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Effect of Naphthoxyacetic Acid (NOA) on the Economic Parameters of the Silkworm *Bombyx mori* L.

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The effect of topical application with naphthoxyacetic acid on economic parameters was analyzed following treatment of fifth instar larvae. Larvae treated during the fifth instar showed significant increase in larval weight along with other enhanced larval, cocoon and adult parameters. The larval period was significantly shortened in all the treated groups with increased cocoon and shell weights in male and shell weight in female in 400 µg/ml treated group and filament length in all the treated groups. Fecundity increased significantly in dose dependent manner in all the treated groups, when compared to that of the carrier control group. This suggests that naphthoxyacetic acid, in addition to affecting larval growth, also affect silk production and reproductive performance.

Key words : Napthoxyacetic acid, Economic parameters, *Bombyx mori*

Introduction

The development of chemical substances to regulate plant bioprocesses has taken a tremendous swing. It was found that among the native substances predominantly cytokines, gibberellins, auxins, abscissic acid and ethylene participate decisively in complex plant bioprocesses. It has been reported that plant growth regulators regulate cell division, growth and replace old tissue in plants and influence the assimilated metabolites and their transport to different parts of plants (Felenberg, 1981). On the other hand plant growth regulators may also exert an influence upon developmental process of insects (Carlisle *et al.*, 1963; Nation and Robinson, 1966; panitz, 1967; Baudisch and Panitz, 1968; Eidt and Little, 1970; Gurra, 1970; Alonso, 1971; Salama and El Sharaby, 1972; Neumann, 1982; Edwards, 1966; Osborne *et al.*, 1968; Neumann, 1980; Besker and Roussaux, 1980; Chrominisle *et al.*, 1982).

The effects of plant growth regulators on the economic parameters of the silkworm, *B. mori* are limited. It has been reported that the treatment with chloramphenicol increases the larval weight and shell ratio in silkworm, *B. mori* (Krishnaswami *et al.*, 1978). Feeding mulberry leaves sprayed with GA_3 or spraying GA_3 in fifth instar larvae is reported to increase the larval weight and cocoon weight in *B. mori* (Kamada and Ito, 1984). Pai *et al.* (1986) have reported that topical application with paraaminobenzoic acid causes a significant reduction in hatchability of eggs of NB_{18} race of *B. mori*. Magadum and Hooli (1989, 1990a, b) have reported that topical application with IAA, GA_3 and 3IBA in different larval stadium of pure Mysore multivoltine breed of *B. mori*, resulted in a significant increase in the larval weight, silk gland weight, cocoon shell weight and egg productivity and a significant decrease in larval duration, cocooning and moth emergence percentage. Recently, it has been reported that the topical application of IAA increased larval weight, silk gland weight, cocoon weight and its shell weight in bivoltine silkworm, *B. mori* (Hugar and Kaliwal, 1997). However, there is no report on the effect of naphthoxyacetic acid on the economic parameters of the silkworm, *B. mori*. Hence, the present investigation was undertaken in the multivoltione silkworm *B. mori*.

Materials and Methods

The desease free layings (DFLS) of multivoltine cross breed (PM x NB_{18}) silkworm were obtained from grainage center Rayapur, Dharwad, Karnataka and reared in the

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laboratory by improved methods of silkworm rearing techniques (Krishnaswami, 1978). The larvae were maintained on fresh mulberry leaves (K2). The fifth instar larvae were divided into six experimental groups including controls and every group consists of uniformly weighed larvae in five replications of 20 worms. The naphthoxyacetic acid procured from M/s. Sigma Laboratories ptv Ltd Bombay. It was dissolved in small quantity of acetone and diluted to form 10, 20, and 30 µg/ml by adding distilled water. Each larva was topically applied with one of the three doses of naphthoxyacetics acid at alternate day. In each application 5 ml of solutions was used to treat 100 larvae.

