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On-Station Yield Trial Evaluation of Promising Silkworm Hybrids in the Philippines

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Abstract

On-station silkworm rearing trials were done in three distinct seasons (January-February, April-May, and July-August) at the Sericulture Research and Development Institute in Bacnotan, La Union, Philippines to evaluate the cocoon yield and quality of the five (5) newly-developed bivoltine silkworm hybrids (DMMMSU 108 x DMMMSU 119, DMMMSU 110 x DMMMSU 113, DMMMSU 110 x DMMMSU 119, DMMMSU 119 x DMMMSU 110), and DMMMSU 119 x DMMMSU 108). These were compared to the local single cross bivoltine hybrid, DMMMSU 222in terms of cocoon characteristics such as cocoon yield, effective rearing rate, single cocoon weight, and cocoon shell percentage. The data gathered were statistically analyzed using the Analysis of Variance (ANOVA) in Completely Randomized Design (CRD). Tukey's Honest Significant Difference (HSD) was used to test the significance among all the hybrids and against the control hybrid. The results revealed variations in the performance of the different hybrids on cocoon characters and in different rearing seasons. Among the five new hybrids, DMMMSU 119 x DMMMSU 108 consistently performed better than the controlin terms of effective rearing rate (ERR) and cocoon yield per box (CYPB), particularly in the July–August and January–February seasons. DMMMSU 108 x DMMMSU 119 also performed better over the control hybrid when reared in the April to May and July to August rearing seasons. DMMMSU 110 x DMMMSU 119 performed betterthan the control hybrid during the January to February rearing season. Overall, these hybrids are recommended for further trials in the farmer's field for validation.

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Introduction

The decline in silk production, combined with rising demand, presents significant opportunities for an emerging sericulture industry in countries like the Philippines. Therefore, it is crucial to prioritize research activities aimed at developing high-yielding silkworm hybrids for cocoon production.

The breeding program of the institute aims to produce varieties that have better characteristics than the existing breeds. After the successful breeding work on the evolution of new bivoltine silkworm purelines, followed by combining ability and multiple evaluation index tests, five bivoltine silkworm hybrids were developed as potential for higher cocoon production. However, producing such high-yielding varieties demands more large-scaletestsand trials on-station and later at farmer's fields. One of the most significant factors that would bring about higher production without incurring additional expenses is the rearing of the right hybrid in the right rearing season.In the genetic resources of the silkworm, agro-climatic conditions entirely influence expression of the economic interest characteristics, whether genetic and biological (percentage of hatching and fecundity, duration of larval and fifth instar period, and rate of pupation) or productive (cocoon weight, relationship between shell and cocoon, percentage of raw silk, filament length (m) and yield of raw silk per box of worm eggs (Thangavelu *et al.*, 2000), as cited by Ruiz and Almanza (2018).

Moreover, breeding programs should aim at continuous development, evaluation, renewal, and change of existing breeds or hybrids with new and superior breeds, with reference to diverse climatic factors for qualitative and quantitative improvement in silk production (Alam *et al.*, 2021).

The study evaluated the newly developed bivoltine single cross silkworm hybrids under an on-station yield trial to identify the suitable hybrid for a particular season for commercial cocoon production.In the long run, this will provide an additional collection of high-yielding silkworm hybrids at the germplasm bank of the DMMMSU-SRDI ready for distribution to the farmers or cocoon producers.Dayananda *et al.*(2009) attested that the potential of newly developed bivoltine hybrids under simulated conditions of farmers before recommending them for field evaluation is imperative.

Kumar*et al.*, (2003a, 2003b) investigated that even though bivoltine breeds/hybrids silkworms are known for their productive merit, the absence of genetic plasticity to buffer against adverse conditions prevailed in the field acts as a constraint to exploit the full economic potential of the newly developed silkworm hybrids. These hybrids continue to suffer badly in adverse conditions prevailing in the field such as high temperature, humidity, germ load, poor leaf quality, and low management, thus requiring more flexible hybrids with genetic plasticity to buffer these adverse situations. Dayananda *etal.*, 2009, also reported that proper evaluation and identification of silkworm hybrids both in the farmer's field and on-stationare very important and play major rolesin deriving suitable hybrids for commercial use to increase the quality of cocoon production.

The F_1 hybrids are more productive and robust and can be reared easily by adopting appropriate rearing technology. Silkworm breeding programs are based on the development and selection of outstanding hybrids from the inbred lines and the performance of hybrids depends largely on yield trials and genetic divergence of the population from which the parental lines are extracted (Dalta*etal.*, 2001).

