Available online at http://www.journalijdr.com

IJDR

ISSN: 2230-9926

International Journal of Development Research

Vol. 07, Issue, 07, pp.13669-13673, July, 2017

ORIGINAL RESEARCH ARTICLE **Open Access**

SIGNIFICANCE OF STANDARDIZED FEED ADDITIVES ON COCOON TRAITS OF MULBERRY SILKWORM HYBRIDS $CSR_2 \times CSR_4$ AND $ND_7 \times CSR_2$ (JAYALAKSHMI)

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ARTICLE INFO

Article History:

Received 25th April, 2017
Received in revised form
14th May, 2017
Accepted 06th June, 2017
Published online 22nd July, 2017

Key Words:

Silkworm hybrids, Feed additives,
Horse gram, Grain amaranthus,
Cocoon traits.

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ABSTRACT

The silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi) reared on mulberry shoots supplemented separately with dusting of nine different feed additives along with unsupplemented control maintained, showed that inclusion of 5g / 10 g flour of Horse gram + Grain Amaranthus (50 : 50) daily once in feeding schedule recorded significantly maximum cocoon weight, shell weight, pupal weight, rate of pupation and dry cocoon weight.

Citation: Sudhakara S. N., Neelu Nangia and Narayana Reddy, R. 2017. "Significance of standardized feed additives on cocoon traits of mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $nd_7 \times CSR_2$ (Jayalakshmi)", *International Journal of Development Research*, 7, (07), 13669-13673.

INTRODUCTION

India is currently the second largest producer of mulberry raw silk recording an annual production of about 18,653 M.T. of raw silk, of which 16,700 M.T. is represented by mulberry silk. tasar, eri and muga silks contribute to the tune of 323, 1514 and 116 M.T. respectively. Major silk production is due to development of new technologies in mulberry cultivation, silkworm rearing and crop protection (Hiriyanna *et al*., 2007). The knowledge of silkworm nutrition is of great fundamental and applied value, involving physiological and chemical activities, which transform food elements into body elements. Insect nutrition primarily involves biochemical substances that are necessary to achieve various metabolic processes resulting in healthy growth and development. After gaph of fifteen years, research on utilization of flours was revived and ever since Ganga and Gowri (1990) reported that flour diet optimizes cocoon characters in mulberry silkworm, research in India has gained momentum to fortify mulberry leaves. Neelu Nangia *et al.* (2005) first reported supplementation of ragi flour to mulberry leaves enhanced economic parameters of new bivoltine $CSR_2 \times CSR_4$ and multivoltines $PM \times CSR_2$ hybrids. As there are efforts by the premier bodies to promote and replace $PM \times CSR_2$ with a new multi × bi cross, in this piece of work Jayalakshmi hybrid was experimented upon long with $CSR_2 \times CSR_4$.

MATERIALS AND METHODS

Mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi) were reared at Main Research Station, Hebbal, Bangalore. Mulberry shoots of variety V_1, harvested from irrigated garden were supplemented individually or in combination with nine different flours in appropriate ratio with measuring cups and plastic sieves. Bulk silkworm rearing was done upto third moult, later separated for two feeding schedules provided daily once or even alternate day. 5 g /10 g flour of each feed additive were transferred separately to plastic measuring cups to mark levels and standardize. The feed additive application were mediated through measuring cups having ensured the flours were sieved (150 µ); and dusted separately on mulberry shoots @ 5 g / 10 g per kg of shoots based on marked levels of measuring cups and fed to silkworm hybrids (CSR_2×CSR_4 and ND_7×CSR_2) by dusting with plastic sieves during late age. There were two batches in the schedule of feed additive application. Shoots of one batch were dusted with the feed additives, 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 to facilitate easy moulting, feeding was resumed half an hour later after dusting bed disinfectant (Resham Jyothi), when more than 95 per cent of the worms were out of moult (Dandin *et al*., 2014). The data were analyzed using three way factorial CRD (Completely Randomized Design) as outlined by Cochron and Cox (2000).

