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Development of Semi-exotic Maize (*Zea mays* L.) Inbred Lines: Performance per se and in Hybrid Combinations

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ABSTRACT

To create positive transgressive segregation of quantitatively inherited traits such as yield of inbred lines, two or more sources which accumulate different classes of favorable alleles are required. Introgression of exotic germplasm into tropical inbred line is one of several possible methods. This study was conducted to asses a potential use of exotic germplasm introduced from different latitudes to improve tropical inbred lines and their performance in hybrid combinations. The results of the present study indicated that all improved exotic germplasm were equally useful as sources of desirable alleles, especially for high yield of semi-exotic inbred lines. The 25 % semi-exotic inbred lines showed earlier days to anthesis and silking, lower grain moisture content, but higher leaf disease infection than the 12.5 % semi-exotic inbred lines. Transgressive segregation of semi-exotic inbred lines was also found in each class of exotic germplasm. Testcross hybrids generated from crossing between tropical testers with 12.5 % exotic inbred lines showed higher yield, earlier maturity, and better disease resistance than the testcross hybrids of 25 % exotic inbred lines. Result of the present study suggested that combining ability of recurrent parent and the tester as well as proportion of exotic alleles in the converted semi-exotic lines are very importance for a success of semi-exotic inbred lines in hybrid combinations.

Key words: maize, exotic, germplasm, transgressive segregation, inbred line, latitude

INTRODUCTION

Hybrid cultivars of maize have been very popular among maize growers. To develop the commercially acceptable hybrid cultivar, the parental lines should possess certain feature including good combining ability, plant vigor, high productivity, good disease and pest resistance. To attain ultimate success in selection for good combining ability and productive inbred lines, plant breeders devote considerable effort and time to increase genetic diversity of the breeding materials. The methods employed to create genetic diversity including hybridization of improved germplasm, introducing new germplasm from other geographical adaptation (exotic), and use of mutagenic agents. Theoretically, continuous selection and improvement of varieties in diverse environments will develop germplasm with different classes of favorable alleles and thus create genetic diversity.

The use of exotic germplasm to broaden genetic diversity in maize breeding has been advocated for many years by several plant breeders (Kramer and Ulstrup, 1959; Eberhart, 1971; Hallauer and Malithano, 1976; Mungoma and Pollak, 1988; Godshalk and Kauffmann, 1995, Holland, 1995). Albrecht and Dudley (1987a,

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1987b) pointed out, that there were three main-reasons for the use of exotic germplasm in U.S. maize breeding program, (1) to increase genetic diversity as a safeguard against unpredictable biological and environmental hazards, (2) as a source of alleles for specific traits such as disease, pest, and stress resistance, and (3) as a source of favorable alleles for yield in increasing of useful genetic diversity and to enhance heterosis.

A general equation for F1 performance is that F1 = Midparent + Heterosis (Hallauer and Miranda, 1988). Theoretically, high yield F1 is combination of high yield parents with high heterosis. The equation, on the other hand, expressed a negative correlation between midparent and heterosis. This phenomena supported by studies conducted by Tokatlidis *et al*.(1998) which indicated that correlation between midparent and potential yield per plant of hybrid showed significant-positive correlation (r = 0.49), but the correlation between best-parent heterosis and best-parent potential yield was negative (r = - 0.73).

There are two roles of genetic diversity in a hybrid breeding program, increasing yield of inbred lines or mid-parent and enhancing heterosis. Enough range of genetic diversity of breeding materials used to develop or improve inbred lines will allow the breeder to generate transgresive segregation among progenies. Therefore, crossing between varieties with different classes of favorable alleles should increase a chance to find transgressive segregation of inbred lines. On the other hand, heterosis is also a product of genetic diversity as amount of heterosis depends on accumulative effect and the square difference of frequency of dominant alleles between the parents (Falconer and Mackay, 1996).

