Development of improved maize varieties in Indonesia

Made J. Mejaya[1], A. Takdir[2], N. Iriany[2], and M. Yasin HG[2]

[1] North Maluku Assessment Institute for Agricultural Technology. Jl. Inpres Ubo-Ubo 241, Ternate 97717, North Maluku, Indonesia.

[2] Indonesian Cereal Research Institute, Jl. Dr. Ratulangi 274, Maros 90514 South Sulawesi.
E-mail: mmejaya@yahoo.com

Abstract. Maize productivity in Indonesia is relatively low (3.66 ton/ha), although in some provinces, productivity is above 4.0 t/ha. The higher productivity is due to adoption of production technology by farmers, one of which is the use of improved varieties. This paper describes the development of several improved maize varieties released by the Indonesian Agency for Agricultural Research and Development (IAARD). Two open pollinated varieties (OPVs) of normal kernel being used widely by farmers in marginal areas are Lamuru and Sukmaraga. Lamuru was developed for tolerance to drought using a Modified Reciprocal Recurrent Selection (MRRS) breeding method and released in 2000 with grain yield productivity 5.60 t/ha. Sukmaraga was selected in high aluminium saturated soil for tolerance to acid soil and released in 2003 with yield productivity of 6.00 t/ha. Both varieties were resistant to downy mildew. Two quality protein maize (QPM) varieties namely Srikandi Kuning-1 (yellow kernel) and Srikandi Putih-1 (white kernel) were released in 2004 with grain yield productivity of 5.40 and 5.89 t/ha, respectively which is similar to normal maize variety Lamuru (yellow kernel). The lysine and trypthofan concentration of Srikandi Kuning-1 were 0.477% and 0.093%, respectively, which higher thann Lamuru (0.278% and 0.064%). The lysine and trypthofan concentration of Srikandi Putih-1 were less than Srikandi Kuning-1 but higher than normal maize variety Bayu (white kernel). These QPM varieties are being programmed by the government to improve the low nutrition value in some parts of Indonesia, especially in the drought prone areas. Bima-1 was the first single cross hybrid released in 2001 with grain yield productivity of 7.30 t/ha. The inbred parents of this hybrid, Mr14 and Mr4, were developed from MRRS breeding program and become the testers of other inbreds. Bima-2 Bantimurung and Bima-3 Bantimurung, two single cross hybrid maize varieties, use inbred Mr14 as male parent and inbreds B11-209 and Nei 9008 as female parents. These two hybrids were released in 2007 with grain yield productivity 8.51 and 8.27 t/ha, respectively. Inbreds B11-209 and Nei 9008 gave better combining ability with Mr14 than Mr4 and had opportunity to be used as testers replacing Mr4 in hybrid breeding program. MRRS effectively improved grain yield of MSJ2 population.

Key-words: maize, open pollinated, hybrid, improved, varieties

Introduction

Maize in Indonesia is the second important food crops after rice. The annual maize harvested areas is 3.35 million ha and total production is 11-12 million ton. Based on survey results conducted in 1999 and 2000, about 75 - 80% of maize area in Indonesia was grown with improved varieties consisted of 47 - 56% open pollinated varieties and 24 - 28% hybrid varieties, while the rest 20 - 25% of total area was grown with local low yielding varieties (Pingali, 2001; Nugraha et al., 2002). In 2007, maize productivity was relatively low (3.66 ton/ha), although in some provinces, productivity were above 4.0 t/ha (CBS, 2008). The higher productivity is due to adoption of production technology by farmers, one of which is the use of improved varieties both open pollinated as well as hybrid varieties.

Since 1956, more than 100 improved maize varieties have been released in Indonesia, which more than 50% consisted of hybrid maize varieties. Almost all of open pollinated varieties (OPVs) were released by the Indonesian Agency for Agricultural Research and Development (IAARD), under the Indonesian Department of Agriculture. While most of hybrid varieties were released by the multinational private seed companies such as BISI, Pioneer, Monsanto, etc. Earlier, IAARD emphasized more to the development of improved OPVs, while the hybrid maize program at IAARD was started in 1987.

This paper describes the progress of breeding program conducted by the IAARD in the development of improved maize varieties in Indonesia.

