PROGRESS ON THE DEVELOPMENT OF HIGH YIELDING COTTON VARIETIES IN INDONESIA

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Abstract: The focus of cotton improvement program is to increase productivity in order to strengthen the competitiveness of cotton farming, and to improve fiber properties in order to meet the textile industry's demand which is export oriented. The cotton improvement program in the Indonesia Tobacco and Fiber Crops Research Institute (IToFCRI) since 1983 has released 15 new varieties, Kanesia 1 – Kanesia 15 which are not only high yielding but also are tolerant to jassids, *A. biguttula* and have better fiber properties and more tolerant to drought. The cotton breeding program in IToFCRI has resulted in a simultaneous genetic improvement in terms of productivity level, tolerance to insect pest especially jassids, as well as fiber properties. Those improvements will lead to the increase of Indonesian national cotton production.

1 Introduction

Indonesia is the 5th biggest textile producing country in the world, but ironically the Indonesian domestic cotton production is < 10 thousand tonnes contributing to less than 2.5% of the national demand for cotton fiber. Table 1 presents the national cotton production, import volume, as well as contribution of national cotton production to national textile industry demand from 2000 to 2004.

Table 1 The national cotton production, import volume of cotton fiber, as well as contribution of national cotton production to national textile industry demand in Indonesia from 2000 to 2004

Year	Domestic production -- 000 tones --	Import -- 000 tones --	Contribution of local production (%)
2000	7.68	638	1.19
2001	13.2	565	2.28
2002	8.88	534	1.63
2003	8.88	516	1.69
2004	8.88	528	1.62

The Indonesian national cotton development program is facing complex problems such as 1) the unavailability of quality seed and irrigation facilities for cotton development on rainfed areas, 2) the lack of farmers' financial stock, 3) the low status of cotton crop as compared to cash crops, 4) the low level of farmers' adoption rate to innovation technology, and 5) the weakness of supporting agencies. The low level of farmers' adoption rate to innovation technology is due to the high yield loss on cotton development especially in rainfed areas, which then results in the idleness of farmers' in putting fertilizer and insecticide, as well as the application of other farming techniques. Consequently, the productivity at the farmers' level is below 1 ton seed cotton per hectare. In addition, the low seed cotton price decided

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by the government is not comparable to the high price of agriculture inputs as well as labor wage, and the low margin resulted from cotton farming.

The focus of cotton improvement program is to increase productivity in order to strengthen the competitiveness of cotton farming, and to improve fiber properties in order to meet the textile industry's demand which is export oriented. This was done by developing hairy varieties that tolerant to jassids, *Amrasca biguttula*, the first attacking insect pest on cotton production in Indonesia. Those varieties would then be the major component in cotton integrated pest management, because the use of those varieties results in less chemical insecticide use and increased role of non-chemical pest control measures. If the farmers' productivity level is reaching 2.5 ton seed cotton/ha, it is estimated that the farmers' income will increase by 15-20%, and the national cotton production will increase by 5% which will decrease the national import volume by 4% (equal to US $24 million).

The cotton improvement program has been conducted since 1983, and since then it has resulted in 15 new released varieties. Simultaneous progress has been achieved, consisting of increased productivity level and resistance to jassids, and improved fiber properties especially fiber strength and fiber length. This paper presents gradual genetic improvement achieved during the development of 15 Indonesian high yielding cotton varieties, Kanesia 1 – Kanesia 15, and the future cotton breeding program in Indonesia.

2 KANESIA, The Indonesian National Cotton Varieties

The variety used in the national cotton development program in Indonesia is facing the genetic degeneration problem, which lower the productivity level significantly. Therefore, the cotton improvement program has to be done continuously. The cotton improvement program in the Indonesia Tobacco and Fiber Crops Research Institute (IToFCRI) since 1983 has released 15 new varieties, Kanesia 1 – Kanesia 15 which are not only high yielding but also are tolerant to jassids, *A. biguttula* and have better fiber properties (Hasnam *et al*., 2004; Sulistyowati *et al*., 2007). Moreover, Kanesia 14 and Kanesia 15 are more tolerant to drought (Sumartini *et al*., 2007).