Breeders assume favorable correlation between plant, ear, and grain yield of the parental lines and performance in hybrid combination. Several studies have shown that correlations between the three corresponding traits of inbred and hybrid is relatively high, except for yield. Although many *r* values of inbred traits, including yield, with hybrid yield have been positive and significant, in most instances, they have been too low to be a predictive value (Hallauer *et al*., 1988). However, Sprague (1964) observed that correlation of inbreds with the mean value of corresponding traits of hybrids progenies is higher than correlation of inbreds with the corresponding single cross hybrids. These results show that inbred yield predicted its general combining ability more accurately than the specific combining ability. Lamkey and Hallauer (1986) observed that selection for high-yielding inbreds would tend to select lines which gave high-yielding hybrids that are above average of overall hybrid yields. Duvick (1999) stated that although the inbred-hybrid yield correlation was positive with a tendency for high yielding inbred to produce high yielding hybrid. The low value of the correlation indicated that it was not high enough to warrant selecting inbred on the basis of their yield per se; performance in cross was and still is essential for evaluating the value of an inbred yield in contributing to a hybrid.

The objectives of the present study are: 1) to evaluate the potential use of an exotic germplasm from different regions as source of unique favorable alleles for improving tropical inbred lines; 2) to compare the per se and the hybrid performance of semi-exotic inbred lines containing different proportions and sources of exotic germplasm.

MATERIALS AND METHODS

Development of semi-exotic inbred line

Six tropical maize inbred lines namely: Nei9008, Nei9202, AMATLC0HS 63-2-5-E-3-1-2, AMATLC0HS 170-2-3-2-1-1-1-B-3, Agron 18, and Ki42, and five groups of exotic hybrids representing each exotic group adapted to each of different regions were used in this study. The adaptation regions of the five groups of hybrids were as follow:

1) Latitude- 1: adapted to > 37.5 °North Latitude

(NL); US Corn Belt, namely: DI7117A, DK602, DK611, ISU # 1, ISU # 2, ISU # 3, Mitos, and Santos.

2) Latitude-2: adapted to > 22.5 – 37.5 ° NL; Southern US namely: DK683, DK687, DK720S, DK743, DK727.

3) Latitude-3: adapted to > 7.5 – 22.5 ° NL; Mexico, namely: D865 and D869.

4) Latitude-4: adapted to > 22.5 – 37.5 ° South Latitude (SL) ; South Africa, Mozambique, namely: SNK2042, SNK2576, SNK2640, SNK2778 and DK834.

5) Latitude-5: adapted to > 37.5 ° SL; Argentina, namely: DK663, DK664, DK669, and DK752

Crosses were made between the tropical inbred lines and the exotic group. Each of the six tropical inbred lines was crossed by bulked pollens of 5 to 7 plants of each exotic hybrid in the same group to generate BC_0F_1. In the following season, the BC_0F_1 plants were self pollinated and backcrossed to the corresponding tropical inbred lines to generate BC_0S_1 and BC_1F_1, respectively. They were further self-pollinated to obtain BC_0S_2 and BC_1S_1, respectively. Simultaneously, the BC_1F_1 was backcrossed to corresponding tropical inbred lines to generate BC_2F_1. To maintain the variability of the S_1 families in the following generation, the S_2 seeds were planted in family-in-row fashion. Due to heavy disease infection, the seed of BC_0S_1 and the BC_0S_2 that could be generated were very limited, therefore, further evaluation of the 50 % exotic was terminated. To generate the 25 % and 12.5 % semi-exotic inbred lines, the BC_1S_1 and BC_2F_1 were self pollinated and 36-visual acceptable families of semi-exotic inbred lines were selected from each class exotic group.

Semi-exotic inbred line yield trial

To conduct inbred line yield trial, five sets of experiment were arranged representing 5 groups of exotic sources. Each set consisted of 81 entries representing 36 BC_1S_3, 36 BC_2S_1, 6 original and 3 additional tropical inbred lines as checks. The experiments were conducted in 9×9 simple lattice design. Plots were arranged in one row plot, 5-m long and two replications. Yield trials were conducted during October 2001 - February 2002 at PT. BISI Research Farm Kediri (Indonesia) is located at 7^0 55’ South, 112^0 01’ East, 110 meter above sea level.. Plant spacing was 0.75 m between rows and 0.20 m within row. Plots were over-planted with 44 seeds per row, after two weeks, plants were thinned to 1 plant per hill or population size of 66,667 plant/ha.

