Advances in Environmental Biology, 5(7): 1632-1637, 2011
ISSN 1995-0756

This is a refereed journal and all articles are professionally screened and reviewed

ORIGINAL ARTICLE

Study on Combining Ability of Maize Inbred Lines in Order to Hybrid Mid-seasons Performance of Hybrid Corns

[1]Alireza Souhani Darban, [2]Ehsan Neamatollahi, [3]Hamid Moghadam

[1]*Agronomy and Plant breeding department, Mashhad branch, Islamic Azad University, Mashhad, Iran*
[2]*Agronomy and Plant breeding department, Mashhad branch, Islamic Azad University, Mashhad, Iran.*
[3]*Agronomy and Plant breeding department, Mohaghegh Ardabili University, Ardabil, Iran.*

A. Souhani darban, E. Neamatollahi, H. Moghadam: Study on Combining Ability of Maize Inbred Lines in Order to Hybrid Mid-seasons Performance of Hybrid Corns

ABSTRACT

This study was conducted to evaluate of genetically combining ability of different maturity groups of elite and commercial inbred lines of grain corn (Zea mays L.) at Agricultural Research and Natural Resources Institute of Razavi Khorasan, Mashhad, Iran on 2009-2010. At first, we evaluated 50 hybrids derived from crosses of 18 inbred lines of different FAO maturity groups in a RCBD with 3 replications on 2009. Then, 30 grain corn hybrids (consisted of 20 new hybrids and 10 commercial single cross hybrids) evaluated at a RCBD with 3 replications on 2010. The measured traits were plant and ear height, leaves no, above ear, ear length and diameter, kernel depth, rows no and kernel no/row, kernel no/ear, 1000-kernel weight, ear no/plant and grain yield based on 14 percent humidity. The results of ANOVA showed significant differences between corn genotypes for many of evaluated traits on both years. The comparison of measured traits at first year (2009) showed that results significant differences between hybrid genotypes for all the traits except for upper ear leaves no., no per plant and anthesis-silking Interval (ASI). The highest and the lowest grain yield with 18/92 and 10/59 ton/ha was belonged to the hybrid of number 15 (L105*K74/1) and 24 (S61*L105) respectively. The higher grain yield of hybrid no. 15 is probably due to its superiority of in ear length, ear diameter, number of seed/row, rows no., higher leaves no., lower ASI, higher plant and height. The lowest GCA with 2.39 and -2.92, respectively. The results of means comparison on 2010, showed superiority of commercial single crosses hybrid Ksc604(B73*K722) with 10/22 ton/ha, while the lowest yield was belonged to K1263/1*M017 of course. The low temperature at early of October on 2010 led to serious frost damage especially on late mature frost corn hybrids. The grain means yield of corn hybrids was higher on 2009 than 2010 due to better weather condition on 2010.

Key words: Corn (Zea mays L.), hybrid, inbred line, maturity group.

Introduction

Maize is the third major cereal crop worldwide in terms of production, ranking after wheat and rice (FAO, 2005). Globally, it contributes 20% of the world's food calories and 15% of the world's annual production of food crop protein (National Research Council, 1988). Maize is a major staple food crop in developing countries in Latin America, Asia and Africa (Crow and Kermicle, 2002). In Eastern Africa, maize is a significant source of protein for young children, pregnant and lactating women, providing up to 60% of their total daily calories and accounting for 17–60% of the daily human protein supply (FAOSTAT, 2003). Normal endosperm maize is deficient in two amino acids, lysine and tryptophan,

Corresponding Author
Ehsan Neamatollahi,Agronomy and Plant breeding department, Mashhad branch, Islamic Azad University, Mashhad, Iran.
Email: neamatollahi_e@ut.ac.ir

that are nutritionally essential for both monogastric animals and humans (Huang *et al.,* 2004). The protein content of 1.81% of lysine and 0.35% of tryptophan in normal maize endosperm is less than one half of the recommended concentrations for human nutri- tion (FAO/WHO/UNU Expert Committee, 1985; FAO/WHO Expert Consultation, 1990). Maize crops grown during the summer–rainy season in tropical or subtropical environments often encounter drought and/or excessive soil moisture. Excessive moisture, caused by a high water table and poor drainage, is one of the most important constraints to maize production in Asia, where an estimated 15% of maize growing areas is affected [15]. Surveys conducted in the late 1970s and mid 1980s on inbred lines showed that some of the inbreds continued to contribute substantially to hybrids marketed in the USA.