Cocoon traits are of the most important economical traits of silkworm and due to high heritability (40-50%), direct selection performance on them is very high (Mirrosseini*et al.*, 2007). It is well documented that F_1 hybrids are superior to their parents in many qualitative and quantitative traits (Toyama, 1906).
Introducing silkworm hybrids with proper genetic potential in multiple economic characteristics along with increasing sericulture hybrids is the most important item in the silkworm industry and it is

considered a key factor in egg quality determination and directly affects the silkworm quality (Zhao *et al.*, 2007).

Materials and methods

The study was conducted at the Sericulture Research and Development Institute (SRDI), Bacnotan, La Union.

From the successful breeding work of silkworm pureline evolution to the combining ability and multiple evaluation index tests at the Silkworm Breeding Unit of SRDI, five promising bivoltine silkworm hybrids were selected and identified. These identified single cross hybrids, DMMMSU 119 x DMMMSU 108, DMMMSU 110 x DMMMSU 119, DMMMSU 119 x DMMMSU 110, DMMMSU 110 x DMMMSU 113 and DMMMSU 108 x DMMMSU 119 along with the control hybrid DMMMSU 222, were reared and evaluated for three different rearing seasons from January-February,April-May, July-August. Rearing trials of these hybrids wereconducted using a 1,000-sample population with three replications for each hybrid.

The study involved a series of breeding activities which included inbreeding and cross-breeding utilizing SRDI's newly evolved bivoltine purelines, DMMMSU 108, DMMMSU 110, DMMMSU 113, and DMMMSU 119. Existing bivoltine purelines were also used as control (DMMMSU 100 and DMMMSU 115). Production of the different hybrid combinations involved major activities as follows: (1) Parental rearing of silkworm purelines; (2)crossbreeding (hybridization); (3) production of silkworm egg hybrids; and (4) rearing of the different silkworm hybrids.

During rearing, standard rearing management procedures were employed. Some important quantitative characteristics of the different hybrids were gathered. The cocoons were harvested and assessed accordingly on the sixth day from mounting. The following data were gathered and analyzed statistically:

1. Cocoon Yield per Box (CYPB) = actual yield weight (g)
2. Cocoon Shell Percentage (CSP) = (weight of cocoon shell/ weight of cocoons) x 100
3. $$\text{Effective Rearing Rate (ERR)} = \frac{\text{total number of cocoons harvested}}{\text{number of silkworm reared}} \times 100$$
4. Single Cocoon Weight (SCW) = weight of single cocoon

Data gathered were tabulated and analyzed statistically using the Statistical Tool for Agricultural Research (STAR). Analysis of Variance (ANOVA) in Completely Randomized Design (CRD) was employed to determine significant differences among treatments. Turkey's Honest Significant Difference (HSD) was used to compare treatment means in pairs.

Results and discussion

Evaluating and identifying the promising silkworm hybrid under large scale at on-station conditions should be the first step before testing it in the farmer's field toevaluate the potentiality of the new hybrids for commercial cocoonproduction (Dayanand*aet al.*, 2009). The study was conducted in three different seasons of the year i.e. January-February, April-May, and July- August. Analysis was done separately in each season to determine significant differences among the treatments and identify season-specific hybrids.

January - February Rearing Season

The performance of the different hybrids under natural environmental conditions during the January-February rearing season is presented in Table 1. Analysis of variance did not reveal significant differences among hybrids in all the parameters evaluated (ERR, CYPB, and CSP) except Single Cocoon Weight (SCW) whereinall the treatment means were found to be statistically the same when subjected to further tests using Tukey's HSD.

The ERR during this season ranged from 76% to 92% where only DMMMSU 110 x DMMMSU 119 was slightly lower than the control hybrid.

Table 1. Comparison of the different silkworm hybrids against the control hybrid (January – February).