The analysis of variance of inbred line yield trial was done in two phases. Firstly, individual set was analyzed using a 9 × 9 simple lattice design. All treatments means were adjusted for lattice blocks if the efficiency of the lattice adjustment was higher than 1.0, otherwise un-adjustment means were used. Significant differences among entries for each trait were tested and adjusted using the effective error mean square or randomized complete block error mean square, depending upon whether adjusted entry means from lattice analysis or unadjusted entries means from randomized complete block analysis were used, respectively. Secondly, the experimental (proportion and sources of exotic) effect combined across sets were analyzed using randomized complete block design. Means were adjusted for differences in set means by subtracting the set mean from each observation. The grand mean over sets was added to this value so that the scale was not altered.

Testcross hybrid yield trial

From the inbred line yield trials, the top-6 semi-exotic inbred lines of each class were chosen. A total of 60 semi-exotic inbred lines were selected, representing 2 classes (25 and 12.5 % exotic) of 5 sources and each class consisted of 6 inbred lines.

The 60 semi-exotic inbred lines were test crossed to two testers namely Agron 20 and Agon 27. Both testers were tropical inbred lines developed by Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok, Thailand.

The performance of the 120 testcross hybrids and Monsanto 949, a popular commercial hybrid in Thailand and Indonesia were evaluated in one set of experiment. The experiment was arranged in a randomized complete block design with 3 replications. Yield trials were conducted in 2003 at three locations viz., National Corn and Sorghum Research Center (Suwan Farm, Nakhon Ratchasima, Thailand) is located at 14^0 30' North, 101^0 30' East, 356 meter above sea level; Bangkok Seed Industry Research Farm (Salaengphan, Saraburi, Thailand) is located at 14^0 30' North, 101^0 30' East, 40 meter above sea level; and PT. BISI Research Farm (Kediri, Indonesia) is located at 7^0 55' South, 112^0 01' East, 110 meter above sea level. Each plot consisted of one 5-m row at Salaengphan and Kediri, and one 4.5-m row at Suwan farm. Plant spacing was 0.75 m between row and 0.2 m within row. Plots were over-planted with 44 seeds per row, after two weeks, plants were thinned to 1 plant per hill or population size of 66,667 plant/ha.

The analysis of variance was done as the following procedure; hybrid means over location were computed by running individual environment analyses and then by averaging across environments. All statistical computations were performed using the MSTAT-C computer program (MSTAT-C, 1988).

Standard cultural practices were followed for both inbred line and testcross hybrid yield trials at all locations. Data were recorded on: days to anthesis and silking, ear and plant height expressed in cm, leaf disease infection "Southern rust and leaf blight" (1 = highly resistance, 9 = highly susceptible), root and stalk lodged expressed in percent of lodged plant per plot, grain moisture content at harvest expressed in percent, and grain yield at 15 % moisture expressed in ton/ha.

RESULTS AND DISCUSSION

Grain yield of inbred lines

Grain yield of the semi-exotic inbred lines ranged from 0.8 ton/ha from 25 % L2 to 5.9 ton/ha from 12.5 % L4, while the six tropical inbred lines (check) ranged from 1.6 ton/h to 4.6 ton/ha. Mean grain yield of semi-exotic inbred lines of each latitude was not statistically different from that of the check inbred lines. Moreover, some of inbred lines from all classes of exotic germplasm yielded statistically the same as the best check. There were three inbred lines; one from 25 % L2 and two from 12.5 % L4 showed significantly higher grain yield than the best check, indicating some of the semi-exotic inbred lines showed positive transgressive segregation over the best check. The result showed a positive effect of the addition of exotic alleles into the tropical inbred lines, and additive effect of gene action is significant in these breeding materials. Therefore, selection for high yield inbred lines from semi-exotic population is possible. However, the majority of the semi-exotic inbred lines were significantly lower yield than the best check. Second cycle of inbred line improvement should help increasing frequency of superior inbred lines.