RESULTS

The late age silkworm hybrids, CSR_2 x CSR_4 and ND_7 × CSR_2 (Jayalakshmi) reared on mulberry shoots with individual flour

Table 1. Influence of feed additives on cocoon weight (g) of Mulberry silkworm hybrids CSR_2 × CSR_4 and ND_7 × CSR_2 (Jayalakshmi)

Feed additive treatments	Hybrids				Feed additive mean
	H_1		H_2		
	D_1	D_2	D_1	D_2	
FA_1: Ragi flour (100 %)	2.046	2.036	1.843	1.826	1.937
FA_2: Horse gram flour (100 %)	2.036	2.026	1.826	1.810	1.924
FA_3: Ragi flour + Horse gram flour (50 : 50 %)	2.110	2.090	1.903	1.893	1.999
FA_4: Horse gram flour + Grain Amaranthus flour (50 : 50 %)	2.170	2.150	1.963	1.950	2.058
FA_5: Fine mesh Ragi flour + 20 % Activated Horse gram flour (50 : 50 %)	2.056	2.046	1.860	1.843	1.951
FA_6: 80 % Activated Horse gram regular flour + 20 % Ragi regular flour	2.120	2.103	1.920	1.910	2.013
FA_7: 80 % Fine mesh Ragi flour + 20 % Activated Horse gram fine mesh flour	2.073	2.060	1.870	1.853	1.964
FA_8: CFTRI mixture (100 %)	2.143	2.130	1.946	1.930	2.037
FA_9: Activated Green gram flour (100 %)	2.090	2.080	1.886	1.870	1.981
FA_{10}:Control / Unsupplemented	2.005		1.795		1.899
F-Test	*				*
S.Em ±	0.01				0.004
CD at 5 %	0.02				0.011

Note: H_1: CSR_2 × CSR_4 H_2: ND_7 × CSR_2 (Jayalakshmi) D_1: Daily once D_2: Alternate day

Table 2. Influence of feed additives on shell weight (g) of Mulberry silkworm hybrids CSR_2 × CSR_4 and ND_7 × CSR_2 (Jayalakshmi)

Feed additive treatments	Hybrids				Feed additive mean
	H_1		H_2		
	D_1	D_2	D_1	D_2	
FA_1: Ragi flour (100 %)	0.451	0.449	0.383	0.379	0.415
FA_2: Horse gram flour (100 %)	0.447	0.346	0.381	0.378	0.388
FA_3: Ragi flour + Horse gram flour (50 : 50 %)	0.462	0.460	0.389	0.387	0.424
FA_4: Horse gram flour + Grain Amaranthus flour (50 : 50 %)	0.473	0.467	0.395	0.393	0.432
FA_5: Fine mesh Ragi flour + 20 % Activated Horse gram flour (50 : 50 %)	0.455	0.451	0.384	0.381	0.417
FA_6: 80 % Activated Horse gram regular flour + 20 % Ragi regular flour	0.466	0.463	0.391	0.389	0.427
FA_7: 80 % Fine mesh Ragi flour + 20 % Activated Horse gram fine mesh flour	0.456	0.455	0.385	0.384	0.420
FA_8: CFTRI mixture (100 %)	0.468	0.465	0.392	0.390	0.428
FA_9: Activated Green gram flour (100 %)	0.459	0.458	0.387	0.385	0.422
FA_{10}:Control / Unsupplemented	0.430		0.372		0.401
F-Test	*				*
S.Em ±	0.03				0.008
CD at 5 %	0.04				0.022

Note: H_1: CSR_2 × CSR_4 H_2: ND_7 × CSR_2 (Jayalakshmi) D_1: Daily once D_2: Alternate day

Table 3. Influence of feed additives on pupal weight (g) of Mulberry silkworm hybrids CSR_2 × CSR_4 and ND_7 × CSR_2 (Jayalakshmi)