Materials and Methods

In 1993, maize breeders at the Malang Research Institute for Food Crops (MARIF), under the IAARD, developed two versions of maize base population pairs as a heterotic pattern namely the late and early maturing version. The late maturing version was Malang Sintetik (MS) J1 versus MS J2, while the early maturing version was MS K1 versus MS K2. These population pairs were

improved using a Modified Reciprocal Recurrent Selection (MRRS) breeding method. One cycle of selection consisted of 4 planting seasons or generations with the following steps: 1. Development of S1 lines by selfing each plant, 2. Development of top-crosses by crossing S1 lines with the opposite population as a tester (J1 vs. J2 and K1 vs. K2), 3. Evaluation of top-crosses in replicated trials, and 4. Recombination of the selected lines to produce a new cycle (n + 1) populations. Two cycles of selection were completed (Dahlan et al., 1996). Due to reorganization, this MRRS program was moved in 1995 from MARIF to the Indonesian Cereal Research Institute (ICERI) located in Maros, South Sulawesi..

The MRRS was aimed to obtain several promising lines having a good general combining abilities (GCA) and/or specific combining abilities (SCA). The combining ability of lines derived from MS J1 were evaluated using MS J2 population as a tester, and vice versa. Lines having a good GCA were recombined (intercrossed) to produce a new cycle population or synthetic varieties. Lines having a good SCA were crossed to produce a new hybrid. Therefore, in one breeding program, the OPVs and hybrids were obtained. From each improved population, several new lines were selected in each cycle having better performance than lines derived from the previous cycle. Five cycles of MRRS had been completed in 2003 for J1, J2, K1, and K2 populations. Two inbred lines, Mr4 and Mr14, were derived from MS J2 C1 and MS J1 C1 (Suwan 3 C7) populations and used as female and male parents of Bima 1 hybrid released in 2001. Since then, Mr4 and Mr14 were used as tester parents for other inbreds.

Four populations of cycle fifth from MRRS program namely K1C5, K2C5, J1C5, and J2C5 were tested in five locations along with 12 other populations and two check varieties (Lamuru and Sukmaraga) in 2004. Each genotype was tested in two rows plot of 1.5 m x 5 m, using RCB design with 3 reps.

Results and discussions

Open pollinated maize varieties

Due to limited land availability in Java, the extension of maize growing are directed to outside Java such as Sumatra, Kalimantan, Papua, Nusa Tenggara and Sulawesi.Development of maize area outside Java posses two constrains of land condition namely high soil acidity and low soil fertility as well as drought stress due to low precipitation or rain fall, therefore, OPVs are still suitable for these kinds of lands.

Nine open pollinated varieties (OPVs) were released by the IAARD since the Indonesian Maize Research Institute was moved to Maros, South Sulawesi in 1995. OPVs Palakka, Lamuru, and Gumarang were derived from MS J2C1, MS J2C2, and MS K2C2, respectively, with grain yield potential of 7.6 – 8.0 t/ha and productivity 5.0 – 6.0 t/ha. Lamuru is relatively tolerant to drought condition and being used widely by farmers, while Gumarang is early maturing variety (82 days). Lagaligo, released in 1996, is also tolerant to drought (Table 1). Sukmaraga was released in 2003 and has a good adaptation in high aluminium saturated soil, resistant to downy mildew, and yield productivity of 7.0 t/ha. Sukmaraga was selected in high aluminium saturated soil in South Kalimantan and West Sumatra.

In 2004, two quality protein maize (QPM) varieties were released namely Srikandi Kuning-1 (yellow kernel) and Srikandi Putih-1 (white kernel). Srikandi Kuning-1 and Srikandi Putih-1 showed grain yield productivity of 5.40 and 5.89 t/ha, respectively , while the normal maize varieties Lamuru (yellow kernel) yielded 5.60 (Table 1). Srikandi Kuning-1 and Srikandi Putih-1 showed grain yield potential 7.90 and 8.10 t/ha, respectively, while the normal maize varieties Lamuru and Bayu (white kernel) showed grain yield potential 7.60 and 5.60 t/ha, respectively (Table 2).

Table 1. Characteristics of open pollinated maize varieties released by IAARD since 1996.