As expected, the 25 % semi-exotic inbred lines had wider range of grain yield than the 12.5 % for all latitudes, except latitude-4. This implied the closer genetic relationship between materials from latitude-4 and the tropical inbred lines in use than other exotic sources. Although, the mean grain yield of 25 and 12.5 % exotic of each source were statistically not different, the 12.5 % exotic showed a tendency of higher yield than the 25 % group, except latitude-1. This resulted from the higher low limit and narrower range of yield of the 12.5 % semi-exotic inbred lines. Thus, there was no clear advantage between 25 and 12.5 % semi-exotic inbred lines. In general, the

Table 1 Mean and range of yield, frequency of semi-exotic inbred lines not significantly lower, not significantly higher, and significantly higher than the best check.

Source of exotic[1)]	Proportion of exotic germplasm	Mean and range of 36 inbred lines		Freq. of inbred not signif. Lower than the best check	Freq. of inbred not signif. Higher than the best check	Freq. of inbred signif. higher than best check
		------ ton/ha ------				
L1	25%	3.00	1.56 - 5.37	8	1	0
(>37.50 N)	12.5%	2.80	1.42 - 4.85	6	1	0
	Average	2.90				
L2	25%	2.81	0.80 - 5.80	4	0	1
(>22.50 N - 37.50 N)	12.5%	2.89	1.59 - 4.74	8	1	0
	Average	2.85				
L3	25%	2.79	1.46 - 5.25	5	3	0
(>7.50 N - 22.50 N)	12.5%	2.98	1.59 - 5.05	7	1	0
	Average	2.88				
L4	25%	2.71	1.05 - 5.01	3	1	0
(>22.50 S - 37.50 S)	12.5%	3.03	1.17 - 5.96	4	1	2
	Average	2.87				
L5	25%	2.82	1.06 - 5.42	6	2	0
(>37.50 S)	12.5%	2.91	1.48 - 5.31	7	1	0
	Average	2.87				
Check (6 inbred lines)	0%	2.50	1.60 - 4.61			
AG20		2.31				
AG29		1.67				
AG4		3.89				
LSD 0.05			0.90			
CV = 16 %						

[1)] L1 - L5 = Exotic germplasm from latitude-1 to -5

highest yield of semi-exotic inbred lines came from 25 % exotic, except latitude-4. With wide range of grain yield and higher maximum limit, the 25 % exotic or one backcrossing to tropical line is preferable in order to maintain desirable alleles from exotic germplasm. The usefulness of semi-exotic lines very much also depend upon other desirable traits such as earliness and disease resistance.

Days to anthesis and silking, grain moisture content and leaf disease

Individually, days to anthesis and silking of semi-exotic inbred lines within each class were significantly different as indicated by wide range of both traits within each class (Table 2). The average of both traits of 25 and 12.5 % exotic of each latitude were only 1 day difference and similar phenomenon was observed for grain moisture content. Therefore, in order to maintain a high variation of other traits for selection, one backcross to tropical line is adequate for the conversion of these three traits into tropical lines. If leaf disease infection was brought into consideration, 2 backcrossing had an advantage. Because the 12.5 % exotic showed higher trend of leaf disease resistance as indicated by lower score of leaf disease infection. The difference of average

Table 2 Mean and range of 36 inbred lines for days to anthesis and silking, grain moisture content and leaf disease infection.