For example, B73 and M017 were used in about 28% of all seed planted in the USA in 1979. This fell to 12.8% of the total seed requirements in 1985 [21]. This may be attributed to a shift in resource allocation from public to private breeding efforts [7]. M017 was released from the University of Missouri in 1964 and B73 was released from Iowa State University in 1972 [20]. Once released, inbred lines have been maintained for decades through periodic seed increases in breeding programs and at germplasm repositories. Effects of artificial selection regimes, natural selection in maintenance environments, drift, migration (contamination) and mutations could lead to genetic changes [1,18,13]. Such genetic changes would be influenced by the frequency of regeneration, methods used for regeneration, unintentional outcrossing and addition of newer versiones of the same inbred from other sources. Variation can be investigated by means of phenotypic and genotypic measures. Quantitative character studies of long-time inbred lines detected genetic changes larger than those expected by breeders [16,17]. Corn is a plant which is mostly grown in different parts of Iran. Recently the farms used to produce corn is significantly increased as it is anticipated that the hands allocated to corn productive in 2011 will be 415000 hectars almost twice as much as space used to corn production now. Since corn is considerd as an important nutritional source is protein production particulary red and white meat. The primary thrust of the CIMMYT maize breeding program for Asia collaboration with the National Agricultural Research Systems (NARS) is to develop stress-tolerant cultivars with improved nutritional value. Priority attention has been given to early-maturing (60–65 days to anthesis) stress-tolerant cultivars targeting the drier mid-altitude agro-ecological zones where QPM is likely to have the maximum impact [4]. To accelerate the development of these cultivars, it is important to determine the usefulness of available QPM inbred lines inhybrid combinations through combining ability studies and other methods, and to obtain information on the association of secondary traits with grain yield in the new germplasm. This study were to showed that results significant differences between hybrid genotypes for all the traits except for upper ear leaves no., no per plant and anthesis-silking Interval (ASI). The low temperature at early of October on 2010 led to serious frost damage especially on late mature frost corn hybrids. The grain means yield of corn hybrids was higher on 2009 than 2010 due to better weather condition on 2010.

Material and methods

This study was conducted for two years in Khorasan Razavi agricultural institute. Promising and commercial inbred line names are these self-fertility six or seven generation and confluence together with attention to FAO group this following Table 1. Parental inbred lines seeds cultivated in three meters lines at blocks that can between desired inbred lines confluence (early maturity*late maturity) and also can hibrids confluence with any lines. Implant lines distance with another was 75 cm and plants between distance was 20cm that can easy for making hybridization. Also with attention to inbred lines maturity difference, for receive to one time to pollination and peak week, some of lines that were very seeds in implant 2 dates. For making hybridization doing that first maternal parent peaks visible before, with put a nylon bag on the peaks, done isolation. After 24 or 48 hours when exit peaks of corn cob tip done paternal parent male flower isolation and after day morning done between parents making hybridization and pollinations. Also lines confluence if possible was bilateral. And then maturity time with parent name and confluence time were notes and keep seeds in store for after year. In two crop year (2009) the results of corn different lines confluence (including new single cross hybrids 20 with 10 promising and commercial corn hybrids) in completely randomized block design at three replications was done comparison grain yield. With attention to difference in seed maturity groups in any hybrid or variety in 2 implant lines with 3.45 m length and 75 cm row distances was done. Experimental farm area was 1500 m^2. For data gathering in any stages of eruption growth stages and then plant harvest, desired traits on the plant measurements and then yield harvest determines yield components, humidity percentage and corn cub wood percentage were done.