The larval, cocoon and adult parameters were recorded separately. The larval and silk gland weights were recorded before commencement of spinning. The larval duration was recorded from the day of hatching till the completion of spinning. The cocoon parameters such as female and male cocoon weight and their shell weights were recorded on the 5th day after the completion of the spinning activity. The filament length was recorded with epprovette by reeling a single cocoon. The reeled silk was dried in hot air oven and weight was taken in the electrical balance. The cocoon shell ratio and denier of the filament was calculated. The fecundity was recorded in the adult after mating. The cocooning, moth emergence and hatching were also calculated by the formulas shown in the tables. Each mean value, a record of 10 worms is shown in Table 1,2 and 3.

The data collected were subjected to analysis of variance tests to find out the significance between the treated and control group (Raghawa Roa, 1983). The percent emergence and hatching percentage were transformed to sine angular values for statistical analysis. The percent index was calculated for each parameter of the experimental groups over these of the corresponding parameters of the cattier control.

Results and Discussion

Larval weight

The results of the present study have shown that the larval weight is significantly increased in all the NOA treated groups when compared with the corresponding parameters of the carrier control (Table 1). The results obtained in the present study are in agreement with that reported for the Indian multivoltine and Japanese race of *B. mori*

Table 1. Effect of naphthoxyacetic acid (NOA) on larval parameters of silkworm, *B. mori*

Treatment	Dose µg/ml	Larval weight (g)	Silk gland weight (g)	Larval duration (h)	Cocooning percentage (%)
Naphthoxyacetic acid	200	3.408*	0.776*	625.0*	99.4 84.38**
		(118)	(111)	(99)	(100)
Naphthoxyacetic acid	400	3.836*	0.771*	625.4*	99.4 84.38**
		(133)	(111)	(99)	(100)
Naphthoxyacetic acid	600	3.903*	0.794*	625.2*	99.4 84.38**
		(136)	(114)	(99)	(100)
Carrier control	Distilled water	2.864	0.693	630	99.4 84.38**
		(100)	(100)	(100)	(100)
Normal control	--	3.110	0.673	629.6	99.2 84.32**
		(108)	(97)	(99)	(99)
		S	S	S	NS
S.Em±		0.165	0.042	0.857	0.604
C.D. at 5%		0.324	0.083	1.818	1.282

* - Significant increase/decrease at 5%
** - Angular transformed values
S - Significant
NS - Non significant
S.Em± - Standard error mean
C.D. - Criticle difference
Per cent increase/decrease over that of the carrier control in parenthesis.

$$\text{Cocooning percentage} = \frac{\text{Number of cocoons formed}}{\text{Total number of larvae kept}} \times 100$$

Table 2. Effect of naphthoxyacetic acid (NOA) on the cocoon parameters of the silkworm, *B. mori*

Treatment	Dose µg/ml	Female cocoon weight (g)	Female cocoon shell weight (g)	Female cocoon shell ratio (%)	Male cocoon weight (g)	Male cocoon shell weight (g)	Male cocoon shell ratio (%)	Filament length (mts)	Filament weight (g)	Denier
Naphthoxyacetic acid	200	1.482	0.214	14.47 22.30**	1.496	0.220*	14.72* 22.55**	405.33*	0.155	3.441*
		(102)	(107)	(104)	(103)	(111)	(107)	(124)	(95)	(77)
Naphthoxyacetic acid	400	1.725*	0.240*	13.91 21.89**	1.567*	0.227*	14.53 22.38**	464.66*	0.175	3.389*
		(119)	(120)	(100)	(108)	(115)	(106)	(142)	(108)	(75)
Naphthoxyacetic acid	600	1.522	0.221	14.52 22.38**	1.558*	0.223*	14.34 22.22**	396.66*	0.156	3.540*
		(105)	(110)	(104)	(107)	(113)	(105)	(121)	(96)	(79)
Carrier control	Distilled water	1.445	0.200	13.85 21.81**	1.446	0.197	13.65 21.64**	326.66	0.162	4.463
		(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Normal control	-	1.760*	0.246*	13.97 21.89**	1.539	0.220	14.35 22.22**	425.33	0.180	3.808*
		(121)	(123)	(100)	(106)	(111)	(105)	(130)	(111)	(85)
		S	S	NS	S	S	S	S	NS	S
S.Em±		0.092	0.012	0.820	0.060	0.009	0.524	43.041	0.015	0.193
C.D. at 5%		0.180	0.024	1.607	0.118	0.018	1.024	99.424	0.036	0.446

