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Improvement in the Commercial Traits of Silkworm, *Bombyx mori* L. by Administration of a Juvenoid, R394

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A synthetic juvenoid, R394 (Ethyl 9-cyclohexyl-3, 7-dimethyl-2, 4-nonadienoate) which is known to be a strong pest control agent was administered to silkworm, *Bombyx mori* L. in minute quantity for improving the silk yield. Based on the result of an earlier preliminary screening, three concentrations of the compound, *viz.*, 0.1563, 0.3125, 31.25 nl/ml were prepared in the form of an emulsion and administered topically as a single dose, to separate batches of 5th instar silkworm at 24, 48, 72 and 96 hrs to determine the required concentration and critical time of application for an economically favourable response. Two popular commercial silkworm hybrids, PM x NB_4D_2 (multivoltine x bivoltine) and KA x NB_4D_2 (bivoltine x bivoltine) were subjected to the experiment. The medium and absolute control were maintained in parallel to compare the results. The results showed that 0.3125 nl/ml was the best concentration of the compound and 72 hrs of 5th instar was the most favourable age for its administration to get the maximum improvement in the commercial traits. The possible role of exogenous juvenoids in eliciting favourable response in silkworm which ultimately leads to improvement in the commercial traits is discussed.

Key words : Silkworm, *Bombyx mori*, Commercial traits, Juvenoid

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Introduction

Juvenile hormone (JH), one of the major circulating hormones regulates a plethora of developmental activities in silkworm, *Bombyx mori* L. The most striking of all is its first and foremost function of retaining the larval features as in the case of any other insects. This physiological principle has been widely exploited in the field of agriculture to control the insect pests using the compounds closely related to the structure and function of the original JH (Nair and Trivedy, 1998). This has been of paramount interest and importance and became highly popular because administration of JH analogues/mimics to the insect pests disrupts the normal developmental pattern and ensures control of the biggest nemesis in agricultural production, the insect attack. These compounds were aptly christened as ëthird generation pesticidesí. Their role in sericulture has been altogether different but beneficial to the silk producers.

Silkworm, *B. mori* is known to respond positively to the administration of minute quantities of juvenoids. The commercially important traits like cocoon weight and cocoon shell weight are enhanced to significant levels when the juvenoids are administered judiciously to silkworm (Akai *et al.*, 1985). Such enhancement is dependent on the dose of the compound applied, time of application and the number of application (Chowdhary *et al.*, 1990). At times the larval feeding period is prolonged when juvenoids are administered but the increased productivity on JH administration need not always be accompanied by a prolonged larval period (Trivedy *et al.*, 1997).

In the present work, a strong juvenoid, R394 was examined for its suitability for yield improvement in silkworm, *B. mori*. The compound was selected out of 24 JH mimicking compounds after an exhaustive screening process based on its encouraging performance (Nair *et al.*, 1999).

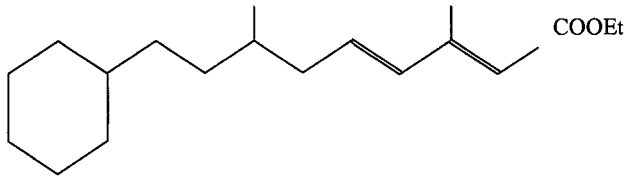

Fig. 1. Structure of R394 (Ethyl 9-cyclohexyl-3, 7-dimethyl-2, 4-nonadienoate).