Also determined forage quality and protein percentages for every samples. Review traits including plant heigth and corn cob heigth, leaf number and leaf over corn cob number, corn cub length, corn cob width, corn cob wood width, grain depth, corn cob wood percentage, grain row number, grain total number in corn cob, grain thousand weight were done in this study. Finally net grain yield in any kurt and grain thosaund weight with attention to grain humidity 14 percentage calculation and registered.

Statistical analysis results and statistical mean comparison was done by SAS and MSTAT-C computing soft wares.

Table.1: Early, moderate and late inbred lines.

Early maturity inbred lines	K1263/2-1, K2331, S61, K1264/1, KE72012/1-12, K2816, TVA926, K1263/1, K722
Moderate maturity inbred lines	K615/1, K1264/5-1
Late maturity inbred lines	OH43/1-42, K18, L105, M017, K19, K74/1, B73, R59

Results and discussion

Statistical variance Analysis showed research genotype in this experiment for every experiment traits except corn cub high leaf number, corn cob per plant number and also anthesis silking interval (ASI) had meaning difference in 1 to 5 % statistical probability level (Table. 3).

Grain Yield:

Grain yield was conducted with fraction of corn cob wood percentage and according to 14% grain humidity and then yield being expressed based on ton/hectare. Grain yield mean comparison results showed that with use of Duncan multi domain test (Table. 3). With attention to grain yield mean comparison results to be mean difference between F1 hybrid composition ($P<5\%$). Respectively maximum and minimum yield were 18.92 and 10.59 tone in hectare that belonging were hybrids number 15 (L105*K74/1) and 24 (S61*L105). Hybrid numbers 42 (OH43/1-42*MO17) and 6 (K1263*K19) with yield 17.954 and 17.951 ton/hectare respectively were without statistical meaning difference with 15 (L105*K74/1) hybrid variety. Early maturity inbred lines S61 and K1263/1 they had optimum potential in commercial varieties grain yield produce and promising variety Ksc340 had a suitable resistance to Fusarium and smut diseases and then it can be a new variety. 15 variety superiority can be optimum traits results this hybrid about corn cub length (22.15 cm), corn cub width (56.55 mm), grain number in row (42), grain row number (21), leaf number in plant (15), anthesis silking interval (2 days), plant height (121.5 cm) and corn cob height (244 cm). also maturity period length in this variety was 117 days that can be very suitable in Khorasan razavi province.

Anthesis Silking Interval and Physiological Maturity Date:

Variety most delay was number 13 (L105*M017) also anthesis and silking times in this variety were 63 and 67 days from implant date and conversely number 8 variety (K1263/1*TVA926) anthesis and silking times in this variety were 44 and 46 days. Number 13 hybrid was produce of FAO 700 group 2 inbred lines confluence while number 8 hybrid was produce of FAO 100 and 300 group 2 inbred lines confluence. Anthesis silking interval minimum and optimum were belonging to number varieties 23 (KE72012/1*K2331) and 21 (M017*K74/1) and ASI maximum was in number 32. Day maximum and minimum of implant to physiological maturity were beloging 123 days number 50 (K74/1*K18) and 105 days number 41 (S61*K1264/1) Table. 3.

Plant and Corn Cob Height:

There are statistical meaning difference between genotypes about plant height and corn cob height traits. Number 13 hybrid (L105*M017) had maximum height (253 cm) and number 25 hybrid had minimum height with 177 cm and these hybrids had corn cob height maximum and minimum with 142 cm and 80.5 cm respectively (Table. 3). There is a positive and meaning relation between grain yield, corn plant height ($r = 0.48^{**}$) and corn cob height ($r = 0.45^{**}$).

Total Leafs Number in Corn Plant and Total Leafs on Corn Cob:

There is a meaning difference between genotipes about total leaf number ($P>0.05$) but did not showed meaning difference about corn cob leaf number. Hybrids number 31(B73*K722) and number 19 (TVA926*L105) were leaf number maximum and minimum with 15 and 11 leafs respectively (Table. 3).