* - Significant increase/decrease at 5%
** - Angular transformed values
S - Significant
NS - Non significant
S.Em± - Standard error mean
C.D. - Criticle difference
Per cent increase/decrease over that of the carrier control in parenthesis.

$$\text{Denier} = \frac{\text{Single cocoon filament weight (g)}}{\text{Single cocoon filament length (m)}} \times 9000$$

$$\text{Female/Male cocoon shell ratio} = \frac{\text{Cocoon shell weight}}{\text{Cocoon weight}} \times 100$$

(Magadum and Hooli, 1989; Kamada and Ito, 1984). The increased larval weight obtained in the present study might be due to the growth stimulating effect of NOA as reported after treatment with another plant hormones (Neuman, 1982).

Silk gland weight

The wet weight of the silk gland did not show any significant change in the treated groups when compared with that of carrier control (Table 1). However the plant growth hormones may regulate the DNA synthesis in insects (De Mann, 1981; Neumann, 1982). Hence, further investigation is essential in this regard.

Larval duration

The results of the present study showed that the larval duration decreased significantly in all the larval groups treated with NOA when compared with that of the carrier controls (Table 1). The decreased larval duration observed in the present study might possibly be due to the increased synthesis of moulting hormone, since the treatment with plant growth regulators is reported to alter the rate of synthesis of the insect-moulting hormone (De Mann, 1981; Neumann, 1982).

Cocooning percentage

Topical application with all the three concentration of NOA had no effect on the cocooning percentage and there by indicating that the used concentration are allowance limits and have not adversely affected the cocooning percentage (Table 1).

Cocoon weight and cocoon shell weight

The female cocoon weight and its cocoon shell weight

Table 3. Effect of naphthoxyacetic acid (NOA) on adult parameters of silkworm, *B. mori*

Treatment	Dose µg/ml	Moth emergence percentage (%)	Fecundity (No.)	Hatching percentage (%)
Naphthoxyacetic acid	200	99.4 84.38** (99)	637.8* (102)	99.12 84.29** (100)
Naphthoxyacetic acid	400	99.2 84.32** (99)	642.0* (103)	98.80 83.71** (99)
Naphthoxyacetic acid	600	98.8 83.71** (99)	670.4* (107)	98.85 83.20** (99)
Carrier control	Distilled water	99.6 84.44** (100)	620.8 (100)	98.85 83.71** (100)
Normal control	--	99.4 84.38** (99)	625.2 (100)	98.19 82.08** (99)
		NS	S	S
S.Em±		0.523	0.596	0.051
C.D. at 5%		1.109	1.264	0.109

* - Significant increase/decrease at 5%
** - Angular transformed values
S - Significant
NS - Non significant
S.Em± - Standard error mean
C.D. - Criticle difference
Per cent increase/decrease over that of the carrier control in parenthesis.

$$\text{Moth emerged percentafe} = \frac{\text{Number of morhs emerged}}{\text{Number of cocoons kept}} \times 100$$

$$\text{Hatching percentage} = \frac{\text{Total number of eggs hatched}}{\text{Total number of eggs laid}} \times 100$$

significantly increased in 400 µg NOA treated group when compared with that of carrier control (Table 2). In males the cocoon shell weight significantly increased in the larvae treated with 400 and 600 µg NOA treated groups when compared with that of the carrier controls (Table 2). The results of the present study suggest that 400 µg of NOA in 5th instar, yields heavier cocoons and cocoon shells in both sexes. The results also suggests that with the topical application of NOA the percent increase in the cocoon shell weight is always more than that of the cocoon weight in both sexes. These results are comparable to the treatment with IAA, GA3, in the different racess (Magadum and Hooli, 1989, 1991; Hugar and Kaliwal, 1997). The increase in the female and male cocoon shell weights is not preceded by the increase in silkgland weight in these groups. Hence, further investigation is essential in this regard.