Silkworm Hybrids	ERR (%)		Cocoon Yield per box (kg)		Single Cocoon Weight (g)		Cocoon Shell Percentage	
	Mean	Percent increase/ decrease	Mean	Percent increase/ decrease	Mean	Percent increase/ decrease	Mean	Percent increase/ decrease
DMMMSU 108 x DMMMSU 119	90	13.92	27.43	9.81	1.67 a	13.61	21.37	13.01
DMMMSU 110 x DMMMSU 113	82	3.80	24.33	-2.60	1.49 a	1.36	20.88	10.42
DMMMSU 110 x DMMMSU 119	76	-3.80	24.66	-1.28	1.63 a	10.88	21.31	12.69
DMMMSU 119 x DMMMSU 108	92	16.46	28.37	13.57	1.61 a	9.52	20.87	10.36
DMMMSU 119 x DMMMSU 110	81	2.53	26.17	4.76	1.68 a	14.29	20.82	10.10
DMMMSU 222 (Control Hybrid)	79		24.98		1.47 a		18.91	
c.v. (%)	11.88		10.24		5.56		7.60	
Significance	ns		ns		*		ns	

**All Means followed by the same letter in a column are not significantly different at 0.05 level (HSD).*

The highest increase of 14.64% was observed in hybrid DMMMSU 119 x DMMMSU 108. This hybrid also registered the highest increase in CYPB with a 13.47% increase against the control hybrid. There were two other hybrids with slightly higher CYPB than the control hybrid. All the hybrids produced cocoons slightly higher than in the control hybrid but HSD did not detect any significant difference among the treatment means. SCW of the hybrids when reared during this season ranged from 1.47 to 1.68 grams per cocoon. The highest increase of 14.29% was observed from the hybrid DMMMSU 119 x DMMMSU 110.

A small range was also observed in terms of the CSP of the different hybrids in which all the hybrids produced CSP of 18.91% to 21.37%. However, all the new hybrids produced a slight percent increase against the control hybrid with a range of 10.10 to 13.01%.

Table 2. Comparison of the different silkworm hybrids against the control hybrid (April – May).

Silkworm Hybrids	ERR (%)		Cocoon Yield per box (kg)		Single Cocoon Weight (g)		Cocoon Shell Percentage	
	Mean	Percent increase/ decrease	Mean	Percent increase/ decrease	Mean	Percent increase/ decrease	Mean	Percent increase/ decrease
DMMMSU 108 x DMMMSU 119	80 b	-2.44	24.47 a	-3.17	1.62 ab	5.19	19.09	3.58
DMMMSU 110 x DMMMSU 113	64 c	-21.95	24.89 a	-1.50	1.58 bc	2.60	18.56	1.19
DMMMSU 110 x DMMMSU 119	83 ab	1.22	27.09 a	7.20	1.70 a	10.39	19.26	4.50
DMMMSU 119 x DMMMSU 108	90 a	9.76	28.12 a	11.28	1.53 bc	-0.65	19.83	7.60
DMMMSU 119 x DMMMSU 110	57 c	-30.49	19.64 b	-22.28	1.47 c	-4.55	19.62	6.46
DMMMSU 222 (Control Hybrid)	82 ab		25.27 a		1.54 bc		18.43	
c.v. (%)	4.68		5.99		2.72		3.34	
Significance	*		*		*		ns	

**All Means followed by the same letter in a column are not significantly different at 0.05 level (HSD).*

April-May Rearing Season

The performance of the different hybrids for April - May rearing season is presented in Table 2. Analysis of variance revealed significant differences among treatment means for Effective Rearing Rate (ERR), Cocoon Yield per Box (CYPB), and Single Cocoon Weight (SCW). On the other hand, no significant difference was observed in Cocoon Shell Percentage (CSP). This means that their ERR, CYPB, and SCW are statistically different when the hybrids are reared

during this season. The CSP ranged from 18.43% (DMMMSU 222) to 19.83% (DMMMSU 119 x DMMMSU 108). Although the differences are not significant, it was observed that all the hybrids performed betterthan the control hybrid with an increase of 1.19% to 7.60%.

On effective rearing rate, only DMMMSU 119 x DMMMSU108 and DMMMSU 110 x DMMMSU 119 were similarto the control hybrid with slight increases of 9.76% and 1.22%, respectively. DMMMSU 119 x DMMMSU 110 and DMMMSU 110 x DMMMSU 113 performed significantly lower than the control hybrid with a 30.49% and 21.95% decrease. In terms of cocoon yield, only DMMMSU 119 x DMMMSU 110 performed significantly lower than all the other hybrids including the control hybrid by 22.28%. All the other hybrids performed comparatively with each other and also with the control hybrid.

The highest SCW of 1.70g was observed from DMMMSU 110 x DMMMSU 119 which is significantly higher than the control hybrid by 10.39%. Although DMMMSU 108 x DMMMSU 119 and DMMMSU 110 x DMMMSU 113 surpassed the control hybrid by 5.19% and 2.60%, respectively, these increases were not significant. The other two hybrids were not significantly lower than the control hybrid.

