with varying levels of exotic germplasm. [Experiment **εII**].

Population	Traits[a]					Kernel type
	EW	GW	GR	MF	SW	
01	8.621	7.339	0.851	68	0.170	*yellow dent*
02	9.478	8.609	0.908	67	0.175	*yellow dent*
03	8.593	7.353	0.856	67	0.170	*orange semident*
04	9.482	8.242	0.869	67	0.175	*orange dent*
05	8.715	7.291	0.837	67	0.175	*orange flint*
06	6.944	6.054	0.872	70	0.165	*yellow dent*
07	8.433	7.394	0.877	62	0.170	*yellow dent*
08	11.472	9.458	0.824	67	0.170	*yellow dent*
09	11.111	8.806	0.793	69	0.170	*orange flint*
10	11.718	9.714	0.829	71	0.175	*orange flint*
11	6.826	5.680	0.832	65	0.170	*orange flint*
12	10.931	9.000	0.823	70	0.170	*yellow dent*
13	9.784	8.859	0.905	68	0.170	*yellow dent*
14	6.954	6.310	0.907	70	0.165	*orange flint*
15	10.104	8.208	0.812	71	0.180	*yellow dent*
16	8.597	7.165	0.833	72	0.175	*orange flint*
17	8.787	7.990	0.909	68	0.170	*yellow dent*
18	8.155	7.449	0.913	71	0.180	*white flint*
19	9.010	7.547	0.838	70	0.170	*orange flint*
20	10.667	8.875	0.832	67	0.185	*orange flint*
21	8.048	6.735	0.837	67	0.180	*orange flint*
22	9.103	7.984	0.877	69	0.170	*white dent*[s]
23	9.669	8.366	0.865	71	0.180	*white dent*[s]
24	9.072	8.033	0.885	71	0.170	*yellow dent*
25	10.048	8.388	0.835	67	0.175	*yellow dent*
26	8.385	7.186	0.857	66	0.165	*orange flint*
m_P	9.181	7.848	0.857	68.4	0.173	---
m_H	11.718	9.714	0.913	72.0	0.185	---
m_L	6.826	5.680	0.793	62.0	0.165	---

[a] See text for symbology. [s] Segregating for white and yellow endosperm. m_o: population mean and its range m_H (higher) and m_L (lower).

recombination of late accesses after crossing with the hybrid P-3041 (Basso & Miranda Filho, 2001).

The trait SW (kg/200ml) varied from 0.165 (**06**: PAQ-2) to 0.185 (**20**: NAP– *flint* A); other outstanding (SW >0.18) populations for this trait were **15** (RCE-02), **18** (Composite GO-B), **21** (NAP– *flint* L) and **23**(NAP– *flint* B). The higher values of SW for the flint types of maize is a well known fact in the maize breeding context and in the present study the identification of three NAP-*flint* populations among the five outstanding was expected at some extent; the population RCE-02 also included several flint types in the original germplasm source (Basso & Miranda Filho, 2001).

The whole set of 26 populations involved in this study can be represented by five sets according to their origin: **I** ≡ Local adapted germplasm [**01**, **02**, **03**, **04**, **18**]; II ≡ Exotic derived from tropical germplasm [**12**, **17**]; III ≡ Semiexotic derived from tropical germplasm [**05**, **06**, **07**, **08**, **09**, **11**, **14**, **15**, **16**, **19**, **25**, **26**]; IV ≡ Semiexotic derived from varying proportion of tropical and temperate germplasm [**20**, **21**, **22**, **23**, **24**]; and V ≡ Semiexotic derived from temperate germplasm [**10**, **13**]. The mean yield (t ha^{-1}) of the five sets in the experiment **εI** were 9.489, 8.882, 9.111, 8.681 and 8.514 for EW, which are equivalent to 79.5%, 74.4%, 76.3% 72.7% and 71.3%, respectively, of the hybrid check; the corresponding means for E10 were 11.032, 10.389, 10.084, 9.928, and 9.630, equivalent to 87.9%, 82.8%, 80.4%, 79.1% and 76.8% of the hybrid check. The highest means were for sets I**,** II and III, and the lowest for sets IV and V, as expected on the basis of their respective origins.

Set IV was represented by five populations symbolized by NAP and their relative performance was already discussed. Populations numbered as 20, 21, 22 and 23 were also studied by Mendes et al. (2015) in crosses with six local and adapted synthetics symbolized by HG; from the 24 hybrid crosses in this set, the number that yielded more than 80% of the hybrid check was 9 in Jatai (GO) and 7 in Rio Verde (GO). Also, a high expression of heterosis for yield was observed in that crosses, varying from 18.8% to 46.5% in Jatai and from 10.7% to 55.4% in Rio Verde, thus indicating that in spite of the apparently poor yielding performance of the NAP populations, they can be rationally exploited under a well oriented breeding strategy.