Source of exotic[1)]	Proportion of exotic germplasm	Days to anthesis		Days to silking		Grain moisture		Leaf disease[2)]	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
		-------------- days		-----------------		--------- % ------		--- score:1 - 9 ---	
L1	25%	56	52 - 61	58	53 - 64	15.5	14.7 - 16.6	5.9	3.5 - 7.8
(>37.50 N)	12.5%	57	54 - 61	59	57 - 64	16.0	14.9 - 17.0	5.7	3.5 - 7.5
	Average	56.5		58.5		15.8		5.8	
L2	25%	56	52 - 61	58	55 - 63	15.6	14.4 - 17.9	6.0	2.8 - 8.8
(>22.50 N - 37.50 N)	12.5%	57	53 - 61	59	54 - 61	15.9	14.4 - 18.0	5.2	2.3 - 7.4
	Average	56.5		58.5		15.8		5.6	
L3	25%	56	52 - 61	58	54 - 63	15.4	13.9 - 18.2	5.7	3.8 - 7.8
(>7.50 N - 22.50 N)	12.5%	57	53 - 60	59	55 - 64	16.1	15.2 - 17.2	5.6	2.3 - 7.8
	Average	56.5		58.5		15.8		5.7	
L4	25%	56	52 - 60	58	55 - 62	15.4	13.3 - 16.8	6.4	3.6 - 8.6
(>22.50 S - 37.50 S)	12.5%	57	53 - 61	59	55 - 64	16.0	14.0 - 18.4	5.2	3.1 - 8.1
	Average	56.5		58.5		15.7		5.8	
L5	25%	56	52 - 60	58	54 - 63	15.6	13.6 - 17.6	6.5	4.2 - 8.7
(>37.50 S)	12.5%	57	53 - 63	59	55 - 65	15.9	14.9 - 18.2	5.6	3.5 - 8.2
	Average	56.5		58.5		15.8		6.1	
Check (6 inbred lines)	0%	57	54 - 60	59	56 - 62	15.8	15.4 - 16.1	4.9	4.0 - 6.0
AG20		54		57		16.3		4.8	
AG29		51		54		15.3		6.0	
AG4		59		60		16.7		4.7	
LSD 0.05			2.28		2.60		1.46		1.87
CV = %			2		2		5		16

1) L1 - L5 = Exotic germplasm from latitude-1 to -5
2) Leaf diseases : 1= highly resistance; 9 = highly susceptible

between class of 25 and 12.5 % was not significant but difference of individual within each class of all latitudes was highly significant. Therefore, selection after 1 or 2 backcrossing is needed for further improvement of leaf disease resistance of semi-exotic inbred lines.

Grain yield of testcross hybrids

Yield of testcross hybrids was presented in Table 3. The average yield of testcross hybrids of each latitude was not statistically different and ranged from 8.00 to 8.26 ton/ha, while the commercial hybrid yielded 9.90 ton/ha. Therefore, by average, all semi-exotic inbred lines from all latitudes responded similarly when crossed to the common inbred testers, Ag20 and Ag27. Similar trend was observed in testcross hybrids of 25 and 12.5 % exotic of each latitude. However, there were wide ranges of individual testcross hybrids within each class of each latitude and only 1 testcross hybrid from 12.5% exotic of latitude-4 yielded 9.51 ton/ha which was not statistically different from 9.90 ton/ha of commercial hybrid. Tarter *et al*. (2003) also found that none of their semi-exotic line testcrosses was competitive with current U.S. commercial hybrids for grain yield.

Table 3 Mean and range of yield of testcross hybrids across three locations and frequency of testcrosshybrids significantly not diferent from the commercial hybrid.

Source of exotic[1)]	Proportion of exotic germplasm	Mean of 12 hybrids	Range	Hybrid signif. not diff to check
		--------------ton/ha--------------		
L1	25%	8.25	7.52 - 8.82	0
(>37.50 N)	12.5%	8.05	7.31 - 8.73	0
	Average	8.15		
L2	25%	7.99	7.18 - 8.71	0
(>22.50 N - 37.50 N)	12.5%	8.28	7.90 - 8.84	0
	Average	8.14		
L3	25%	8.10	7.32 - 8.97	0
(>7.50 N - 22.50 N)	12.5%	8.15	7.23 - 8.99	0
	Average	8.12		
L4	25%	7.97	6.87 - 8.81	0
(>22.50 S - 37.50 S)	12.5%	8.55	7.20 - 9.51	1
	Average	8.26		
L5	25%	8.06	7.75 - 8.40	0
(>37.50 S)	12.5%	7.94	7.46 - 8.54	0
	Average	8.00		
Check (Monsanto 949)		9.90		
LSD 0.05 :			0.65	
CV (%)			14.33	