Feed additive treatments	Hybrids				Feed additive mean
	H_1		H_2		
	D_1	D_2	D_1	D_2	
FA_1: Ragi flour (100 %)	1.579	1.574	1.461	1.457	1.517
FA_2: Horse gram flour (100 %)	1.566	1.560	1.444	1.441	1.502
FA_3: Ragi flour + Horse gram flour (50 : 50 %)	1.649	1.644	1.516	1.514	1.580
FA_4: Horse gram flour + Grain Amaranthus flour (50 : 50 %)	1.703	1.692	1.561	1.555	1.627
FA_5: Fine mesh Ragi flour + 20 % Activated Horse gram flour (50 : 50 %)	1.599	1.592	1.479	1.477	1.536
FA_6: 80 % Activated Horse gram regular flour + 20 % Ragi regular flour	1.669	1.664	1.521	1.519	1.593
FA_7: 80 % Fine mesh Ragi flour + 20 % Activated Horse gram fine mesh flour	1.616	1.611	1.485	1.480	1.548
FA_8: CFTRI mixture (100 %)	1.683	1.677	1.541	1.538	1.609
FA_9: Activated Green gram flour (100 %)	1.636	1.628	1.509	1.506	1.569
FA_{10}:Control / Unsupplemented	1.550		1.419		1.484
F-Test	*				*
S.Em ±	0.0001				0.001
CD at 5 %	0.001				0.002

Note: H_1: CSR_2 × CSR_4 H_2: ND_7 × CSR_2 (Jayalakshmi) D_1: Daily once D_2: Alternate day

Table 4. Influence of feed additives on rate of pupation (%) of Mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi)

Feed additive treatments	Hybrids				Feed additive mean
	H_1		H_2		
	D_1	D_2	D_1	D_2	
FA_1: Ragi flour (100 %)	89.49	89.23	92.70	92.60	91.01
FA_2: Horse gram flour (100 %)	88.42	88.20	91.61	91.50	89.93
FA_3: Ragi flour + Horse gram flour (50 : 50 %)	91.79	91.64	95.28	95.20	93.47
FA_4: Horse gram flour + Grain Amaranthus flour (50 : 50 %)	92.49	92.29	95.82	95.71	94.08
FA_5: Fine mesh Ragi flour + 20 % Activated Horse gram flour (50 : 50 %)	90.57	90.38	93.20	93.11	91.81
FA_6: 80 % Activated Horse gram regular flour + 20 % Ragi regular flour	92.18	92.09	96.26	95.44	93.99
FA_7: 80 % Fine mesh Ragi flour + 20 % Activated Horse gram fine mesh flour	91.23	91.11	94.39	94.23	92.74
FA_8: CFTRI mixture (100 %)	92.35	92.23	95.73	95.63	93.98
FA_9: Activated Green gram flour (100 %)	91.47	91.30	94.68	94.53	92.99
FA_{10}:Control / Unsupplemented	85.76		90.83		88.30
F-Test	*				*
S.Em ±	0.38				0.109
CD at 5 %	0.61				0.307

Note: H_1: $CSR_2 \times CSR_4$ H_2: $ND_7 \times CSR_2$ (Jayalakshmi) D_1: Daily once D_2: Alternate day

Table 5. Influence of feed additives on dry cocoon weight (g) of Mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi)

Feed additive treatments	Hybrids				Feed additive mean
	H_1		H_2		
	D_1	D_2	D_1	D_2	
FA_1: Ragi flour (100 %)	1.476	1.450	1.353	1.343	1.405
FA_2: Horse gram flour (100 %)	1.456	1.440	1.336	1.323	1.388
FA_3: Ragi flour + Horse gram flour (50 : 50 %)	1.550	1.530	1.426	1.413	1.479
FA_4: Horse gram flour + Grain Amaranthus flour (50 : 50 %)	1.610	1.573	1.456	1.446	1.521
FA_5: Fine mesh Ragi flour + 20 % Activated Horse gram flour (50 : 50 %)	1.496	1.483	1.373	1.363	1.428
FA_6: 80 % Activated Horse gram regular flour + 20 % Ragi regular flour	1.560	1.543	1.436	1.426	1.491
FA_7: 80 % Fine mesh Ragi flour + 20 % Activated Horse gram fine mesh flour	1.516	1.496	1.396	1.383	1.447
FA_8: CFTRI mixture (100 %)	1.570	1.556	1.446	1.436	1.502
FA_9: Activated Green gram flour (100 %)	1.533	1.513	1.410	1.400	1.464
FA_{10}:Control / Unsupplemented	1.411		1.291		1.351
F-Test	*				*
S.Em ±	0.01				0.002
CD at 5 %	0.01				0.006