In fact, the highest yielding group (set I) justifies its position by including populations derived from adapted germplasm. Set II is represented by two populations: (i) GO-SPR (**12**) that is a narrow base subpopulation derived from Suwan-1, formerly introduced from Thailand as a source for resistance to downy mildew caused by *Peronosclerospora sorghi* (Lima et al., 1982); and (ii) Comp. TUTU (**17**) derived from the cross between BR-106 (a population derived directly from Tuxpeño germplasm, introduced from Mexico) and Tusón, a Cuban germplasm mentioned as one of the most important tropical races (Goodman & Brown, 1988; Goodman, 2005). Set III involves 12 sources of tropical exotic germplasm of widely distinct origins; in fact, the subset [**05**, **06**, **07**, **11**] were derived by incorporation of one source from Pakistan, which is characterized by its high tolerance to heat stress (temperature above 40º C) and by earliness in the Brazilian conditions, thus differing substantially from the others populations of the same set. The subset [**08**, **09, 14**, **15**, **16**] involved local and exotic sources of several origins, most of them introduced from Mexico; the subset [**25**, **26**] were obtained by incorporation of one source from Honduras, two from Mexico and three from the Northeast Brazil (all of them with potential for heat tolerance) into two local and adapted populations, GO-Dent and GO-Flint, respectively; the population **19** was developed from different sources of exotic germplasm with resistance to fall armyworm. Set IV was represented by five populations obtained from a program (NAP-Milho) specially developed for resistance to leaf diseases by selection from a collection of 1273 accesses of the Brazilian Germplasm Bank, which included germplasm from diverse origins (Miranda Filho et al., 2000). Populations numbered as 20, 21, 22 and 23 were also studied by Mendes et al. (2015) in crosses with six local and adapted synthetics symbolized by HG; from the 24 hybrid crosses in this set, the number that yielded more than 80% of the hybrid check was 9 in Jatai (GO) and 7 in Rio Verde (GO). Also, a high expression of heterosis for yield was observed in that crosses, varying from 18.8% to 46.5% in Jatai and from 10.7% to 55.4% in Rio Verde, thus indicating that in spite of the apparently poor yielding performance of the NAP populations, they can be rationally exploited under a well oriented breeding strategy.

Finally, set V was represented by only two population: (i) CUBAEX (**10**) obtained from three Cuban sources in crosses with the temperate lines **B73** and **Mo17**; and (ii) ARGITA (**13**) derived from crosses between a sample of commercial hybrids from Argentina, representing temperate germplasm, with a local population (ITA, a variant of IAC-Taiúba). Miranda Filho (1992) introduced 13 sources of exotic germplasm with varying proportions of tropical and temperate origins, and divided the whole set in two groups: G-1, represented by introductions of the American Corn Belt; and G-2, represented by sources with higher proportions of tropical germplasm. The whole set was evaluated for ten traits and compared with the local population, ESALQ-PB1; the mean yields (ear weight and grain weight) for G-1 and G-2 were around 60% and 54% of ESALQ-PB1, respectively. The two groups were used for the synthesis of four composites: CEX-1 and CEX-2, derived from crosses G-1 x ESALQ-PB1 and G-2 x ESALQ-PB1; and CEX-3 and CEX-4, derived from crosses within G-1 and G-2, respectively. It was concluded that CEX-1 and CEX-2 should be used in recurrent selection for population improvement, but the incorporation of germplasm from temperate origin has limited perspectives in a short term. The lower mean yield of set ***V*** shown in the present work is in accordance with the results discussed by Miranda Filho (1992). On the other hand, results reported by Regitano Neto et al. (1997) referring to eight plant and ear traits involving 20 sources representing largely temperate germplasm, indicated that many of them should be used to improve traits particularly useful for the tropical region. In fact, traits such as plant and ear height, tassel size, ear length and diameter, kernel row number and kernels per row have low effect on the pattern of adaptation when incorporating them into local populations, and careful selection to attain the desirable proportion of exotics in the new populations may approximate to the expected results.

In spite of the fairly good potential of the whole set of populations in the present study, it seems reasonable to extend the study toward the enhancement of the intrinsic genetic values of the most promising ones. For that purpose, a sample of 12 populations was chosen to continue the project; seven populations belong to the same set of the present study and the other five were identified in the remaining set (10 populations) of the 36 already mentioned. The 12 populations were crossed with two local and adapted testers with good performance for yield and agronomic traits. In general, there are positive expectations in relation to the forthcoming results.

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