[1)] L1 - L5 = Exotic germplasm from latitude-1 to -5

Days to anthesis and silking of testcross hybrids in each class of exotic were 1 or 2 days difference (Table 4) which was similar to days to anthesis and silking of the corresponding classes of inbred lines (Table 2). However, days to anthesis and silking of testcross hybrids were 5 to 7 days earlier than the corresponding classes of inbred lines. This is a common phenomenon of fast development of hybrid (hybrid vigor) over the corresponding inbred. Days to flowering of all testcross hybrids were few days earlier than the commercial hybrids but by average, grain moisture content were 4 % to 5 % lower. Besides, grain moisture content of testcross hybrids ranged from 20 % to 26 % as compared to 27 % of the commercial hybrids. Therefore, some of the testcross hybrids had relatively earlier maturity with comparable yield to commercial hybrids, especially a testcross hybrid from latitude-4. All of testcross hybrids were moderately resistant to leaf disease as compared to a highly resistant commercial one.

The 10 highest yielded of testcross hybrids were presented in Table 5. All of top-10 testcross hybrids were from inbred lines which were converted from tropical inbred lines, Nei9008 and Nei9202 except one from AMATLC0HS 63-2-5-E-3-1-2. The exotic sources contributed to the top-10 testcross hybrids were from latitude-1 to -4 and

Table 4 Mean and range of the 12 testcross hybrids of each class semi-exotic germplasm for days to anthesis and silking, grain moisture content and leaf disease infection.

Source of exotic[1)]	Proportion of exotic germplasm	Days to anthesis		Days to silking		Grain moisture		Leaf disease[2)]	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
		------------- days	-----------------			--------- % ------		--- score:1 - 9 ---	
L1	25%	50	49 - 51	52	51 - 53	22.3	20.6 - 24.0	5.6	4.9 - 6.6
(>37.50 N)	12.5%	49	49 - 50	52	51 - 53	22.8	20.7 - 24.0	5.6	4.7 - 6.5
	Average	49.6		51.8		22.6		5.6	
L2	25%	49	48 - 50	51	50 - 53	22.4	20.7 - 24.0	5.5	4.6 - 6.6
(>22.50 N - 37.50 N)	12.5%	50	49 - 51	52	51 - 53	22.9	20.2 - 24.5	5.1	3.8 - 6.0
	Average	49.4		51.7		22.7		5.3	
L3	25%	50	49 - 52	52	51 - 55	23.0	20.4 - 25.2	5.5	4.8 - 6.8
(>7.50 N - 22.50 N)	12.5%	50	49 - 52	52	51 - 54	23.2	21.6 - 26 0	5.2	4.3 - 5.9
	Average	50.0		52.2		23.1		5.4	
L4	25%	49	48 - 50	51	50 - 52	22.6	21.1 - 23.8	5.8	4.8 - 6.9
(>22.50 S - 37.50 S)	12.5%	50	49 - 51	52	51 - 54	22.9	21.3 - 24.7	5.1	3.9 - 6.3
	Average	49.5		51.8		22.8		5.5	
L5	25%	50	48 - 51	52	51 - 53	23.3	21.8 - 24.8	5.5	4.8 - 5.9
(>37.50 S)	12.5%	50	49 - 50	52	51 - 53	23.0	21.8 - 24.6	5.5	4.7 - 6.2
	Average	49.6		51.9		23.2		5.5	
Check (Monsanto 949)		51.1		54.2		27.7		3.0	
LSD 0.05			0.88		0.87		0.99		0.56
CV = %			2.82		2.09		5.42		12.90

1) L1 - L5 = Exotic germplasm from latitude-1 to -5
2) Leaf diseases : 1= highly resistance; 9 = highly susceptible