Materials and Methods

The juvenoid, R394 (Ethyl 9-cyclohexyl-3, 7-dimethyl-2, 4-nonadienoate) (Fig. 1) was procured from Dr. L. Streinz, Institute of Organic Chemistry and Biochemistry, Czech Republic. Multi x bivoltine (PM x NB_4D_2) and bivoltine x bivoltine (KA x NB_4D_2) silkworm hybrids were reared on fresh mulberry leaves (S36 variety) in the laboratory at 25 ± 1°C and 75 ± 5% RH under 12:12 (L:D) photoperiod following standard procedure. On resumption to 5th instar, 250 worms of PM x NB_4D_2 and 225 worms of KA x NB_4D_2 each were counted and reared in ventilated plastic rearing trays measuring 90 x 60 cm in three replicates for the administration of the juvenoid. Three concentrations *viz.*, 0.1563, 0.3125, 31.25 nl/ml of the compound were prepared in the form of an emulsion using minimum quantity of acetone and tween-20, in water. The concentrations were decided based on the results of the screening process (Nair *et al.*, 1999). The emulsion was administered topically to silkworm in precleaned trays @ 12.5 ml/100 worms as a single dose by spraying it on to the worms. After leaving the bed for half an hour, the worms were fed with fresh mulberry leaves. Different such batches were treated at 24, 48, 72 and 96 hrs of 5th instar. Medium control and absolute control were maintained side by side to compare the results. The larval weight was recorded on maximum growth (on the sixth day of 5th instar). The total number of good cocoons, cocoon weight and cocoon shell weight (average of 10 males and 10 females per tray) and filament length were recorded. Further, effective rate of rearing by number (ERR/no.) and weight (ERR/wt.), shell ratio (%) and denier of the filament were calculated as reported earlier (Nair *et al.*, 1997). The experiment was repeated twice. The data of the two trials were analyzed employing ANOVA to ascertain the statistical significance.

Results and Discussion

The data on the effect of application of R394 on the economic traits of the commercial silkworm hybrids, PM x NB_4D_2 and KA x NB_4D_2 are presented in Table 1 and 2, respectively.

Larval weight and duration

Major influence in larval weight could be noticed when the treatment was done at 72 hrs followed by 48 and 24 hrs. In the multi x bivoltine hybrid, PM x NB_4D_2, the maximum positive change was observed with 0.3125 nl/ml R394 with a percentage change of 10.69 when treated at 72 hrs. This was followed by a change of 9.47 and 8.3% with the same concentration when treated at 48 and 24 hrs, respectively (Table 1). In KA x NB_4D_2, almost the same pattern was followed with a maximum change of 10.57% followed by 9.48 and 8.11% with 0.3125 nl/ml in the order of 72, 48 and 24 hrs treatment. The other two concentrations *viz.*, 0.1563 and 31.25 nl/ml also showed significant influence at 24, 48 and 96 hrs (Table 2). The medium controls at any of the treatment hours did not show any difference whatsoever in the larval weight when compared with the absolute control. Many workers have reported the increase in weight of silkworm body on juvenoid application. As per Subba Rao *et al.* (1988), manta was effective in improving larval weight up to 12% when 5th instar larvae of *B. mori* were treated at 48 hrs. Juliang *et al.* (1989) have noticed that the larval weight increased enormously and was significantly high compared to that of the control when 2.5 µg methoprene/ml was smeared to silkworm in the 5th instar. Further, Trivedy *et al.* (1993) have found a significant positive change in the larval weight when treated with Labomin, a JHA. Recently, Changamma *et al.* (2000) reported significant increase in weight of silkworm on hypodermal injection of methoprene. So, present observation is in agreement with the earlier reports and proves that R394 is potent juvenoid, which can be used on silkworm.

There was an obvious difference in the larval feeding period when R394 was administered, which was dependent on the time of the treatment. The pattern was similar in both the hybrids. The R394 application at 48 and 72 hrs invariably prolonged the larval period by 24 hrs whereas that at 24 and 96 hrs did not induce any change. In many of the reported cases of JH administration to silkworm, a prolongation in larval period was imminent (Ito *et al.*, 1975). But, Muroga *et al.* (1975) did not find any change in the developmental simultaneity between the JH treated and the control worms although the treated larvae were heavier than the control ones. Fairly recent reports also suggest that some JH compounds on application to silkworm induce a prolongation in larval feeding period (Trivedy *et al.*, 1997). But in the present study, the increase in the larval feeding period was confined to the larvae treated at 48 and 72 hrs of 5th instar. This does not