Table 3. Comparison of the different silkworm hybrids against the control hybrid (July – August).

Silkworm Hybrids	ERR (%)		Cocoon Yield per box (kg)		Single Cocoon Weight (g)		Cocoon Shell Percentage	
	Mean	Percent increase/ decrease	Mean	Percent increase/ decrease	Mean	Percent increase/ decrease	Mean	Percent increase/ decrease
DMMMSU 108 x DMMMSU 119	76 ab	47.06	22.53 ab	52.98	1.54	0.00	20.34	1.14
DMMMSU 110 x DMMMSU 113	55 c	5.88	14.95 c	2.33	1.54	0.00	19.88	-1.14
DMMMSU 110 x DMMMSU 119	44 c	-13.73	13.80 c	-5.54	1.58	2.60	20.69	2.88
DMMMSU 119 x DMMMSU 108	91 a	78.43	27.36 a	87.27	1.49	-3.25	19.93	-0.90
DMMMSU 119 x DMMMSU 110	62 bc	19.61	17.72 bc	21.29	1.40	-9.09	20.76	3.23
DMMMSU 222 (Control Hybrid)	52 c		14.61 c		1.54		20.11	
c.v. (%)	11.00		10.99		6.71		3.15	
Significance	**		**		ns		ns	

All Means followed by the same letter in a column are not significantly different at 0.05 level (HSD).

July – August Rearing Season

The performance of the different hybrids during the July – August rearing season with the corresponding increase/decrease from the control hybrid are presented in Table 3. Significant analyses of variance were observed from ERR and CYPB while no significant difference was noted in SCW and CSP.

The highest ERR of 91% was observed from DMMMSU 119 x DMMMSU 108 followed by DMMMSU 108 x DMMMSU 119 with a comparable ERR of 72%. These two hybrids were 78.43% and 47.06% significantly higher than the control hybrid with only 52% ERR. The same trend as in ERR was observed in terms of CYPB where the highest was observed in the hybrid DMMMSU 119 x DMMMSU 108 which produced 27.36 kg per box and outperformed the control hybrid by an 87.27% increase in yield. However, improvement was also seen in DMMMSU 108 x DMMMSU 119 (22.53 kg/box) with an increase of 52.98% against the control hybrid. These two hybrids are not significantly different from each other. The lowest was observed in DMMMSU 110 x DMMMSU 119 with only 13.80 cocoon yield per box and is comparable with the control hybrid with 14.61 kg/box yield.

The SCW and CSP of the different hybrids evaluated as stated above were not significantly different from each other when reared during this season of the year. The SCW observed ranged from 1.40 g to 1.58 g while the CSP only ranged from 19.88% to 20.76%.

Conclusion

The study successfully evaluated five newly developed bivoltine silkworm hybrids (DMMMSU 108 x DMMMSU 119, DMMMSU 110 x DMMMSU 113,

DMMMSU 110 x DMMMSU 119, DMMMSU 119 x DMMMSU 110, and DMMMSU 119 x DMMMSU 108) under on-station conditions across three rearing seasons (January-February, April-May, and July-August).

The findings indicate significant variation in the performance of these hybrids across different seasons. Notably, DMMMSU 119 x DMMMSU 108 consistently outperformed the control hybrid (DMMMSU 222) in cocoon yield per box (CYPB), effective rearing rate (ERR), and single cocoon weight (SCW) during the July-August and January-February seasons, making it the most promising hybrid overall. Other hybrids also showed season-specific strengths, such as DMMMSU 110 x DMMMSU 119 performing well in the January-February season. Overall, these new hybrids have demonstrated potential for commercial cocoon production, especially in specific rearing seasons, and are recommended for further field validation.

Recommendation

Based on the study's findings, it is recommended that the top-performing hybrids, particularly DMMMSU 119 x DMMMSU 108, undergo further validation trials in farmers' fields to assess their adaptability and performance in real-world conditions. This hybrid, along with other promising hybrids like DMMMSU 108 x DMMMSU 119, should be tested under varying agro-climatic conditions to confirm their suitability for large-scale commercial use. Additionally, efforts should focus on evaluating the economic feasibility of adopting these hybrids, considering their improved cocoon yield and quality, to ensure their practical benefit to silk producers. Continuous breeding and research should also aim at developing hybrids with greater resilience to environmental stressors, ensuring stable yields across diverse conditions.

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