

Enhancement of Standardized Feed Additives on Cocoon Parameters of Mulberry Silkworm Hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi)

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Abstract Late age silkworms reared on mulberry shoots fortified with flours of horse gram $\times$ grain amaranthus (50:50) from fourth instar onwards up to ripening once daily and alternate day produced significantly higher maximum cocoon yield, cocoon length, cocoon width, single cocoon filament length, single cocoon filament weight, bold but lesser number of cocoons per liter and reduced percentage of melted cocoon when compared to unsupplemented control.

Keywords Silkworm hybrids, Feed additives, Horse gram, Grain amaranthus, Cocoon parameters.

Introduction

Leaves of mulberry, *Morus alba* L. are the only food of mulberry silkworm *Bombyx mori* L. Available information reveals partial or total crop failures mainly at late instars are many times attributed to poor leaf quality. It becomes imperative to improve nutritive value of mulberry leaves, which influence growth and development of the silkworm *Bombyx mori* L. One way of improving the cocoon yield is through achieving an increase in larval weight by enriching the feed of silkworm by supplementing mulberry leaves with extra nutrients. The present investigation was conducted using two popular silkworm hybrids ($CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$) and two feeding schedules.

Materials and Methods

Mulberry silkworm hybrids of $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi) were experimented with mulberry shoots of V_1 harvested from irrigated garden and supplemented individually or in combination with nine different flours in appropriate ratio and also maintaining unsupplemented control. Individual measuring cups and plastic sieves were maintained for each feed additive treatment. Bulk rearing was done upto third moult and worms were separated, to maintain two feeding schedules (once daily and alternate day) with feed additive treatments. The flours of 5 g/10 g each of the feed additives were weighed and placed in plastic measuring cups in order to mark levels of

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Table 1. Influence of feed additives on cocoon yield (kg/100 dfles) of mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi). H_1 : $CSR_2 \times CSR_4$; H_2 : $ND_7 \times CSR_2$ (Jayalakshmi); D_1 : Daily once, D_2 : Alternate day.

Feed additive treatments	Hybrids				Feed additive mean
	H_1 D_1	H_1 D_2	H_2 D_1	H_2 D_2	
FA ₁ : Ragi flour (100%)	81.52	81.26	84.00	83.66	82.61
FA ₂ : Horse gram flour (100%)	80.86	80.39	83.78	83.35	82.09
FA ₃ : Ragi flour+Horse gram flour (50:50%)	88.57	88.22	92.60	92.05	90.36
FA ₄ : Horse gram flour+Grain Amaranthus flour (50:50%)	91.68	91.16	94.67	94.21	92.93
FA ₅ : Fine mesh Ragi flour+20% Activated Horse gram flour (50:50%)	85.72	85.18	89.77	89.38	87.51
FA ₆ : 80% Activated Horse gram regular flour+20% Ragi regular flour	89.66	89.29	93.66	93.19	91.45
FA ₇ : 80% Fine mesh Ragi flour+20% Activated Horse gram fine mesh flour	86.03	86.00	90.00	89.64	87.91
FA ₈ : CFTRI mixture (100%)	90.65	90.23	94.39	94.07	92.33
FA ₉ : Activated Green gram flour (100%)	87.49	87.20	92.46	92.15	89.82
FA ₁₀ : Control / Unsupplemented	77.83		80.60		79.21
F-test	*		*		*
SEm±	0.09		0.09		0.027
CD at 5%	0.15		0.15		0.075

each cup.

The feed additive application was mediated through measuring cups having ensured the flours were sieved (150 μ) and dusted on mulberry shoots @ 5 g/10 g per kg of shoots based on marked levels and fed to silkworm hybrids ($CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$) by plastic sieves during late age. There were two batches in the schedule of feed additive application. Shoots dusted with the feed additives

were provided once daily during fourth instar till spinning. In the second batch, feed additives were provided once every alternate day from fourth instar till spinning. In both batches however, the remaining two feeds/day were normal (unsupplemented). In order to keep the bed dry and facilitate easy moulting, feeding was resumed half an hour later after dusting bed disinfectant (Resham Jyothi), when more than 95% of the worms were out of moult [1]. Observations on silkworm hybrids were made on cocoon parameters

Table 2. Influence of feed additives on number of cocoons per liter of mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi). H_1 : $CSR_2 \times CSR_4$; H_2 : $ND_7 \times CSR_2$ (Jayalakshmi); D_1 : Daily once, D_2 : Alternate day.