The cotton germplasm held in IToFCRI's collection is limited to around 700 accessions only. If the availability of cotton genetic variation in IToFCRI can be broadened, the cotton breeding program can be strengthened. Cotton varieties, Kanesia 1 – Kanesia 15 are developed from 18 elite cotton germplasm accessions, i.e. Reba BTK 12, Tak Fa 1, HG P-6-3, Stoneville 825, Reba B-50, Reba-1887, TAMCOT SP-37, LRA 5166, DPL Acala 90, Deltapine 5690, Tashkent 2, SRT 1, Pusa 1, Reba BTK 12 Thailand, MCU 9, Auburn 200, ISA 205 A, and ALA 73-2M which are originated from the USA, Africa, Rusia, Thailand, and India. There are only 662 cotton accession in the IToFCRI's collections comprises of 642 accessions of *G. hirsutum*, 14 accessions of *G. barbadense*, 3 accessions of *G. arboreum*, and 3 accession of *G. herbaceum*, Therefore, germplasm exchange program to augment the current gene pool is needed to enhance cotton gene pools in the IToFCRI. Table 2 presents the genetic background of national Indonesian cotton varieties, Kanesia 1- Kanesia 15, whereas Table 3 presents description of Kanesia 10-Kanesia 15.

Tabel 2 Genetic background of Kanesia 1 – Kanesia 15

Variety – Year release	Genetic Background	Selection Number
Kanesia 1 - 1990	Reba BTK 12	Reba BTK 12/28
Kanesia 2 - 1990	Tak Fa 1	Tak Fa 1/111
Kanesia 3 - 1993	Reba BTK-12 x HG P-6-3	(168x96)x168x168x168
Kanesia 4 - 1998	Stoneville 825 x Reba B-50	85010/15/3
Kanesia 5 - 1998	Stoneville 825 x Reba 1887	85011/14/3
Kanesia 6 - 1998	Acala 1517-77 x Reba B-50	85019/16/1
Kanesia 7 - 2000	TAMCOT SP-37 X LRA 5166	88004/1/2
Kanesia 8 - 2003	DPL Acala 90 x LRA 5166	88003/16/2
Kanesia 9 - 2003	DPL Acala 90 x SRT 1	92016/6
Kanesia 10 - 2006	Pusa 1 x Deltapine 5690	97023/8
Kanesia 11 - 2006	LRA 5166 x SRT 1	98017/2
Kanesia 12 - 2006	Tashkent 2 x Pusa 1	98021/2
Kanesia 13 - 2006	DPL Acala 90 x Tashkent 2	98030/10
Kanesia 14 - 2007	(Reba B 50 x Reba BTK 12 Thailand) x (MCU 9 x Auburn 200)	(135x182)(351x268)9
Kanesia 15 - 2007	ISA 205 A x ALA 73-2M	(339x448)2

In addition to 15 Kanesia series mentioned above, two introduced varieties were also released, i.e. LRA 5166 from India in 1998 and ISA 205A from IRCT in 2004. LRA 5166 is no longer used, whereas LSA 5166 is still being used in limited areas of cotton development in East Java. To date Kanesia 8 is being used in the national cotton development program in Indonesia, whereas preparation for the dissemination of Kanesia 10 – Kanesia 15 is performed by increasing the availability of foundation seed of those varieties. The use of Kanesia 8 in the national cotton development program is replacing that of Kanesia 7, because it was observed that the genetic purity of Kanesia 7 was decreasing due to the pure national seed propagation system, which then caused significant genetic contamination to Kanesia 7. Since 2006, Kanesia 7 was under varietal maintenance for improving its genetic purity.

Table 3 Description of Kanesia 10 – Kanesia 15

Description	**KANESIA 10**	**KANESIA 11**	**KANESIA 12**
			
Crossing Code	LRA 5166 ×SRT 1	Tashkent 2 × Pusa 1	Pusa 1 ×Deltapine 5690
- Yield Potency - Gin Turnout - Fiber Length Fiber Strength Fiber Fineness - Resistance to *A. biguttula*	3025.5 kg 45% 28.9 mm 27.1 g/tex 4.3 mic Susceptible	3027.8 kg 38.9% 27.9 mm 27.7 g/tex 4.5 mic Moderate	2750 kg 34.5% 29.3 mm 29.5 g/tex 4.57 mic Moderate

Description	KANESIA 13	KANESIA 14	KANESIA 15
			
Crossing Code	Deltapine Acala 90 × Tashkent 2	(Reba B 50 x Reba BTK 12 Thailand) x (MCU 9× Auburn 200)	ISA 205 A × ALA 73-2M
- Yield Potency	3174 kg	3933 kg	3617 kg
- Gin Turnout	36.4 %	39.0 %	44.1 %
- Fiber Length	26.9 mm	28.5 mm	30.0 mm
Fiber Strength	28.3 g/tex	31.16 g/tex	32.2 g/tex
Fiber Fineness	5.08 mic	4.7 mic	4.9 mic
- Resistance to *A. Biguttula*	Moderate	Resistant	Resistant
- *Resistance to drought*	-	Moderate	Moderate

3 Simultaneous Improvement in the Development of KANESIA: Productivity, Tolerance to Insect Pests, and Fiber Properties

The cotton breeding program in IToFCRI has resulted in a simultaneous genetic improvement in terms of productivity level, tolerance to insect pest especially jassids, as well as fiber properties. Those improvements will lead to the increase of Indonesian national cotton production.