Table 1. Effect of R394 on the commercial traits of silkworm, *Bombyx mori* L. (Hybrid: PM x NB_4D_2)

Treat-ment hour (5^{th} instar)	Concen-tration (nl/ml)	Larval weight (g) (10 nos.)	5^{th} instar larval period (h)	ERR/ num-ber	ERR/ weight (kg)	Cocoon weight (g)	Shell weight (g)	Shell ratio (%)	Average filament length (m)	Denier
24	0.1563	43.83	168	9100	15.12	1.928	0.378	19.62	813.98	2.52
		(6.80)*	(0.00)	(3.17)*	(4.28)*	(4.97)*	(7.08)*	(2.01)	(5.57)*	(1.27)
	0.3125	44.45	168	9210	15.74	1.991	0.387	19.44	857.17	2.49
		(8.30)*	(0.00)	(4.42)	(8.55)*	(8.42)*	(9.58)*	(1.08)	(11.17)*	(0.20)
	31.25	43.19	168	9060	14.91	1.944	0.375	19.30	784.66	2.51
		(5.22)*	(0.00)	(2.72)*	(2.83)*	(5.87)*	(6.23)*	(0.37)	(1.77)	(1.07)
	Medium control	41.52	168	8880	14.62	1.901	0.356	18.75	797.52	2.50
		(1.16)	(0.00)	(0.68)	(0.83)	(3.52)	(0.92)	(-2.50)	(3.43)	(0.40)
48	0.1563	44.10	192	8960	15.22	1.938	0.382	19.71	826.03	2.47
		(7.44)*	(14.29)*	(1.59)	(4.97)*	(5.56)*	(8.15)*	(2.46)	(7.13)*	(-0.74)
	0.3125	44.93	192	9067	15.68	1.966	0.390	19.83	856.93	2.49
		(9.47)*	(14.29)*	(2.80)*	(8.14)*	(7.04)*	(10.38)*	(3.13)*	(11.14)*	(0.13)
	31.25	43.84	192	9040	15.38	1.958	0.374	19.10	802.71	2.52
		(6.82)*	(14.29)*	(2.49)*	(6.07)*	(6.64)*	(5.90)*	(-0.69)	(4.11)	(1.27)
	Medium control	41.29	168	8860	14.70	1.835	0.354	19.30	798.94	2.48
		(0.60)	(0.00)	(0.45)	(1.38)	(-0.06)	(0.28)	(0.35)	(3.62)	(-0.34)
72	0.1563	42.70	192	8980	15.20	1.917	0.376	19.62	837.36	2.50
		(4.04)*	(14.29)*	(1.81)*	(4.83)*	(4.39)*	(6.50)*	(2.03)	(8.60)*	(0.67)
	0.3125	45.43	192	9067	16.00	2.055	0.404	19.66	897.13	2.49
		(10.69)*	(14.29)*	(2.80)*	(10.34)*	(11.90)*	(14.35)*	(2.20)	(16.35)*	(0.27)
	31.25	43.41	192	8947	15.76	1.958	0.369	18.87	794.01	2.51
		(5.76)*	(14.29)*	(1.44)	(8.69)*	(6.61)*	(4.58)*	(-1.90)	(2.98)	(0.80)
	Medium control	41.17	168	8810	14.84	1.858	0.347	18.68	799.15	2.52
		(0.30)	(0.00)	(-0.11)	(2.34)	(1.17)	(-1.74)	(-2.87)*	(3.65)	(1.41)
96	0.1563	42.24	168	8947	14.90	1.877	0.366	19.26	815.64	2.49
		(2.90)	(0.00)	(1.44)	(2.76)*	(2.23)	(3.63)	(0.16)	(5.78)*	(0.20)
	0.3125	41.74	168	8980	14.99	1.876	0.372	19.32	808.59	2.50
		(1.690	(0.00)	(1.81)*	(3.38)*	(2.17)	(5.19)*	(0.48)	(4.87)*	(0.54)
	31.25	41.29	168	8990	14.32	1.872	0.364	19.12	798.04	2.53
		(0.60)	(0.00)	(1.93)*	(-1.24)	(1.96)	(3.18)	(-0.59)	(3.50)	(1.81)
	Medium control	40.69	168	8860	14.24	1.852	0.348	18.76	777.16	2.44
		(-0.87)	(0.00)	(0.45)	(-1.79)	(0.86)	(-1.60)	(-2.44)	(0.79)	(-2.08)
Absolute control		41.04	168	8820	14.50	1.836	0.353	19.23	771.04	2.49
SE ±		0.513	3.650	52	0.128	0.024	0.005	0.169	11.31	NS
CD at 5%		1.449	10.940	146	0.361	0.068	0.014	0.478	31.93	