not single one from latitude-5. Since performance per se of semi-exotic inbred lines from all latitudes were more or less the same (Table 2), lack of heterosis between semi-exotic inbred lines from latitude-5 and the tester (Agron 20 and 27) should be the major cause of lower yield of testcross hybrids from latitude-5. With the same reason, there was no semi-exotic inbred line involving with the tropical lines; Agron 18, Ki42, and AMATLC0HS 170-2-3-2-1-1-1-B-3 in the top-10 testcross hybrids. This evidence suggested that both tropical and exotic sources are very important for effective integrating exotic germplasm in hybrid breeding program. Šimič *et al.* (2003) also found that the choice of germplasm seems to be more important than the integration method. Moreover, there were 7 out of top-10 testcross hybrids came from 12.5 % exotic inbred lines (2 backcrossing) indicated that they performed better than 25 % exotic inbred lines in testcross hybrids. Therefore, besides the good heterotic pattern of tropical recurrent parent and the tester, adaptation as indicated by lower proportion of exotic germplasm is also very importance for the success of converted lines in hybrid combination. Troyer (1999) stated that adaptedness is more important than genetic diversity in increasing yield.

Yield of the top-testcross hybrid was 9.506 ton/ha and not statistically different from 9.900 ton/ha of check hybrid. It was also not statistically

Table 5 Mean grain yield, plant and ear aspects of the best-10 testcross hybrids.

Rangked	Pedigree of inbred lines[1)]		Tester	Grain yield	Plant aspect[1)]	Ear aspect[2)]
				-- ton/ha --	-------- (1 - 9)	---------
1	Nei9008 *3 /	Latitude 4 : 1-1	Agron 27	9.51	7.3	6.5
2	Nei9008 *3 /	Latitude 3 : 2-1	Agron 27	8.99	7.3	6.0
3	Nei9008 *2 /	Latitude 3 : 6-6-1	Agron 20	8.97	7.0	5.5
4	Nei9202 *3 /	Latitude 4 : 4-1	Agron 20	8.92	7.8	7.3
5	Nei9008 *3 /	Latitude 2 : 1-1	Agron 27	8.84	6.8	5.0
6	Nei9008 *3 /	Latitude 2 : 1-1	Agron 20	8.83	6.5	6.8
7	AMATLCOHS 63 *2 /	Latitude 1 : 9-9-1	Agron 20	8.81	6.3	7.0
8	Nei9008 *2 /	Latitude 4 : 15-15-1	Agron 20	8.81	5.8	6.8
9	Nei9008 *3 /	Latitude 4 : 1-1	Agron 20	8.78	7.3	7.8
10	Nei9202 *3 /	Latitude 3 : 19-1	Agron 20	8.76	7.8	7.5
Check (Monsanto 949) :				9.90	8	8
LSD 0.05 :				0.65		
CV (%)				14.33		

1) *2, *3 = 1 and 2 backcross to the recurrent parent, respectively.
2) Plant and ear aspects : 1 = very poor; 9 = very good

different from the 2nd to the 4th ranked testcross hybrids. While, plant and ear aspects of testcross hybrids were relatively inferior to the check hybrid. It was because of more susceptibility to leaf disease and pale-orange grain color of testcross hybrid compared to the check hybrid (Table 4). Further improvement for leaf disease resistance and grain color of semi-exotic inbred lines is needed before they could be used in a commercial production. The results revealed that there is no single step for the introgression of useful alleles from exotic germplasm into the local adapted lines. The same experience was founded in the germplasm conversion programs in USA (Goodman, 1997).

CONCLUSION

Most of improved exotic germplasm from latitude < 37.5 ° North to < 37.5 ° South, especially commercial hybrids are very useful in broadening the germplasm of tropical breeding materials. Introgression of exotic germplasm by 1 or 2 backcrosses to local adapted lines was adequate as indicated by non-significant different of the performance of inbred lines extracted from population of BC_1 and BC_2 of all exotic sources. Transgressive segregation was observed for yield of converted inbred lines. Most of converted inbred lines matured earlier with lower grain moisture content than the corresponding tropical inbred lines. The 12.5 % exotic inbred lines (inbred line from 2 backcrossing) performed better than the 25 % exotic inbred lines (inbred lines from 1 backcrossing) in combination with the tropical inbred testers. Moreover, the top-10 testcross hybrids represented only converted inbred lines from 2 out of 6 tropical recurrent inbred lines. Therefore, the combining ability of recurrent parent and tester as well as proportion of exotic germplasm in the semi-exotic inbred lines are equally importance for the success of semi-exotic inbred lines in hybrid combinations.

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