Feed additive treatments	Hybrids				Feed additive mean
	H_1 D_1	H_1 D_2	H_2 D_1	H_2 D_2	
FA ₁ : Ragi flour (100%)	75.59	76.07	80.22	81.50	78.34
FA ₂ : Horse gram flour (100%)	76.08	76.78	81.21	82.33	79.10
FA ₃ : Ragi flour+Horse gram flour (50:50%)	73.72	74.06	77.36	78.36	75.87
FA ₄ : Horse gram flour+Grain Amaranthus flour (50:50%)	72.31	72.72	75.36	76.16	74.13
FA ₅ : Fine mesh Ragi flour+20% Activated Horse gram flour (50:50%)	75.12	75.71	79.23	80.86	77.73
FA ₆ : 80% Activated Horse gram regular flour+20% Ragi regular flour	73.20	73.71	76.26	77.24	75.10
FA ₇ : 80% Fine mesh Ragi flour+20% Activated Horse gram fine mesh flour	74.78	75.08	78.84	80.19	77.22
FA ₈ : CFTRI mixture (100%)	72.82	73.05	75.86	76.77	74.62
FA ₉ : Activated Green gram flour (100%)	74.16	74.72	78.14	79.35	76.59
FA ₁₀ : Control / Unsupplemented	76.94		83.79		80.36
F-test	*		*		*
SEm±	0.10		0.10		0.029
CD at 5%	0.16		0.16		0.082

Table 3. Influence of feed additives on cocoon length (mm) of mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi). H_1 : $CSR_2 \times CSR_4$, H_2 : $ND_7 \times CSR_2$ (Jayalakshmi); D_1 : Daily once, D_2 : Alternate day.

Feed additive treatments	Hybrids				Feed additive mean
	H_1 D_1	D_2	H_2 D_1	D_2	
FA ₁ : Ragi flour (100%)	3.623	3.606	3.910	3.870	3.752
FA ₂ : Horse gram flour (100%)	3.600	3.580	3.873	3.846	3.724
FA ₃ : Ragi flour+Horse gram flour (50:50%)	3.740	3.716	4.110	4.080	3.911
FA ₄ : Horse gram flour+Grain Amaranthus flour (50:50%)	3.956	3.960	4.226	4.196	4.084
FA ₅ : Fine mesh Ragi flour+20% Activated Horse gram flour (50:50%)	3.650	3.633	3.940	3.900	3.780
FA ₆ : 80% Activated Horse gram regular flour+20% Ragi regular flour	3.780	3.750	4.150	4.120	3.950
FA ₇ : 80% Fine mesh Ragi flour+20% Activated Horse gram fine mesh flour	3.676	3.663	3.980	3.953	3.818
FA ₈ : CFTRI mixture (100%)	3.840	3.806	4.180	4.170	3.999
FA ₉ : Activated Green gram flour (100%)	3.710	3.686	4.070	4.020	3.871
FA ₁₀ : Control / Unsupplemented	3.496		3.770		3.633
<i>F</i> -test			*		*
SEm±			0.02		0.005
CD at 5%			0.03		0.015

and three way factorial CRD (completely randomized design) analysis was adopted.

Results and Discussion

The late age silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (jayalakshmi) reared on mulberry shoots with individual flour or combination of feed additives for both feeding schedules viz., daily once and alternate days were accepted and exhibited better cocoon pa-

rameters than control (unsupplemented).

Significantly maximum cocoon yield (91.68 kg/100 dfls, 91.16 kg/100 dfls; 94.67 kg/100 dfls, 94.21 kg/100 dfls) (Table 1), cocoon length (3.956 mm, 3.960 mm,; 4.226 mm, 4.196 mm), cocoon width (2.963 mm, 2.946 mm; 3.040 mm, 3.00 mm), single cocoon filament length (1048.04 m, 1042.51 m; 954.35 m, 945.45 m), single cocoon filament weight (0.276 g, 0.274 g; 0.199 g, 0.197 g), lesser number of cocoons per liter (72.31,

Table 4. Influence of feed additives on cocoon width (mm) of mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi). H_1 : $CSR_2 \times CSR_4$, H_2 : $ND_7 \times CSR_2$ (Jayalakshmi); D_1 : Daily once, D_2 : Alternate day.