Improvement in Productivity Level

In the first 15 year of cotton breeding program in IToFCRI (1983-1998) in which Kanesia 1 – Kanesia 6 were released, the acceleration of yield increase was ranging from 10% to 15% per each selection cycle. It was increased from 0.8-1.1 ton to 1.85-1.91 ton seed cotton per ha. It means that in that period the selection progress achieved is 35 kg seed cotton per year which is equal to 12.4 kg cotton fiber per year. This achievement was derived from selection held in rainfed areas which have erratic climate under minimal insect pest control which was limited to only less than 2 l insecticide/ha (Hasnam *et al*., 1994; 1998). Significant yield increase was derived after the release of Kanesia 7 – Kanesia 15. Kanesia 7 – Kanesia 15 showed significant yield increase of about 1 ton seed cotton/ha higher than Kanesia 1 – Kanesia 6. Kanesia 7 and Kanesia 8 share similarity in male parental of LRA 5166, an introduced variety from India. From 1998 to 2007, the improvement in yield potency was reaching 210 kg seed cotton per year which is equal to 82.32 kg fiber per year (Sulistyowati *et al.*, 2007; Sumartini *et al*., 2007). The yield increase was accomplished by higher boll set and boll weight.

The yield boosting achieved in the development of Kanesia 1 – Kanesia 15 was also associated with significant increase in gin turnout (Figure 2). Two best Kanesia varieties which have gin turnout of > 40% are Kanesia 10 (45.98%) and Kanesia 15 (44.46%). The high gin turnout will benefit the textile industries which are users of domestic cotton fiber in Indonesia. Therefore, the price of seed cotton at

the farmer level should be higher than that other varieties'. To date, the price of seed cotton is decided by the government and that is the same for every variety.

