

Breeding of Hansaengjam a Parental Sex-limited Larval Marking Strain Suitable for Spring Rearing Season

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Normally the first generation of hybrid is supplied for farm rearing, precise and labor saving sex discrimination is needed. The new strain "Hansaengjam" is sex-limited (♀:larval markings, ♂:no-markings) strain which was bred from both sex-limited strain Japanese originated Jam 153 and Chinese originated strain Jam 154. Productivity test of Hansaengjam during 2007 and 2009 showed high healthiness and cocoon yield. The Hansaengjam is evaluated as an excellent strain from healthiness, cocoon yield and other test results.

Key words: Silkworm, Breeding, Sex-limited larval marking

Introduction

Normally the first generation of hybridized silkworm is used for farm rearing, discrimination of female and male larvae should be finished before egg collection. Improving precision and efficiency of discrimination need much efforts and this made problems. Many studies were conducted to solve these problems. In discrimination, studies on various discrimination methods such as using genital gland of larvae or pupae, body weight difference between male and female pupae, and egg colors, larval marking and cocoon colors by sex-limited inheritance have been conducted.

Several silkworm varieties such as Daesungjam (Sohn *et al.*, 1987), Buhungjam (Kang *et al.*, 2004), Daepoogjam (Kang *et al.*, 2006) are now supplied to farms and the silk-

worms are easily discriminated during larval period. Other sex-limited varieties which are supplied to farms are Yangwonjam (Kang *et al.*, 2000) with parental sex-limited larval marking and Kumhwangjam (Kang *et al.*, 2004) with parental sex-limited yellow cocoon. These varieties showed similar or less yield compared to authorized general healthy strains but they were designated as authorized strain because of their sex-limited marking characteristics.

The Hansaengjam is healthier and showed higher yield than Yangwonjam (Kang *et al.*, 2000) which is current authorized parental sex-limited strain, so it was designated as spring-autumn authorized strain. Because both of parent strains have sex-limited markings, so the hybrid strain has same characteristics it makes discrimination in larval stage possible and is advantageous in practical use. It is possible to reduce 20% of labor with this strain and saving of time and labor for discrimination in male pupae production. This strain was designated as authorized strain in December 2009 as the recognition of its superiority by the local adaptability test conducted by 7 provincial sericultural experiment stations during 2009 spring and autumn season.

Materials and Methods

Silkworm strains for test

The tested silkworm strain Hansaengjam was crossbred from Japanese original strain Jam153 and Chinese original strain Jam 154, the control strain Yangwonjam (Kang *et al.*, 2000) which was bred by RDA NAAS for spring authorized rearing strain, and also its parent strain Jam 143 (Japanese originated) and Jam 144 (Chinese originated) were used as control.

Rearing method & cocoon characteristics examination

The rearing was begun in 2009 spring under conditions of hatching temperature 15-26°C, humidity 75-80%, and pho-

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toperiod of 16 hour light and 8 hour darkness. Silkworms were reared following Sericultural Experiment Guide, during 1st~3rd instar under conditions of 25-26°C temperature, 75-80% humidity and covered with wax paper, and during 4th~5th instar under conditions of 23-24°C temperature, 65-75% humidity in silkworm baskets. Silkworms were fed three times a day with mulberry leaves. Each hybrid groups were consisted of 1500 silkworms and mounted with rotating mounting frames. Cocoon characteristics examination was conducted 8 days after mounting, pupation rate and 10,000 cocoon weight were examined then single cocoon weight, cocoon shell weight and cocoon shell percentage of male and female were measured respectively and averages were calculated. Characteristics of original strains, artificial diet adaptability and cocoon quality were examined based on Sericultural Experiment Guide.

Examination of hypoglycemic agent content in silkworm

For the quantification of hypoglycemic agent, 1-Deoxyryojirimycin (DNJ) was extracted from 0.1 g of dried sample. Sample was intensely stirred 2 times for 15 seconds in the 10 mL 0.05 M HCl solution and diluted with 100 mL water. After adding "FMOC99-Fluorenyl Methyl Oxy Carbonyl, quantification was conducted following "Quality control guidance for DNJ quantification".

Cordyceps productivity examination of silkworms

For the *Cordyceps* productivity examination, 3 repetitions

of 250 silkworms of 4th instar 2nd day were tested, spawn was inoculated three times with 12 hr period into when 90% of silkworms became 5th instar. Cultivation of *Cordyceps* and productivity examination were conducted based on guidance.

Results and Discussion

Combining ability test

As the cross breeding combination of Japanese and Chinese strain generally shows highest heterosis (Sohn and Hong, 1986) the hybrids of these strains are normally used as selected superior combination. Especially, Diallel cross and Top cross are used for quantitative characteristics analysis, and Top cross is known as more efficient method (Sohn and Hong, 1986; Harada, 1961).

Table 1 shows the 3×3 Top cross combining ability test of Japanese and Chinese strain with Baekokjam as control. Hansaengjam showed lower pupation ratio and single cocoon weight but showed higher cocoon shell weight and percentage. But its raw silk yield was similar with control.