Grain Thousand Weight:

Grain thousand weight is very important in grain finally yield. Grain thousand weight maximum and minimum were respectively in number 20 hybrid (TVA926*M017) with 309.8 g and number 30 hybrid (K2816*K1264/1) with only 169.7 g. Of course in this experiment grain thousand weight had a positive relation with corn cob length ($r = 0.33^{**}$) also grain thousand weight had a negative relation with grain row number (r = -0.36**) and corn cob woody percentage (r = -0.28**) (Table. 3).

Corn Cob Width and Length:

Corn cob width and length traits are very important to grain yield. Corn cob width and length maximum and minimum were in number 13 hybrid (L105*M017) with 24.8 cm and number 30 hybrid (K2816*K1264/1) with 14 cm respectively. Number 38 (B73*OH43/1-42) and number 20 (TVA926*M017) were corn cob width maximum and minimum with 56.9 mm and 44.2 mm respectively. Corn cob trait had a positive and meaning relation with grain yield (r = 0.45**), total grain number in corn cob (r = 0.61**), corn cob woody width (r = 0.7**), moisture percentage (r = 0.5**) and grain depth (r = 0.64**) respectively (Table. 3).

Corn Cob Woody Width, Corn Cob Woody Percentage, Moisture Percentage and Grain Depth:

Number 15 hybrid (L105*K74/1) had corn cob width maximum and corn cob woody percentage with 34.15 mm and 24.84 mm respectively but number 29 hybrid (ksc704) with 22.4 mm had corn cob woody width minimum and corn cob woody percentage minimum was for number 18 hybrid (M017*k2816) with 13.02%. number 4 hybrid (K1264/1*M017) and number 24 hybrid (S61*L105) were grain depth maximum and minimum respectively with 13.7 and 8.95 mm.

There is a positive and meaning relation between grain depth and grain yield (r = 0.41**). Grain moisture percentage in harvest time is very important and so that genotypes with minimum moisture percentage are optimum. Number 34 hybrid (B73*K74/1), number 50 hybrid (K74/1*K18) and number 13 hybrid (L105*M017) had grian moisture percentage amount maximum with 33.6, 31.95 and 31.15% repectively but number 46 hybrid (K1264/1*K615) and number 8 hybrid (K1263/1*TVA926) were with grain moisture amount minimum 15 and 15.4% respectively.

There is a positive and meaning relation between grain yield and moisture percentage about (r = 0.28**) (Table. 3).

Grain Row Number, Grain Number in Row and Grain Total Number in Corn Cob:

These traits are very important. Number 38 hybrid (B73*OH43/1-42) and number 39 (M017*K19) were respectively grain row number maximum and minimum with 21 and 14 and also number 38 genotype had minimum grain number in row with 31.75. maximum grain number in row obtained in number 4 hybrid (M017*K1264/1) and 13 number (L105*M017) with 44.9 and 44.1. We showed a positive and meaning relation between grain yield with grain number in row (r = 0.32**) and grain number in corn cob (r = 0.36**) but there is a negative relation between grain yield with grain number in row (r = 0.13ns).

Table 2: Grain corn hybrides names to evaluated.

Arrangement	Hybrids name	Arrangement	Hybrids name
1	K1264/1*KE72012/1-12	16	K1263/1*TVA926
2	K1264/1*L105	17	KE72012/1-12*TVA926
3	K1264/1*TVA926	18	M017*K1263/1
4	K1264/1*B73	19	OH43/1-42*B73
5	K2816/1*L105	20	M017*K74/1
6	K2816/1*B73	21	Ksc260 (K615*K1264/1)
7	K2816/1*M017	22	Ksc302 (K1263/1*K2331)
8	L105* M017	23	Ksc301 (K1263/1*K2331)
9	L105*K1263/1	24	Dc370
10	L105*K74/1	25	Ksc400(K1263/1*KE72012/1-12
11	L105*B73	26	Ksc500(OH43/1-42*R59)
12	OH43/1-42*B73	27	Ksc604(K722*B73)
13	K722*B73	28	Ksc647(M017*K1264/1*B73)
14	L105*K74/1	29	Ksc700(K18*K74/1)
15	K1264/1*TVA926	30	Ksc704(B73*M017)

Table 3: The results of yield variance components in corn lines confluence.