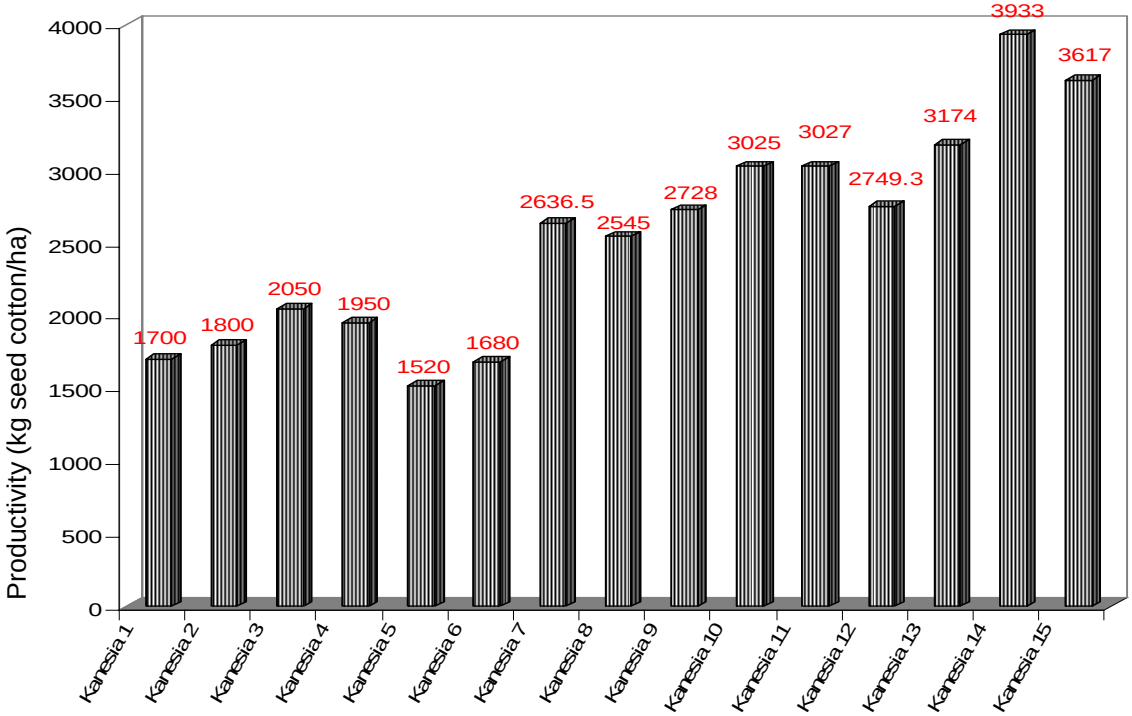

Fig. 1 Range of yield potency of Kanesia 1 – Kanesia 15

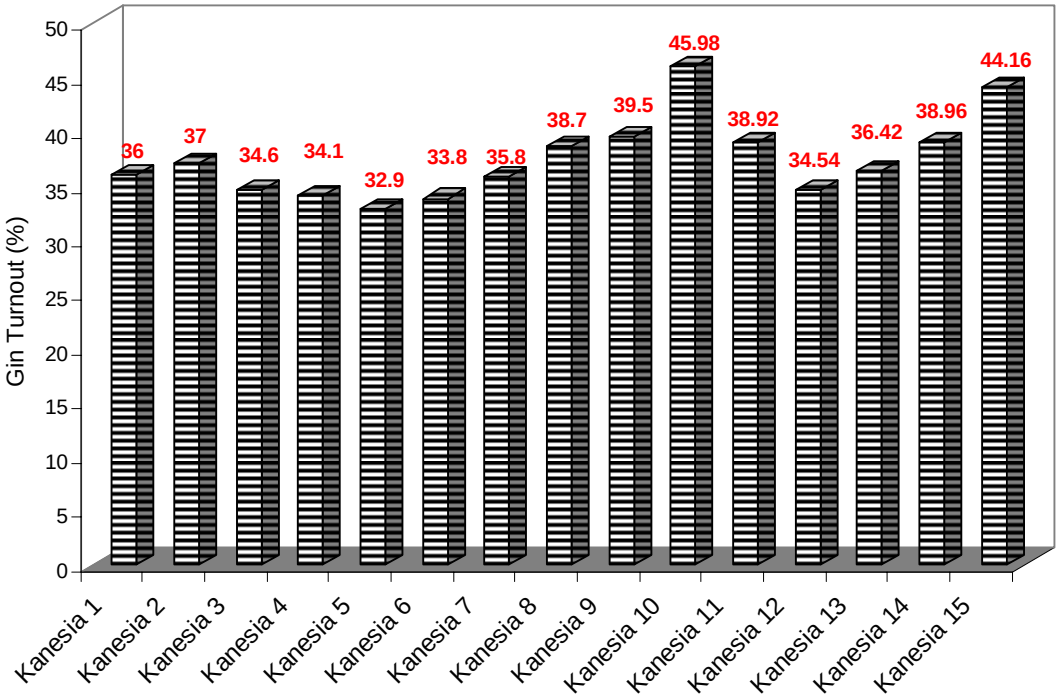

Fig. 2 Gin turnout percentage of Kanesia 1 – Kanesia 15

Improvement in Tolerance to Insect Pests

Genetic improvement to build up resistance to bollworms, *H. armigera*, has not given any good progress. The development of Kanesia 3 by involving HG P-6-3 as male parent that has a high gossypol content has not confer any resistance, because the rate of insect damage squares was still high reaching

66-90% (Hasnam *et al.*, 1994). This may be due to the gossypol content in Kanesia 3 is not high enough to induce antibiosis effect against bollworm complex. McColl and Noble (1992) stated that antibiosis effect decreases under high infestation of *H. armigera*.

Jassids, *A. biguttula* is the very first insect that attack young cotton plant. To cope with that problem, hairy varieties were developed as physical mechanism to resist the attack of jassids, LRA 5166, SRT 1, Pusa 1 and ALA 73-2M were used as donor of high hair density on the leaves and stems. Kanesia 14 which was developed by gene pooling approach is more resistant to jassids as compared to other varieties of Kanesia series.

Improvement in Fiber Properties

Fiber properties influence the spinning ability, as well as the quality and grade of the yarn being produced. Paroda and Koranne (1996) stated that the fiber properties required are 25-28 mm fiber length for rotor or friction spinning machine, or >30 mm for air-jet spinning machine, >7% elasticity, > 28 g/tex on 3.2 mm gauge for fiber strength, 3.0-3.8 mic fiber fineness, and >80% fiber maturity.

There was no significant genetic improvement in terms of fiber properties in the development of Kanesia 1 – Kanesia 15. Figure 3 presents the range of fiber length and fiber strength of Kanesia 1 – Kanesia 15. Except for Kanesia 13, other Kanesia varieties have fiber length measurement of > 28 mm, which can pass the requirement of spinning industries which use rotor or friction spinning machine. Kanesia 4 and Kanesia 8 have longer fiber than others (> 30 mm). In terms of fiber strength, significant improvement was achieved after the release of Kanesia 10 – Kanesia 15 in which fiber strength is above 27 g/tex. Kanesia 14 and Kanesia 15 have the highest fiber strength (> 30 g/tex) as compared to other varieties in Kanesia series.