Local adaptability test

Silkworm rearing results

Table 2 shows the productivity and local adaptability test results of Hansaengjam conducted by NAAS and 7 local

Table 1. The important economic characteristics of Hansaengjam from the combining ability test in spring, 2008

Variety	Larval period	Pupation percentage	Cocoon* yields	Single cocoon weight	Cocoon shell weight	Cocoon shell percentage	Filament length	Reel-ability
	days.hrs	%	kg	g	cg	%	m	%
Baegokjam	22.03	96.8	24.5	2.57	59.7	23.2	1,410	74
Hansaengjam	22.03	95.9	23.2	2.49	61.3	24.6	1,496	74

*10,000 3rd molted larvae

Table 2. Rearing results of Hansaengjam through the local adaptability test performed at 8 places in spring, 2009

Variety	Useful hatchability	Larval period	Pupation percentage	Best cocoon rate	Double cocoon rate
	%	days.hrs	%	%	%
Yangwonjam	96	23.13	95.9	93.2	0.7
Hansaengjam	96	23.23	96.2	94.8	0.9

Variety	Cocoon yield per 10,000 3rd molted larvae	No. of cocoons per liter	Single cocoon weight	Cocoon shell weight	Cocoon shell percentage
	kg	ea	g	cg	%
Yangwonjam	20.8	54	2.25	54.2	24.0
Hansaengjam	22.7	52	2.43	61.2	25.2

Table 3. Cocoon reeling results of Hansaengjam through the local adaptability test performed at 8 places in spring, 2009

Variety	Filament length	Filament weight	Filament size	Reelability	Non-broken filament length
	m	cg	d	%	m
Yangwonjam	1,622	48.9	2.72	81	1,309
Hansaengjam	1,581	53.1	3.03	82	1,301

Variety	Non-broken filament weight	Raw silk percent	Raw silk yield*	Neatness	Degumming rate
	cg	%	kg	point	%
Yangwonjam	39.3	20.81	4.32	99	25.8
Hansaengjam	43.5	21.43	4.86	99	26.2

*Raw silk yield was calculated from multiplication between cocoon yield per 10,000 3rd molted larvae and raw silk percent.

Table 4. Artificial diet adaptability test of young silkworm in spring, 2010

Variety	Bristling percentage	Larval period from 1st to 3rd	Molting percentage			Adaptability
			2nd	3rd	4th	
	%	days.hrs	%	%	%	
Baegokjam	98	9.23	98	98	98	Excellent
Hansaengjam	90	11.10	85	90	90	dad

Table 5. The major commercial characteristics of the parents of hansaengjam

Variety	Useful hatchability	Larval period	Pupation rate	Cocoon yield per 10,000 3rd molted larvae	Single cocoon weight	Cocoon shell weight	Cocoon shell percentage
	%	days.hrs	%	kg	g	cg	%
Japanese races							
Jam 143	85	23.8	95.8	13.2	1.63	40.4	24.8
Jam 153	94	24.07	94.5	15.8	1.87	44.9	24.0
Chinese races							
Jam 144	97	24.01	91.2	15.7	2.02	45.5	22.5
Jam 154	98	23.08	83.6	11.6	1.79	44.9	25.1

Variety	Percentage of moth emergence	Duration from incubation to moth emergence	No. of eggs per batch	Percentage of moth laid normal eggs	Laval marking	Cocoon shape
	%	days	ea	%		
Japanese races						
Jam 143	100	55	537	100	♀ : mark, ♂ : plain	long peanut
Jam 153	100	56	650	100	♀ : mark, ♂ : plain	"
Chinese races						
Jam 144	100	54	541	100	♀ : mark, ♂ : plain	short elliptical
Jam 154	99	54	545	100	♀ : mark, ♂ : plain	"

sericultural experiment stations. The Hansaengjam showed 96% of hatching ratio same with control Ynagwonjam (Kang *et al.*, 2000) higher than the standard hatching ratio 90% needed for designation of authorized strain and had

10 hrs longer larval period. The pupation ratio was 96.2%, single cocoon weight was 2.43 g which was 8% higher than control, and 10 thousand cocoons weight was 22.7 kg which was 1.9 kg heavier than control.

Cocoon reeling results

Table 3 shows the reeling characteristics of Hansanjam compared with Yangwonjam (Kang *et al.*, 2000). Hansaengjam showed shorter filament length, but showed higher 10 thousand cocoons weight with 4.86 kg and 82 % of reelability. The filament size which means the fineness of silk was 3.03 d.

Artificial diet adaptability test of young silkworm

Table 4 shows artificial diet adaptability test results of Hansaengjam young silkworm. The control Baegokjam (Lee *et al.*, 1984) showed better results in every item, so this strain was evaluated as low artificial diet adaptability.

DNJ(1-Deoxynojirimycin) content and Cordyceps productivity test

The Hansanjam showed 4.19 mg, 21% more content of DNJ (1-Deoxynojirimycin) than control, and produced 1.60 g/ea of *Cordyceps* which was heavier than 1.45 g/ea of control.

Major characteristics of parent strains

The major characteristics of parent strains of Hansaeng-

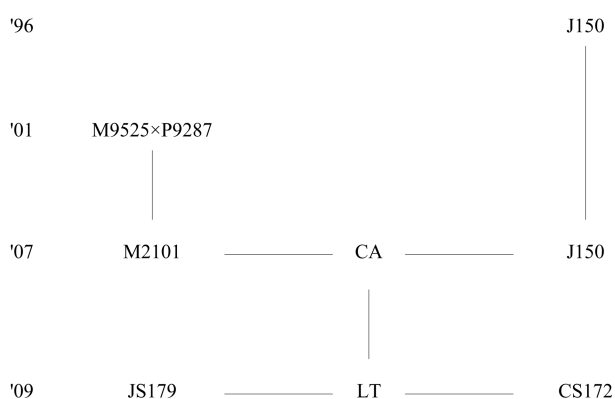


Fig. 1. The Pedigree of Hansaengjam, the F₁ hybrid between JS179×CS172.

CA : Combining ability test, LT : Local adaptability test



Female : markings

Male : no markings

Fig. 2. Pictures of Hansaengjam.

jam Jam 153 and Jam154 compared to the parent strains of control Yangwonjam (Kang *et al.*, 2000) Jam143 and Jam144 are shown in table 5.

The original strain Jam153 is sex-limited larval marking strain of which female larvae have markings but male does not and its cocoon is peanut shaped.

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