Mean square							Degree of freedom	Change source
Leaf number on the corn cob	Leaf total number	Plant heigth (cm)	Corn cob heigth (cm)	ASI	Silking date (day)	Pollination date (day)		
0.16 n.s	1.96 n.s	549.902 n.s	40.96 n.s	2.25n.s	0.04 n.s	2.89 n.s	1	Replication
0.47 n.s	1.954*	518.426**	418.878**	1.523 n.s	28/.73**	28.964**	49	Genotype
0.344	1.082	179.466	61.271	1.168	7.367	6.012	49	Error
8.55	7.89	6.19	7.3	36.15	4.75	4.5	99	Total

Table 3: The results of yield variance components in corn lines confluence.

Mean square						Degree of freedom	Change source
Grain total number in corn cob	Grain row number	Number grain in row	1000 grain weight	Corn cob number in plant	Physiological maturity date (day)		
8441.025n.s	0.292 n.s	12.89 n.s	3757.118*	0.069 n.s	193.21*	1	Replication
10422.118**	5.974**	19.27**	1835.405**	0.029 n.s	49.612*	49G	enotype
4532.083	0.643	8.825	868.846	0.024	27.353	49	Error
10.01	4.56	7.74	12.83	15.35	4.67	99	Total

Table 3: The results of yield variance components in corn lines confluence.

Mean square							Degree of freedom	Change source
Total yield (ton/ha)	Corn cob woody percentage	Grain moisture percentage	Grain depth (mm)	Corn cob woody width	Corn cob width	Corn cob length		
1.911 n.s	0.716 n.s	6.605**	4.223*	2.993 n.s	34.106**	0.384 n.s	1	Replication
7.697*	16.722**	33.806**	2.025**	12.693**	18.076**	7.790**	49	Genotype
4.093	2.664	12.303	0.896	1.26	4.569	1.416	49	Error
13.58	9.26	14.65	8.15	4.15	4.25	6.79	99	Total

Table 4: Yield solidarity coefficients and dependent traits in corn hybrids.

18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	A	T
																		0.58**	1
																	0.84**	0.43**	2
																0.38**	0.34**	0.46**	3
															0.55**	0.23*	0.065n.s	0.24*	4
														0.12n.s	0.23*	0.12n.s	0.20*	0.48**	5
													-0.15n.s	0.057n.s	0.13n.s	0.044n.s	0.033n.s	-0.05 n.s	6
												-0.12n.s	0.011n.s	-0.3**	-0.4**	0.035n.s	-0.026n.s	-0.31**	7
											0.12n.s	0.038n.s	0.2n.s	-0.18n.s	-0.006n.s	0.13n.s	0.18n.s	0.16n.s	8
										-0.21*	-0.36**	-0.081n.s	0.17n.s	0.22*	0.23*	0.13n.s	0.11n.s	0.063n.s	9
									-0.32**	0.63**	0.33	0.18n.s	0.21*	-0.26*	-0.028n.s	0.30**	0.32**	0.25*	10
								0.083n.s	-0.031n.s	0.1n.s	-0.097n.s	0.078n.s	0.022n.s	0.032n.s	0.16n.s	0.092n.s	0.018n.s	0.16n.s	11
							-0.105n.s	0.011n.s	0.68**	0.097n.s	-0.034n.s	-0.14n.s	0.53**	0.18n.s	0.31**	0.29**	0.3**	0.26**	12
						0.7**	-0.037n.s	0.21*	0.57**	0.087n.s	-0.17n.s	-0.15n.s	0.34**	0.028 n.s	0.17n.s	0.23*	0.26**	0.27**	13
					0.37**	0.5**	0.11n.s	0.34**	0.19n.s	0.27**	-0.14n.s	-0.14n.s	0.68**	0.077n.s	0.25**	0.31**	0.4**	0.64**	14
				0.49**	0.69**	0.4**	0.002n.s	0.42**	0.25*	0.12n.s	-0.28**	-0.17n.s	0.34**	-0.021n.s	0.2*	0.32**	0.34**	0.43**	15
			0.43**	0.61**	0.29**	0.29**	-0.12n.s	0.23*	0.072n.s	0.13n.s	-0.28**	-0.074n.s	0.48**	0.23*	0.42**	0.41**	0.58**	0.96**	16
		0.098 n.s	-0.19 n.s	0.3**	-0.104 n.s	0.64**	-0.11 n.s	-0.21*	0.33**	0.041 n.s	0.14 n.s	-0.028 n.s	0.37**	0.21*	0.25*	0.15n.s	0.13n.s	0.068n.s	17
	0.29 **	*0.14 n.s	0.29 **	0.35 **	0.52**	0.61**	0.049n.s	0.22*	0.64**	0.61**	-0.19n.s	-0.035n.s	0.3**	0.039n.s	0.17n.s	0.19n.s	0.21n.s	0.16n.s	18
0.36 **	0.41 **	0.15 n.s	0.052 n.s	0.28**	0.21*	0.45**	.0n.s	0.25*	0.13n.s	0.32**	0.13n.s	0.43	0.25*	0.13n.s	0.25*	0.48**	0.450 **	.149n.s	19