Figures in parentheses are percentage difference from the control.
*Significant ($P < 0.05$)
NS Not significant.

mean that the batches treated at 24 hrs did not induce any change in other parameters like larval, cocoon and cocoon shell weight. In fact, there was considerable influence. It has become clear that the JH administration need not always bring in a prolonged feeding period. Trivedy *et al.* (1997) have proved this by closely monitoring the changes in the haemolymph ecdysteroid titre in the JH treated silkworm and correlating this with prolongation in feeding period and enhanced production. This unequivocally proves that increase in economic traits of silkworm on JH application need not necessarily be accompanied always by an increase in larval feeding period.

Cocoon weight, cocoon shell weight and shell ratio (%)

Cocoon and cocoon shell weight along with their ratio have to be considered the most important commercial parameters in sericulture. The ultimate objective of JH application in sericulture has been enhanced silk produc-

Table 2. Effect of R394 on the commercial traits of silkworm, *Bombyx mori* L. (Hybrid: KA x NB_4D_2)

Treatment hour (5^{th} instar)	Concentration (nl/ml)	Larval weight (g) (10 nos.)	5^{th} instar larval period (h)	ERR/ num-ber	ERR/ weight (kg)	Cocoon weight (g)	Shell weight (g)	Shell ratio (%)	Average filament length (m)	Denier
24	0.1563	49.25 (6.22)*	168 (0.00)	8778 (1.54)*	16.56 (4.49)*	2.036 (7.48)*	0.415 (7.93)*	20.40 (0.44)	925.19 (7.47)*	2.54 (3.74)*
	0.3125	50.12 (8.11)*	168 (0.00)	8711 (0.77)	16.41 (3.58)*	2.076 (9.56)*	0.417 (8.37)*	20.09 (-1.09)	952.01 (10.58)*	2.47 (0.68)
	31.25	49.16 (6.03)*	168 (0.00)	8433 (-2.44)*	16.29 (2.81)*	2.028 (7.03)*	0.407 (5.68)*	20.05 (-1.26)	870.26 (1.08)	2.51 (2.45)
	Medium control	46.62 (0.56)	168 (0.00)	8456 (-2.19)*	15.58 (-1.68)	1.918 (1.25)	0.392 (1.89)	20.44 (0.64)	863.09 (0.25)	2.51 (2.59)
48	0.1563	50.27 (8.43)*	192 (14.29)*	8663 (0.21)	16.46 (3.86)*	2.051 (8.27)*	0.420 (9.06)*	20.46 (0.75)	941.72 (9.38)*	2.55 (3.95)*
	0.3125	50.76 (9.48)*	192 (14.29)*	8667 (0.26)	16.56 (4.49)*	2.074 (9.44)*	0.423 (10.01)*	20.42 (0.52)	953.34 (10.74)*	2.49 (1.57)
	31.25	50.58 (9.09)*	192 (14.29)	8700 (0.64)	16.27 (2.66)*	2.059 (8.66)*	0.403 (4.82)*	19.59 (-3.54)*	863.82 (0.34)	2.54 (3.74)*
	Medium control	46.52 (0.35)	168 (0.00)	8556 (-1.03)	15.89 (0.28)	1.901 (0.31)	0.391 (1.72)	20.60 (1.40)	866.04 (0.59)	2.49 (1.84)
72	0.1563	50.06 (7.97)*	192 (14.29)*	8733 (1.03)	16.57 (4.56)*	2.023 (6.78)*	0.414 (7.55)*	20.46 (0.71)	913.88 (6.15)*	2.49 (1.70)
	0.3125	51.26 (10.57)*	192 (14.29)*	8659 (0.17)	17.16 (8.27)*	2.165 (14.27)*	0.445 (15.73)*	20.57 (1.28)	985.20 (14.44)*	2.49 (1.70)