No.	Variety	Year of released	Source Population	Yield Potential (t/ha)	Productivity (t/ha)	Maturity (days)	Specific trait
1	Lagaligo	1996	Arjuna	7,50	5,25	90	drought tolerant
2	Gumarang	2000	MS.K2(RRS)C2	8,00	5,00	82	early maturity
3	Kresna	2000	AC(FS)C7	7,00	5,20	90	early maturity
4	Lamuru	2000	MS.J2(RRS)C2	7,60	5,60	95	drought tolerant
5	Palakka	2002	MS.J2(RRS)C1	8,00	6,00	95	early maturity
6	Sukmaraga	2003	AMTL x Local	8,50	6,00	105	Acid soil tolerant
7	Srikandi Kuning-1	2004	S99TLYQ-AB	7,92	5,40	110	QPM, yellow kernel
8	Srikandi Putih-1	2004	S98TLWQ(F/D)	8,09	5,89	110	QPM, white kernel
9	Anoman (white Kernel)	2006	MS2 (Tuxpeno Sequia C6)	6,60	4,60	103	drought tolerant, short plant stature

Table 2. Grain yield potential, concentrations of protein, lysine and trypthofan of QPM varieties Srikandi Kuning-1, Srikandi Putih-1, and normal maize varieties.

Varieties	Grain yield potential (t/ha)	Protein (%)	Lysine (%)	Trypthofan (%)
Srikandi Kuning-1	7.90	10.38	0.477	0.093
Lamuru (yellow kernel)	7.60	8.49	0.278	0.064
Srikandi Putih-1	8.10	10.44	0.410	0.087
Bayu (white kernel)	5.60	-	0.252	0.062

Table 3. Characteristic of hybrid maize varieties released by IAARD since 1992

No.	Variety [a, b]	Year of released	Female parent [c]	Male parent	Yield potential (t/ha)	Productivity(t/ha)	Maturity (days)
1	Semar-1	1992	GM12 x GM19	GM15	9.0	5.3	100
2	Semar-2	1992	GM25 x GM30	GM27	8.0	5.0	91
3	Semar-3	1996	GM26 x GM30	GM15	9.0	5.3	94
4	Semar-4	1999	Mr01 x Mr02	Mr03	8.5	5.9	90
5	Semar-5	1999	Mr05 x Mr06	Mr04	9.0	6.8	98
6	Semar-6	1999	Mr07 x Mr08	Mr04	8.9	6.9	98
7	Semar-7	1999	Mr08 x Mr06	Mr04	9.0	6.8	98
8	Semar-8	1999	Mr09 x Mr10	GM15DMR	9.0	6.9	94
9	Semar-9	1999	Mr11 x Mr12	GM15DMR	8.5	6.6	95
10	Semar-10	2001	Mr13 x Mr04	Mr14	9.0	7.2	97
11	Bima-1	2001	Mr04	Mr14	9.0	7.3	97
12	Bima-2 Bantimurung	2007	B11-209	Mr14.	11.0	8.51	100
13	Bima-3 Bantimurung	2007	Nei 9008	Mr14	10.0	8.27	100

[a] Bima is Single cross (SC); Semar is Three-way cross (TWC) hybrids.
[b] All hybrids are resistant to downey mildew, leaf rust, and leaf spot diseases.
[c] GM and Mr = Inbred lines developed in Malang and Maros, respectively.

The lysine and trypthofan concentrations of Srikandi Kuning-1 were 0.477% and 0.093%, respectively, while Lamuru were 0.278 and 0.064%, respectively. The lysine and trypthofan concentrations of Srikandi Putih-1 were 0.410% and 0.087%, respectively, while Bayu were 0.252 and 0.062%, respectively (Table 2). These QPM varieties are now being programmed by the government to improve the low nutrition value of children in some parts of Indonesia, especially in the drought prone areas.

Hybrid maize varieties

Thirteen hybrid maize varieties had been released since 1992, consisted of 10 "three-way cross" hybrids (Semar-1 – Semar 10) and four "single cross" hybrids (Bima-1 – Bima-3). Eight hybrid varieties (Semar 4 – Semar 10 and Bima 1) were released from the MRRS breeding program. Table 3 showed two single cross hybrid maize varieties, Bima-2 Bantimurung and Bima-3 Bantimurung, which were released in 2007 with grain yield productivity above 8.0 t/ha, while grain yield potential of 11.0 and 10.0 t/ha, respectively. Bima-2 Bantimurung was a single cross hybrid of B11-209 x Mr14, while Bima-3 Bantimurung was a single cross hybrid of Nei 9008 x Mr 14 (Table 3). Since Bima 1 was developed from Mr4 and Mr14, this fact suggested that inbred lines B11-209 and Nei 9008 were better than Mr4 as a combination with Mr14. Therefore, B11-209 and Nei 9008 inbred lines could be used as testers replacing Mr4.