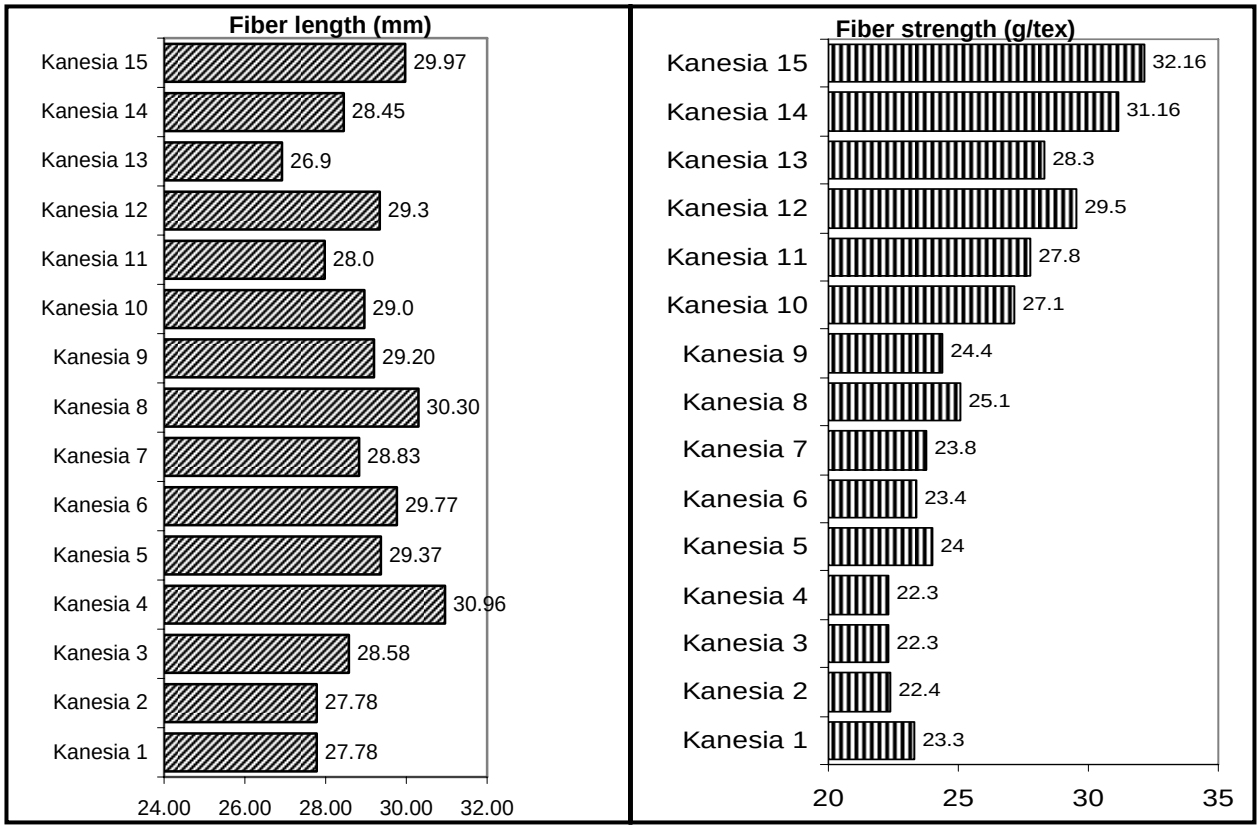

Fig. 3 Fiber Length and Fiber strength of Kanesia 1- Kanesia 15

4 Future Direction of Cotton Improvement Program in Indonesia

4.1 The evaluation and characterization of cotton accession collected in IToFCRI will be intensified, so that the 642 accessions can be selected as workable nice sets comprises of varied gene pools. To meet this goal, molecular techniques, physiological analysis, phenotypic screening for interesting characters have to be applied to enable the finding of valuable genes for future cotton improvement program. Marker-Assisted Selection (MAS) program will also be developed to enhance the breeding program.

4.2 Transgenic approached should be deployed to confer resistance to insect pests as well as to boost the yield potency as well as fiber properties. In addition, development of cotton varieties which are resistant to drought will also be achieved to target the development of cotton in rainfed areas which has erratic climate such as by over-production of proline, polyol, glycine betaine, trehalose or poliamina (Ho and Wu, 2004).

4.3 The development of national hybrid varieties will also be conducted by involving male sterile female parents and local adapted varieties as male parents.

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