Note: H_1: $CSR_2 \times CSR_4$ H_2: $ND_7 \times CSR_2$ (Jayalakshmi) D_1: Daily once D_2: Alternate day

Table 6. Influence of feed additives on silk productivity (cg/day) of Mulberry silkworm hybrids $CSR_2 \times CSR_4$ and $ND_7 \times CSR_2$ (Jayalakshmi)

Feed additive treatments	Hybrids				Feed additive mean
	H_1		H_2		
	D_1	D_2	D_1	D_2	
FA_1: Ragi flour (100 %)	5.523	5.486	4.723	4.656	5.097
FA_2: Horse gram flour (100 %)	5.446	5.433	4.670	4.616	5.041
FA_3: Ragi flour + Horse gram flour (50 : 50 %)	6.446	6.390	5.466	5.420	5.930
FA_4: Horse gram flour + Grain Amaranthus flour (50 : 50 %)	6.700	6.616	5.623	5.586	6.131
FA_5: Fine mesh Ragi flour + 20 % Activated Horse gram flour (50 : 50 %)	5.600	5.540	4.783	4.730	5.163
FA_6: 80 % Activated Horse gram regular flour + 20 % Ragi regular flour	6.550	6.493	5.516	5.480	6.009
FA_7: 80 % Fine mesh Ragi flour + 20 % Activated Horse gram fine mesh flour	5.643	5.606	5.346	5.323	5.479
FA_8: CFTRI mixture (100 %)	6.620	6.563	5.560	5.526	6.067
FA_9: Activated Green gram flour (100 %)	5.716	5.653	5.413	5.370	5.538
FA_{10}:Control / Unsupplemented	4.748		4.283		4.515
F-Test	*				*
S.Em ±	0.09				0.027
CD at 5 %	0.15				0.076

Note: H_1: $CSR_2 \times CSR_4$ H_2: $ND_7 \times CSR_2$ (Jayalakshmi) D_1: Daily once D_2: Alternate day

or combination of feed additives for both feeding schedules viz., daily once and alternate days were accepted and exhibited better cocoon traits than unsupplemented control. Significantly higher cocoon weight (2.170 g, 2.150 g; 1.963 g,1.950 g) (Table 1), shell weight (0.473 g, 0.467 g; 0.395 g, 0.393 g) (Table 2) and pupal weight (1.703 g, 1.692 g; 1.561 g,1.555 g) (Table 3), rate of pupation (92.49 per cent, 92.29 per cent; 95.82 per cent, 95.71 per cent) (Table 4), dry cocoon weight (1.610 g, 1.573 g; 1.456 g, 1.446 g) (Table 5), silk productivity (6.700 cg/day, 6.616 cg/day; 5.623 cg/day, 5.586 cg/day) (Table 6), respectively 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) feed additive application daily once and alternate day from fourth instar up to 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 weight (2.143 g, 2.130 g; 1.946 g, 1.930 g) (Table 1), shell weight (0.468 g, 0.465 g; 0.392 g, 0.390 g) (Table 2), pupal weight (1.683 g, 1.677 g; 1.541 g, 1.538 g) (Table 3), rate of pupation (92.35 per cent, 92.23 per cent; 95.73 per cent, 95.63

per cent) (Table 4), dry cocoon weight (1.570 g, 1.556 g; 1.446 g, 1.436 g) (Table 5), silk productivity (6.620 cg/day, 6.563 cg/day; 5.560 cg/day, 5.526 cg/day) (Table 6), respectively. Comparatively lower values for cocoon traits were recorded in unsupplemented control for hybrid $CSR_2 \times CSR_4$ ($H_1D_1FA_{10}$ and $H_1D_2FA_{10}$), in respect of cocoon weight (2.005 g; 1.795 g) (Table 1), shell weight (0.430 g; 0.372 g) (Table 2), pupal weight (1.550 g; 1.419 g) (Table 3), rate of pupation (85.76 per cent; 90.83 per cent) (Table 4), dry cocoon weight (1.411 g; 1.291 g) (Table 5) and silk productivity (4.748 cg/day; 4.283 cg/day) (Table 6), respectively followed by new hybrid Jayalakshmi ($H_2D_1FA_{10}$ and $H_2D_2FA_{10}$).