Table 5: The results of grain yield comparison in corn hybrids.

Hybrid name	Number	Grain yield mean (Ton/ha)	Classification	Hybrid name	Number	Grain yield mean (Ton/ha)	Classification
K 722*B73	27	10.221	A	L105*K1263/1	9	9	AB
K1264/1*L105	4	10.124	A	M017*K74/1	20	20	AB
K2816*B73	6	9.908	AB	K1264/1*KE72012	3	3	AB
K1264/1*KE72012	1	9.873	AB	Ksc70	30	30	AB
Ksc500	26	9.838	AB	L105*B73	11	11	AB
Ksc260	21	9.646	AB	K722*B73	13	13	AB
DC370	24	9.459	AB	OH43/1-42*M017	19	19	AB
Ksc400	25	9.423	AB	Ksc302	22	22	AB
K1264/1*KE72012	2	9.087	AB	M017*K1264/1*B73	28	28	AB
K2816*M017	7	9.041	AB	Ksc340	23	23	AB
K2816*L105	5	8.863	AB	K74/1*L105	10	10	AB
KE72012*TVA926	17	8.758	AB	OH43/1-42*B73	12	12	AB
K1263/1*TVA926	16	8.741	AB	M017*L105	8	8	AB
Ksc700	29	8.733	AB	K74/1*B73	14	14	AB
K1264/1*TVA926	15	8.683	AB	K1263/1*M017	18	18	B

Conclusion:

This study showed that different inbred lines of the same seed contribute a potentially important source of genetic variation and finally we can inset corn best seeds. Hybrid Maize production is based on development and crossing of inbred lines. Since the 1920s, over 600 public inbred lines have been developed, some of which are now extinct [21,8]. Most of the modern inbreds being used in public breeding programs are second or third cycle lines that were developed from other inbred lines or from synthetic populations derived from crossing inbreds [2].

Although the older generation inbred lines have been retired from hybrid seed production, they are still widely used in inbred line development, genetic studies and as testers in many breeding programs [19,14,11,9]. The availability of different inbred lines from different sources [12,10].

Acknowledgements

This research was conducted at the Khorasan Razavi agricultural and natural resources research institute.