	31.25	49.95 (7.73)*	192 (14.29)*	8667 (0.26)	16.33 (3.09)*	2.089 (10.25)*	0.411 (6.72)*	19.66 (-3.20)*	867.29 (0.74)	2.51 (2.45)
	Medium control	46.31 (-0.11)	168 (0.00)	8522 (-1.41)*	16.00 (0.98)	1.937 (2.26)	0.391 (1.67)	20.20 (-0.54)	880.74 (2.30)	2.51 (2.31)
96	0.1563	48.14 (3.82)*	168 (0.00)	8681 (0.43)	16.11 (1.68)	1.949 (2.89)	0.397 (3.21)*	20.38 (0.32)	868.78 (0.91)	2.52 (2.93)*
	0.3125	48.69 (5.01)*	168 (0.00)	8600 (-0.51)	16.13 (1.82)	1.961 (3.51)	0.394 (2.39)	20.09 (-1.06)	863.18 (0.26)	2.51 (2.59)
	31.25	47.36 (2.15)	168 (0.00)	8667 (0.26)	16.04 (1.26)	1.938 (2.26)	0.395 (2.52)	20.36 (0.25)	861.71 (0.09)	2.50 (1.91)
	Medium control	46.09 (-0.59)	168 (0.00)	8537 (-1.24)	15.60 (-1.54)	1.919 (1.28)	0.393 (2.21)	20.50 (0.93)	853.73 (-0.84)	2.43 (-0.75)
Absolute control		46.36	168	8644	15.84	1.895	0.385	20.31	860.92	2.45
SE ±		0.540	3.650	43	0.136	0.023	0.004	0.189	11.59	0.020
CD at 5%		1.526	10.940	121	0.386	0.065	0.011	0.538	32.75	0.058

Figures in parentheses are percentage difference from the control.
*Significant ($P < 0.05$)

tion. Administration of R394 had a substantial positive influence on cocoon characters. In PM x NB_4D_2, the enhancement in cocoon weight was in the range of 5-12%, the maximum being 11.90% with 0.3125 nl/ml when treated at 72 hrs. This was followed by an increase of 8.42 and 7.04% with the same concentration when treated at 24 and 48 hrs, respectively (Table 1). In the case of KA x NB_4D_2, the maximum change (14.27%) was noticed with 0.3125 nl/ml when the compound was administered at 72 hrs. 31.25 nl/ml at 72 hrs (10.25%), 0.3125 nl/ml at 24 hrs (9.56%) and at 48 hrs (9.44%) also had significant influence on the cocoon weight (Table 2).

The influence of R394 on the cocoon shell weight was almost corresponding to the changes noticed in cocoon weight. In PM x NB_4D_2, the highest positive change was seen when the compound was administered at the dose of 0.3125 nl/ml at 72 hrs (14.35%) followed by the same concentration at 48 hrs (10.38%) and 24 hrs (9.58%). The other two concentrations also had notable positive influence at these three treatment hours. The treatment at 96

hrs however did not show much difference (Table 1). In KA x NB_4D_2 also, the maximum increase was recorded with 0.3125 nl/ml when treated at 72 hrs. This was to the tune of 15.73%. This was followed by a change of 10.01% with the same concentration when treated at 48 hrs (Table 2). Treatments at 24 hrs also elicited favourable response in the cocoon shell weight when compared to the control. Here again, 96 hrs treatment did not show much influence on cocoon shell weight. The medium control responded almost at par with the absolute control.