Selection progress

Table 4 showed four populations (K1C5, K2C5, J1C5, and J2C5) derived from MRRS breeding program showed grain yield higher than Lamuru (6.36 t/ha). Among four populations, MSJ2C5 gave highest grain yield of 7.38 t/ha which was 16% higher than Lamuru (derived from MS J2C2) or the selection progress was 339 kg/cycle. This suggested that MRRS effectively improved grain yield of MSJ2 population (Table 4). The four populations of cycle fifth from MRRS program namely are being improved for next cycle of selection. Selection progress is depend on genetic variation of base population in RSS. Moll dan Hanson (1984) obtained 24% yield increased on Jarvis population

Table 4. Grain yield of open pollinated maize genotypes average of five locations during 2004

No.	Populations	Grain yield (t/ha)	No.	Populations	Grainyield (t/ha)
1	MS.K1(RRS)C5	6.83	10	MS.BK(S1)C1	6.58
2	MS.K2(RRS)C5	7.06	11	MS.BK(HS)C1	6.45
3	MS.J1(RRS)C5	7.14	12	Bisma(S1)C1	6.75
4	**MS.J2(RRS)C5**	7.38	13	Bisma(S2)C1	6.56
5	SATP-1(S2)C6	6.69	14	SA4-1(S1)C1	5.22
6	SATP-2(S2)C6	7.66	15	MS.QP-1	7.06
7	AMATL(S1)C3	7.42	16	MS.QK-1	6.72
8	MS.HK(S1)C3	7.22	17	**Lamuru =J2C2**	6.36
9	MS.KH(S1)C3	6.57	18	**Sukmaraga**	6.59

selected for 10 cycles of RSS on Jarvis and Indian Chief populations. Keeratinijakal and Lamkey (1993) conducted a RSS on Iowa Stiff Stalk Synthetic (BSSS, R) and Iowa Corn Borer Synthetic M1 (BSCB1, R) populations for 11 cycles and obtained yield increased on BSCB of 1.94% (0.06 t/ha = 60 kg/ha) per cycle, while there was no change observed on BSSS population.

Conclusions

- B11-209 and Nei 9008, female parents of hybrids Bima-2 and Bima-3, gave better combining ability with Mr14 than Mr4 and had opportunity to be used as testers replacing Mr4 in hybrid breeding program.
- MRRS effectively improved grain yield of MSJ2 population.
- OPVs are still needed especially for area outside Java having high soil acidity, low soil fertility, and drought stress due to low precipitation or rain fall.
- Development of QPM varieties is needed to improve the low nutrition value of children in some parts of Indonesia, especially in the drought prone areas.

Acknowledgements

Special thanks to IAARD under the Indonesian Department of Agriculture which have been funding this maize MRRS program since 1993.

References

Dahlan, M.M., S. Slamet, M.J. Mejaya, Mudjiono, J.A. Bety, dan F. Kasim. 1996. Peningkatan Heterosis Populasi Jagung untuk Pembentukan Varietas Hibrida. Balitjas. Maros. p. 50.

Keertanijakal, V. and K.R. Lamkey. 1993. Responses to reciprocal recurrent selection in BSSS and BSCB1 maize populations. Crop Sci. 33 : 73 – 77.

Moll, R.H. and W.D. Hanson. 1984. Comparison of effects of intrapopulation vs interpopulation selection in maize. Crop Sci. 24 : 1047 – 52.

Nugraha, U.S., Subandi, A. Hasanuddin dan Subandi. 2002. Perkembangan teknologi budidaya dan industri benih jagung. *Dalam:* Kasryno *et al., (eds.)* Ekonomi Jagung Indonesia. Badan Penelitian dan Pengembangan Pertanian. Deptan. P. 37-72.

Pingali, P. (ed.). 2001. CIMMYT 1999/2000 World Maize Facts and Trends. Meeting World Maize Needs: Technological Opportunities and Priorities for the Public Sector. Mexico, D.F. : CIMMYT

Takdir, A., R.N. Iriany, and M.J. Mejaya. 2007. Adaptasi genotype calon hibrida jagung di beberapa lokasi. Penelitian Pertanian Tanaman Pangan, 26(1): 20-25.