Feed additive treatments	Hybrids				Feed additive mean
	H_1 D_1	D_2	H_2 D_1	D_2	
FA ₁ : Ragi flour (100%)	2.513	2.473	2.526	2.490	2.500
FA ₂ : Horse gram flour (100%)	2.346	2.303	2.360	2.326	2.333
FA ₃ : Ragi flour+Horse gram flour (50:50%)	2.836	2.806	2.836	2.790	2.817
FA ₄ : Horse gram flour+Grain Amaranthus flour (50:50%)	2.963	2.946	3.040	3.000	2.987
FA ₅ : Fine mesh Ragi flour+20% Activated Horse gram flour (50:50%)	2.633	2.600	2.636	2.610	2.619
FA ₆ : 80% Activated Horse gram regular flour+20% Ragi regular flour	2.880	2.856	2.926	2.803	2.866
FA ₇ : 80% Fine mesh Ragi flour+20% Activated Horse gram fine mesh flour	2.693	2.673	2.686	2.743	2.698
FA ₈ : CFTRI mixture (100%)	2.923	2.900	3.000	2.966	2.947
FA ₉ : Activated Green gram flour (100%)	2.746	2.720	2.760	2.703	2.732
FA ₁₀ : Control / Unsupplemented	2.236		2.310		2.273
<i>F</i> -test			*		*
SEm±			0.005		0.015
CD at 5%			0.08		0.042

Table 5. Influence of feed additives on single cocoon filament length (m) of mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi). H_1 : $CSR_2 \times CSR_4$, H_2 : $ND_7 \times CSR_2$ (Jayalakshmi); D_1 : Daily once; D_2 : Alternate day.

Feed additive treatments	Hybrids				Feed additive mean
	H_1 D_1	D_2	H_2 D_1	D_2	
FA ₁ : Ragi flour (100%)	942.22	935.42	855.67	851.28	896.14
FA ₂ : Horse gram flour (100%)	923.00	917.69	845.40	840.41	881.62
FA ₃ : Ragi flour+Horse gram flour (50:50%)	1004.67	997.64	911.63	906.03	954.99
FA ₄ : Horse gram flour+Grain Amaranthus flour (50:50%)	1048.04	1042.51	954.35	945.45	997.58
FA ₅ : Fine mesh Ragi flour+20% Activated Horse gram flour (50:50%)	968.69	963.75	871.49	867.32	917.81
FA ₆ : 80% Activated Horse gram regular flour+20% Ragi regular flour	1016.51	1010.59	923.07	917.67	966.96
FA ₇ : 80% Fine mesh Ragi flour+20% Activated Horse gram fine mesh flour	980.08	975.72	885.21	880.64	930.41
FA ₈ : CFTRI mixture (100%)	1035.42	1028.28	934.37	930.80	982.21
FA ₉ : Activated Green gram flour (100%)	993.04	989.03	896.46	889.92	942.11
FA ₁₀ : Control / Unsupplemented	889.86		837.38		863.62
<i>F</i> -test			*		*
SEm±			3.24		0.935
CD at 5%			5.26		2.632

72.72; 75.36, 76.16) (Table 2) and lesser percentage of melted cocoons (3.33, 4.33; 3.66, 4.66) was registered in $H_1D_1FA_4$, $H_1D_2FA_4$, $H_2D_1FA_4$ and $H_2D_2FA_4$, respectively with Horse gram + Grain Amaranthus flour (50 : 50%) application daily once and alternate day from fourth instar upto spinning in both hybrids.

However, the next best feed additive was CFTRI mixture in $H_1D_1FA_8$, $H_1D_2FA_8$, $H_2D_1FA_8$ and $H_2D_2FA_8$ compared to unsupplemented control, in respect of

cocoon yield (90.65 kg/100 dfls, 90.23 kg/100 dfls, 94.39 kg/100 dfls, 94.07 kg/100 dfls) (Table 1), cocoon length (3.840 mm, 3.806 mm; 4., 180 mm, 4.170 mm) (Table 3, cocoon width (2.923 mm, 2,900 mm; 3.00 mm 2.966 mm) (Table 4), single cocoon filament length (1035.42m, 1028.28 m; 934.37 m, 930.80 m) (Table 5), single cocoon filament weight (0.274 g, 0.271 g; 0.197 g, 0.195 g, Table 6), lesser number of cocoon per liter (72.82, 73.05; 75.86, 76.77) (Table 2) and lesser percentage of melted cocoon (4.33, 5.33; 4.66, 5.66) (Table 7), re-

Table 6. Influence of feed additives on single cocoon filament weight (g) of mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi). H_1 : $CSR_2 \times CSR_4$, H_2 : $ND_7 \times CSR_2$ (Jayalakshmi); D_1 : Daily once, D_2 : Alternate day.