In PM x NB_4D_2, there was no significant change in the shell ratio on administration of R394 except with 0.3125 nl/ml where the change was 3.113%. But the shell ratio was reduced to some extent with medium controls at 24, 72 and 96 hrs though they were statistically not significant (Table 1). In KA x NB_4D_2, the shell ratio was substantially low with the concentration 31.25 nl/ml when treated at 48 and 72 hrs (Table 2).

There are lots of reports in support of the present work. But these reports speak about different compound tried in sericulture for yield improvement and many of them proved successful. Ito *et al.* (1975) could achieve about 14% increase in cocoon weight and about 20% in cocoon shell weight when juvenoids were administered to silkworm. Kamada *et al.* (1979) could get 10-14 and 13 -20% increases in cocoon and cocoon shell, respectively by treating silkworm with methoprene. Chowdhary *et al.* (1990) have reported an increase of about 42% in the silk content when silkworm was treated with juvenoids between 48 and 72 hrs of 5th instar. The report of Subba Rao *et al.* (1988) has indicated an improved cocoon production by 16% on application of JHA, manta whereas, Trivedy *et al.* (1993) could achieve an increase of 14% in cocoon shell weight when the JHA, labomin was administered to silkworm. In many of the instances of juvenoid administration to silkworm, the silk ratio has not been influenced by the compounds administered. But Kamada *et al.* (1979) have seen an increase in the ratio of cocoon shell to cocoon. In the present work, there was no much change in the SR% although the cocoon and cocoon shell weight improved in the vicinity of 14-15%. This is mainly attributed to the fact that, SR% is a breed character and the cocoon and cocoon shell weight do not change to that extent independent of the pupal weight to result in a remarkable change in SR% unless the compounds used are anti-juvenoids (Nair *et al.*, 1998). But the report by Juliang *et al.* (1989) indicate a decrease in shell ratio by 4-18% owing to comparatively low increase in cocoon shell weight (13-35%) as against the cocoon weight (23-46%). As the present study did not show any such extreme alteration in this important parameter, it is clear that the dose and time of application arrived at, do not cause any deleterious effect on the normal silkworm development.

Effective rate of rearing by number and weight

Table 1 furnishes the difference in the ERR by number in PM x NB_4D_2 which was only in the range of 2- 4%. The maximum change was 4% with 0.3125 nl/ml when treated at 24 hrs. In the bivoltine hybrid, there was no much change in this parameter except with 31.25 nl/ml at 24 hrs where a 2% reduction was noticed (Table 2).

The effective rate of rearing (ERR) which may otherwise be understood as survival in a general entomological arena was not largely affected. In sericulture, ERR by number is considered as one of the important parameters and this largely reflects the management capacity of the person who oversees the silkworm as well apart from the effect of the compound administered. In the present study, the ERR by number did not change significantly. This underlines the fact that as long as the dose of the compound is below the threshold level of lethal effects, the compound may not affect the ERR by number. That may be the reason why earlier workers too did not notice any remarkable change in ERR by number (Trivedy *et al.*, 1993). Apart from this, Muroga *et al.* (1975) have pointed out that when JH applications were intended for an increased silk production, it did not affect the survival rate. In contrast to this, Kamada *et al.* (1979) observed a slight decrease in the survival of pupae on administration of JH to 5th instar silkworm larvae.