Silk filament length, weight and denier

A significant increase in the filament length was obtained in all the NOA when compared with that of the carrier control (Table 2). The filament weight did not show any significant change in all the treated groups. However, There was a significant decrease in the denier in all the NOA treated groups when compared with that if the carrier control (Table 2). Similar results have been reported with topical application of IAA to bivoltine of the silkworm, *B. mori* (Hugar and Kaliwal, 1997).

Moth emergence percentage

There is no significant change in the moth emergence in all the treated groups when compared with that of carrier control (Table 4). This indicates that at these concentration NOA has no toxic effect on the cocoon crop. However, it has been reported that moth emergence percentage decreased in the groups treated with GA_3, IAA and IPA

plant hormones depending on the concentration and duration of the treatment in the silkworm, the pure Mysore breed, *B. mori* (Magadum and Hooli, 1989; 1991a, b).

Fecundity

The result suggests that the fecundity increased significantly in dose dependent manner in all the NOA treated groups (Table 4). This results supports the views of earlier workers (Magadum and Hooli, 1989, 1990,1991; Hugar and kaliwal, 1997). The results, therefore, suggest that the used concentrations had no adverse effect on fecundity of the silkworm, *B. mori.*

Egg hatching percentage

The result of the present study showed that the topical application with 200, 400 and 600 µg/ml NOA has no effect in egg hatching percentage when compared with that of carrier control (Table 4). This indicates that the used concentrations had no adverse effect on the egg hatching percentage.

The silkworm is entirely dependent on mulberry leaves as a food source and plant growth regulators play an important role in the silkworm growth and reproduction. It is important to note that the compounds belonging to all five classes of plant growth regulators have shown to alter insect growth as well as reproduction (Neumann, 1982) but a paradoxial thing is that the results due to the effect of these plant growth regulators on insect growth and reproduction do not reveal similar effects in all the insects. The precise mechanism of action of plant growth regulators is still obscure although the effect of plant growth regulators (either added to the diet, injected or topically applied) has been investigated in insects. Pantiz (1967) has found a specific effect of GA_3 upon the activity of the genome, expressed by puffs in the polytene chromosomes of larvae of midge *Acricotopus indicus*. The specific changes in the pattern of puffs, which are thought to reflect gene activity, indicated that GA_3 interfered with normal development (Boudisch and Panitz, 1968). Plant growth regulators mimic the moulting hormones and restrict the growth of *Drosophila hydei* (Alonso, 1971), serves as biochemical signals to regulate insect growth, DNA synthesis and reproduction of *Aulocase ellitti* (Neumann, 1982). De Mann *et al.* (1981) have suggested that dietary supplementation of plant growth regulators may regulate insect growth and reproduction directly by altering the rate of DNA synthesis and/or the rate of synthesis of insect moulting hormone. Of course, it is difficult to draw clear conclusion from these data, but it seems of great interest to mention here in each case the results agree with the four working hypothesis of the different authors viz; 1, Plant growth regulators have specific effect on the insect growth probably as a result of plant growth regulator action upon the activity of the genome (Pantiz, 1967) and thought to reflect gene activity, interfered with normal development (Baudisch and Panitz, 1968). 2, plant growth regulators have specific effect on insect growth, plant growth regulator mimics the moulting hormones and restricted the insect growth of *Drodophils hydei* (Alonso, 1971). 3, plant growth regulators have specific effect on insect growth, DNA synthesis and reproduction probably plant growth regulators serve as biochemical signals since, ABA, GA_3 and JH III are biochemically similar compounds derived from mevalonte (Neumann, 1980, 1982). 4, plant growth regulators regulate insect growth and reproduction probably by altering the rate of DNA synthesis and or the rate of synthesis of insect moulting hormone (De Mann *et al.*, 1981).

In our study it is interesting to note that the naphthoxyacetic acid enhance the larval weight, male cocoon weight, male and female cocoon shell weight, filament length, and fecundity. However, larval duration was significantly decreased. Additional studies using other races of silkworm and variety of exsercise paradigms will be necessary to determine the physiological significance and generalizability of the present results.

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