DISCUSSION

These findings are important and necessary from the view point of silkworm rearing for commercial cocoon production as enhanced pupal weight increases the cocoon weight thereby add revenue while transacting the cocoons in market. From the data it is evident that feed fortificant (Horse gram + Grain Amaranthus) has got a profound influence on the growth of silkworms and inturn on spinning of quality cocoons which is proved by improvement in cocoon weight, pupal weight, shell weight *etc*., when compared to feeding of worms on normal Mulberry shoots. The cocoon shell as such contains silk proteins namely fibroin and sericin which are inturn made up of polypeptide chain of amino acids, particularly sericin, alanine and glycine. These amino acids are perhaps assimilated by the worms in the course of supplemented feeding with proteinaceous source in the form of flour can be exploited to enhance shell ratio and shell weight. According to Vanderstoep (1981) germinated mungbeans, common beans (Matki) are associated with turnover of protein and amino acids with the greatest increase in glutamic and aspartic acids. These amino acids are necessary in silk synthesis. The feed additives utilized in present study perhaps optimize quantity of nutrient assimilated which are channelized for maximum silk production by silkworms. Silkworms feeding on mulberry shoots fortified with the palatable nutrient rich source viz., protein, fats, carbohydrates, minerals and amino acids enhanced the cocoon characters. The protein content of experimented mulberry leaves (V_1 variety) was estimated as 22.20 per cent. The present findings are in agreement with the findings of Vanisree *et al*. (1996), Sundar Raj (1998), Sundar Raj *et al*. (2000a and 2000 b) and Manimegalai *et al*. (2002) who reported higher cocoon parameters on soyabean protein supplement. Artificial diet containing wheat bran increased female cocoon weight of two multivoltine breeds (Nistari and BSRI-85/3) as reported by Sarkar and Absar (1994), Nagesh (1998) reported similar trend on 'Sericare', and on cereal flour by Ganga and Gowri (1990), Rekha (2004), Vanitha (2006), Andal (2006) and Sumathi (2006) respectively.

However, Babu *et al*. (1992) reported the beneficial effects of ascorbic acid as feed supplement in obtaining high cocoon weight on an old hybrid of silkworm, PM x NB_4D_2. Bongale and Krishna (1996) reported that fortification of Mulberry leaves with sucrose as feed supplement increased the cocoon traits of pure bivoltine silkworm race NB_4D_2. Strangely Narayanaswamy *et al*. (2005) concluded that *Kohiko silcare* supplementation with an observed quantification increased the silk productivity from 4.834 to 5.377 cg/day. The present findings are also in tune with earlier findings of Babu *et al*. (1994) who attributed significantly higher shell weight on glycine supplemented Mulberry leaves, Nagesh (1998) reported maximum cocoon traits on 'Sericare', Vanisree *et al*. (1996) and Manimegalai *et al*. (2002) reported higher cocoon traits of silkworm reared on soya flour protein supplementation, Recently, Neelu Nangia *et al*. (2005) reported that dusting of Ragi flour on Mulberry enhanced the cocoon characters of CSR_2 x CSR_4 and PM x CSR_2 which is a boon for sericulturists as it is locally available. Vanitha (2006) reported best cocoon parameters with 80 per cent fine mesh Ragi flour + 20 per cent activated Horse gram fine mesh flour, as compared to control. From the present investigation, practicing shoot feeding with the feed additive flour combination of Horse gram + Grain amaranthus applied in equal quantities during late age enhances all cocoon traits of bi × bivoltine (CSR_2 x CSR_4) and multi × bivoltine hybrid ($ND_7 \times CSR_2$).

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