ERR by weight, a commercially more important trait, had a substantially positive change in the treated silkworm. ERR by weight was significantly and positively affected with the administration of R394. In PM x NB4D2, administration of 0.3125 nl/ml of R394 at 72 hrs could improve the ERR by weight significantly by 10.34%. This was followed by a change in the range of 4-8% with other two concentrations at other treatment hours (Table 1). In the case of KA x NB_4D_2, the response was almost similar but the change was in the range of 3-8%, the maximum being 8.27% with 0.3125 nl/ml when treated at 72 hrs (Table 2). A general trend was obvious that the difference in ERR by weight between the treated and control worms is almost corresponding to such difference in cocoon weight though the difference may not be that prominent. This increase must be attributed mainly to the increased cocoon weight on juvenoid application. On many occasions, ERR by weight gets a positive influence by juvenoid largely because of its positive effect on the cocoon characters. An unchanged ERR by number between the treated and control but at the same time a substantial change in the ERR by weight in silkworm was reported earlier also (Nair *et al.*, 2000).

Filament length and denier

The length of the filament and its thickness is of paramount importance in sericulture because ultimately these two are among the most important traits which decide the profitability of sericulture. In the present investigation, the juvenoid induced a positive change in the length of the filament. This was obvious in both the hybrids. In PM x NB_4D_2, the maximum improvement in the filament length was observed in the case of treatment with 0.3125 nl/ml of R394 at 72 hrs. The improvement was 16.35% and quite significant. Highly significant improvement was also recorded with the same concentration at 24 (11.17%) and 48 hrs (11 14%) (Table 1). These changes were corresponding to the improvement in cocoon shell weight. In KA x NB_4D_2 also, the maximum improvement was in the silkworms treated with 0.3125 nl/ml of R394 at 72h. The quantitative change was to the tune of 14.44% (Table 2). This was followed by 10.74% and 10.58% increase at 48 and 24 hrs, respectively with the same concentration. Although the filament length was influenced by the treatment of silkworm with R394, there was no significant change in the denier compared to the control in the case of PM x NB_4D_2 (Table 1). But in the case of the bivoltine hybrid, there was an increase in the denier of the filament in the range of 3-4% with 0.1563 nl/ml at 24, 48 and 96 hrs. 31.25 nl/ml of the compound also showed similar effect (Table 2).

The results are conclusive enough to state that the increase found in the cocoon and cocoon shell weight was satisfactorily transformed to the silk filament. This assumes much significance because, the improvement in the shell weight as an after effect of juvenoid application need not necessarily be transformed into the length of the silk filament but it can be manifested in the thickness of the filament as well. If the filament length remains constant, the thickness of the filament could be more. But such thicker filament may not be of much demand. The industry requirement is always thinner and finer silk filament. To that extent, the juvenoid application is not a dampener of the sericulturist's cause. In the present work, though the filament length got enhanced considerably in response to the treatment, the denier did not change considerably, which implies that the juvenoid application does not affect the thickness of the filament. Tsukada *et al.* (1987) reported to have obtained longer silk filament and better quality on administration of juvenoids to silkworm, *B. mori.* As per Kamada *et al.* (1979), the length and weight of the cocoon filament increased considerably on JH administration to silkworm.

It can be surmised that the R394 is a potent juvenoid, which can be used in sericulture. The most favourable concentration of R394 to improve economic characters in silkworm is 0.3125 nl/ml and the most suitable age for treatment is 72 hrs of 5^{th} instar in both the hybrids tested regardless of the increase in the larval period. The reasons for the enhanced production must be a concerted effect of the conversion of additional quantity of leaf consumed during the extended period and a direct stimulatory effect of the compound on protein synthesis as suggested by Kajiura and Yamashita (1989). These changes at the physiological and molecular level might be the result of an alteration in the ratio of the circulating hormones.

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References

Akai, H., K. Kimura, M. Kiuchi and A. Shibukawa (1985) Increase of silk production by repeated treatments with a juvenile hormone analogue. *J. Seric. Sci. Jpn.* **54**, 297-299.

Changamma, C., R. Rajasekhar and S. Govindappa (2000) Influence of methoprene on *Bombyx mori* L. *Indian J. Seric.* **39**, 135-138.