Feed additive treatments	Hybrids				Feed additive mean
	H_1 D_1	D_2	H_2 D_1	D_2	
FA ₁ : Ragi flour (100%)	0.257	0.254	0.186	0.183	0.220
FA ₂ : Horse gram flour (100%)	0.252	0.250	0.184	0.183	0.217
FA ₃ : Ragi flour+Horse gram flour (50:50%)	0.268	0.265	0.194	0.191	0.229
FA ₄ : Horse gram flour+Grain Amaranthus flour (50:50%)	0.276	0.274	0.199	0.197	0.236
FA ₅ : Fine mesh Ragi flour+20% Activated Horse gram flour (50:50%)	0.257	0.257	0.188	0.195	0.224
FA ₆ : 80% Activated Horse gram regular flour+20% Ragi regular flour	0.270	0.268	0.195	0.194	0.231
FA ₇ : 80% Fine mesh Ragi flour+20% Activated Horse gram fine mesh flour	0.261	0.259	0.189	0.186	0.223
FA ₈ : CFTRI mixture (100%)	0.274	0.271	0.197	0.195	0.234
FA ₉ : Activated Green gram flour (100%)	0.265	0.263	0.191	0.189	0.227
FA ₁₀ : Control / Unsupplemented	0.245		0.178		0.211
<i>F</i> -test			*		*
SEm±			0.0001		0.0001
CD at 5%			0.0001		0.0001

Table 7. Influence of feed additives on percentage of melted cocoons (%) of mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi). H_1 : $CSR_2 \times CSR_4$, H_2 : $ND_7 \times CSR_2$ (Jayalakshmi); D_1 : Daily once; D_2 : Alternate day.

Feed additive treatments	Hybrids				Feed additive mean
	H_1 D_1	D_2	H_2 D_1	D_2	
FA ₁ : Ragi flour (100%)	11.00	12.00	11.33	12.66	11.74
FA ₂ : Horse gram flour (100%)	12.00	13.00	12.33	13.66	12.74
FA ₃ : Ragi flour+Horse gram flour (50:50%)	6.33	7.33	7.00	8.00	7.16
FA ₄ : Horse gram flour+Grain Amaranthus flour (50:50%)	3.33	4.33	3.66	4.66	3.99
FA ₅ : Fine mesh Ragi flour+20% Activated Horse gram flour (50:50%)	10.00	11.00	10.33	11.66	10.74
FA ₆ : 80% Activated Horse gram regular flour+20% Ragi regular flour	5.33	6.33	5.66	6.66	5.99
FA ₇ : 80% Fine mesh Ragi flour+20% Activated Horse gram fine mesh flour	9.00	10.00	8.66	10.00	9.41
FA ₈ : CFTRI mixture (100%)	4.33	5.33	4.66	5.66	4.99
FA ₉ : Activated Green gram flour (100%)	7.33	8.66	7.66	9.00	8.16
FA ₁₀ : Control / Unsupplemented	16.00		17.66		16.83
F-test		*			*
SEm±		0.76			0.220
CD at 5%		1.24			0.620

spectively.

Comparatively lower cocoon yield was recorded in unsupplemented control for hybrid $CSR_2 \times CSR_4$ ($H_1D_1FA_{10}$ and $H_1D_2FA_{10}$), in respect of cocoon yield (77.83 kg/100 dfls; 80.60 kg/100 dfls) (Table 1), cocoon length (3.496 mm; 3.770 mm) (Table 3), cocoon width (2.236 mm; 2.310 mm) (Table 4), single cocoon filament length (889.86 mm; 837.38 m) (Table 5), single cocoon filament weight (0.245 g; 0.178 g) (Table 6), lesser number of cocoons per liter (76.94; 83.79) (Table 2) and lesser percentage of melted cocoons (16.00; 17.66) (Table 7), respectively followed by hybrid Jayalakshmi ($H_2D_1FA_{10}$ and $H_2D_2FA_{10}$).

These findings are important and necessary from the view point of silkworm rearing for commercial cocoon production thereby adding revenue while transacting in cocoon markets. From the data it is evident that flour of feed additives (Horse gram + Grain Amaranthus) has got a profound influence on the growth of silkworms and inturn on spinning of quality cocoon when compared to rearing worms on normal mulberry shoots.

Mulberry silkworm hybrids of $PM \times CSR_2$ and

$CSR_2 \times CSR_4$ reared on mulberry (M_5 variety) supplemented with Ragi flour was a boon to sericulturists in Karnataka [2]. Recently, bigger cocoons with flour of Ragi and Horse gram supplementation was noticed [3, 4]. The spraying of *Kahiko silcare* supplementation @ 1000 g which is unrealistic and impractical and increased the silk productivity from 4.834 to 5.377 cg/day [5].

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