References

1. Ajmone-Marsan, P., P. Castiglioni, F. Fusari, M. Kuiper, M. Motto, 1998. Genetic diversity and its relationship to hybrid performance in maize as revealed by RFLP and AFLP markers. Theor. Appl. Genet. 96: 219-227
2. Baker, R., 1984. Some of the open pollinated varieties that contributed the most to modern hybrid corn. P. 1-19. In Proc. Of the 20th Annual Illinois Corn Breeders School. 6-8 May 1984. Univ. of Illinois, Urbana-Champaign.
3. Bing, J.W., W.D. Guthrie, FF. Dicke, 1992. Genetics of resistance to the corn leaf aphid (Homoptera: Aphididae). J. Econ. Entomol. 85: 1474-1479.
4. CIMMYT., 2003. A users Manual for Field Book 5. 1/7. 1 and Alpha. Maize Program, CIMMYT, D.F. Mexico.
5. Darrah, L.L., M.S. Zuber, 1985. United States farm maize gerplasm base and commercial breeding strategies. Crop Sci., 26: 1109-1113.
6. Fleming, A.A., G.M. Kozelnicky, EB. Browne, 1964. Variations between stock within long-time inbred lines of maize (Zea mays L.). Crop Sci., 4: 291-295.
7. Frey, K.J., 1996. National Plant Breeding Study I. Human and financial resources devoted to plant breeding research and development in the United States in 1994. Special Report, 98: 45 pages. Iowa Agriculture and Home Economics Experiment Station. Iowa State University.
8. Gerdes, J.T., C.f. Behr, J.G. Coors, W.F. Tracy, 1994. Compilation of North American maize breeding gerplasm. CSSA, W.I. Madison
9. Hallauer, R., K.R. Lamkey, P.R. White, 2000. Registration of genetic similarity among maize inbred lines detected by RLFPs, RAPDs, SSRs and AFLPs. Theor. Appl. Genet. 97:1248-1255
10. Livini, C., P. Ajmone-Marsan, A.E. Melchinger, M.M. Messmer, M. Motto, 1992. Genetic diversity of maize inbred lines within and amoung heterotic groups revealed by RFLPs. Theor. Appl. Genet. 84:17-25
11. Marcon, A., S.M. Kaeppler, S.G. Jensen, L. Senior, C. Stuber, 1999. Loci controlling resistance to high plains virus and wheat streak mosaic virus in a B73*Mo17 population of maize. Crop Sci., 39: 1171-1177.
12. Mauria, S., N.N. Singh, A.K. Mukherjee, K.V. Bhatt, 2000. Isozyme characterization of Indian maize inbreds. Euphytica, 112: 253-259.
13. Mumm, R.H., J.W. Dudley, 1994. A classification of 148 U.S. maize inbreds: I. Cluster analysis based on RFLPs. Crop Sci., 34: 842-851.
14. Nedev, T., M. Kruleva, B. Krapchev, 2000. Genetic relationship amoung cytoplasm analogs and morphogenis potential of maize inbreds. Maize Genetics Coop. Newsl., 74: 63.
15. Rathore, T.R., M.Z.K. Warsi, N.N. Singh, S.K. Vasel, 1998. Production of maize under excess soil moisture (water logging) conditions, Second Asian Regional Maize Workshop PCCARD Los Banos, Philippines, February, 23-27.
16. Russell, W.A., G.F. Sprague, L.H. Penny, 1963. Mutations affecting quantitative characters in long-time inbred lines of maize. Crop Sci., 3: 175-178.
17. Russell, W.A., U.A. Vega, 1973. Genetic stability of quantitative characters in successive generations in maize inbred lines. Euphytica, 22: 172-180.
18. Senior, M.L., J.P. Murphy, M.M. Goodman, C.W. Stuber, 1998. Utility of SSRs for determining genetic similarities and relationships in maize using an agarose gel system. Crop Sci., 38: 1088-1098.
19. Smith, M.E., V.E. Gracen, 1993. Registration of NYLB31 and NYRD4058 parental lines of maize. Crop Sci., 33: 361.
20. Troyer, F., 1999. Background of U.S. hybrid corn. Crop Sci., 39: 601-626.
21. Zuber, M.S., L.L. Darrah, 1980. 1979 U.S. corn germplasm base. P. 234-249. In H.D. Loden and D.W. Wilkinson (ed.) Proc. Of the 35th Annual Corn and Sorghum Industry Res. Conf. Chicago, IL. 9-11 Dec. Am. Seed Trade Assoc., D.C. Washington.