Chowdhary, S. K., P. S. Raju and R. K. Ogra (1990) Effect of JH analogues on silkworm, *Bombyx mori* L. growth and development of silk gland. *Sericologia* **30**, 155-165.

Ito, T., Y. Mizuta, K. Takamiya, S. Ueda, R. Kimura, T. Higuchi and S. Takahashi (1975) Growth, development and cocoon production in artificial diet rearing of the silkworm, *Bombyx mori*, with or without application of a synthetic juvenile hormone analog. *J. Agric. Chem. Soc. Jpn.* **49**, 39-48.

Juliang, X., F. Mukaiyama, K. Hamano and M. Hashimoto (1989) Investigations on the enhancement of the efficiency of transferring diet into silk by domestic silkworm. V. Increase of silk production by treatment with JHA- Methoprene. *Acta Sericologia Sinica* **15**, 118-124.

Kajiura Z. and O. Yamashita (1989) Super growth of silk glands in the dauer larvae of the silkworm, *Bombyx mori*, induced by a juvenile hormone analogue. *J. Seric. Sci. Jpn.* **58**, 39-46.

Kamada, A., S. Shimada and S. Asano (1979) Studies on the utilization of methoprene, a synthetic compound with juvenile hormone activity, for the silkworm rearing. II. Effect on the development of fifth instar larvae. *J. Sericult. Sci. Jpn.* **48**, 129-136.

Muroga, A., M. Nakajima, S. Aomori, Y. Ozawa and M. Nihmura (1975) Utilization of the synthetic juvenile hormone

analog to the silkworm rearing on mulberry leaves. *J. Sericult. Sci. Jpn.* **44**, 267-273.

Nair, K. S., J. S. Nair, K. Trivedy, C. M. Babu and R. K. Datta (1998) Influence of chemically induced precocious metamorphosis in the growth rate pattern and economic traits of silkworm, *Bombyx mori* L. *Russian Entomol. J.* **7**, 101-105.

Nair, K. S. and K. Trivedy (1998) Juvenile hormone mimics and silk productivity. *Indian Silk* **37**, 23-25.

Nair, K. S., K. Trivedy, S. B. Magadum and R. K. Datta (1997) Improvement of economic characters of mulberry silkworm, Bombyx *mori* L. by a phytohormone, Abscisic acid. *J. Entomol. Res.* **21**, 343-349.

Nair, K. S., V. A. Vijayan, J. S. Nair and K. Trivedy (1999) Juvenilomimic compounds for enhanced productivity in silkworm *Bombyx mori* L. - A screening. *Indian J. Seric.* **38**, 119-124.

Nair, K. S., V. A. Vijayan, J. S. Nair, K. Trivedy and P. K. Chinya (2000) Influence of a plant based juvenile hormone mimic, ù -formyl longifolene oxime citronellyl ether on silkworm, *Bombyx mori* L. *Sericologia* **40**, 551-557.

Subba Rao, G., S. K. Das, S. K. Sen, S. Nandi, R. Sompomu and S. K. Sen (1988) A study on the effect of juvenile hormone analogue on the bivoltine silkworm, *B. mori* L. *Sericologia* **28**, 534-548.

Trivedy, K., O. K Remadevi, S. B. Magadum and R. K. Datta (1993) Effect of juvenile hormone analogue, labomin on the growth and economic characters of silkworm, *Bombyx mori* L. *Indian J. Seric.* **32**, 162-168.

Trivedy, K., K. S. Nair, M. M. Ahsan and R. K. Datta (1997) A juvenile hormone mimic modulated enhancement in silk productivity in silkworm, *Bombyx mori* L. *Indian J. Seric.* **36**, 35-38.

Tsukada, M., K. Kimura, A. Shibukawa, A. Shimazaki and H. Akai (1987) Effect of treatment with juvenile hormone analogue and atni-juvenoid on the size of the cocoon filament. *J. Seric. Sci. Jpn.* **56**, 231-234.