Int. J. Indust. Entomol. Vol. 10, No. 2, 2005, pp. 107~117

International Journal of
Industrial Entomology

Synergetic Effect of Minerals Mixture of Potassium Bromide and Nickel Sulphate on the Economic Traits of CSR_2, CSR_4 and $CSR_2 \times CSR_4$ Crossbreed Races of the Silkworm, *Bombyx mori* L.

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(Received 28 January 2005; Accepted 1 May 2005)

Oral supplementation of minerals mixture of potassium bromide and nickel sulphate on CSR_2, CSR_4, and $CSR_2 \times CSR_4$ crossbreed races with different concentrations (70, 110 and 160 μg/ml) were fed to the fifth instar larvae. Two of the four normal feeds per day was substituted with treated leaves fed to silkworm at fifth instar larvae. The controls were fed with the leaves sprayed with distilled water and normal leaves. The CSR_4 race treated larvae showed a significant increase in silkgland weight, cocooning percentage, female cocoon weight, male cocoon weight, male cocoon shell weight, male cocoon shell ratio, filament length, filament weight, denier, fecundity, number of eggs per ovariole and length of the ovariole when compared with those of the corresponding parameters of the carrier control, whereas in CSR_2 and $CSR_2 \times CSR_4$ crossbreed races showed a significant increase in larval weight and other parameters similar to that of CSR_4 race. The results suggested that the silkgland showed good response to minerals mixture of potassium bromide and nickel sulphate only in CSR_4 race when compared with those of other two races of the silkworm, *B. mori*.

Key words: Potassium bromide, Nickel sulphate, Silkworm, Economic traits

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Introduction

The silkworm, *Bombyx mori*, is a monophagous insect derives almost all the nutrients required for its growth from the mulberry leaf only. It has been well established that the silkworm requires certain essential sugars, proteins, amino acids, fatty acids, vitamins and micronutrients for its growth and higher production of good quality of silk. The low productivity is mainly attributed to low mulberry yield and poor quality of leaf (Chamundeswari and Radhakrishnaiah, 1994). Thus it appears that to boost up silk production, some supplements are essential to the silkworm in addition to their natural food depending upon the agroclimatic conditions. Recently, Etebari *et al.* (2004) in their review article are attempted to discuss the results of other workers on enrichment of mulberry leaves with supplementary compounds to enhance the silk productivity. It has also been reported that feeding with minerals to silkworm have shown to increase the commercial characters (Khan and Saha, 1997; Venkataramana *et al.*, 2001; Etebari and Fazilati, 2003; Hugar and Kaliwal, 2003; Bhattacharya and Kaliwal, 2003). Feed with various food additives was found to increase the economic characters and play a vital role in the larval developed (Ito and Niminura, 1966a, b; Prasad *et al.*, 1994). Minerals are essential elements and effect various metabolic processes in the insect body (House, 1974). These results indicate that the economic parameters of the silkworm are affected on feeding them with mulberry leaves supplemented with different salts and response varies with different doses and races of the silkworm. Therefore, the present investigation has been undertaken to study and compare the synergetic effect of minerals mixture of potassium bromide and nickel sulphate of different concentrations on the economic parameters of CSR_2, CSR_4 and $CSR_2 \times CSR_4$ crossbreed races of the silkworm, *B. mori*.

Materials and Methods

The disease free layings (DFLS) of silkworm *i.e.,* CSR_2, CSR_4 and $CSR_2 \times CSR_4$ crossbreed were obtained from the grainage center Rayapur, Dharwad, Karnataka. After hatching the larvae were fed with mulberry leaves (K_2) variety. The fifth instar larvae were used for the experiment, larvae were selected randomly and grouped into different batches for the experiment. Each group consisted of five replication each with 20 silkworms. The chemical potassium bromide and nickel sulphate were dissolved completely in distilled water and mixed each other to form 70, 110 and 160 µg/ml dilutions. These chemicals were procured from British Drug House (India) Limited, Worli Mumbai. Eggs were incubated at 25°C with 80% relative humidity. The hatched larvae were reared in the rearing room and fed four times a day by maintaining optimum humidity (85 – 95%) and temperature 27°C providing optimum spacing and *ad libitum* mulberry leaves raised by improved methods of rearing techniques (Krishnaswami, 1978a, b, c). The mineral solutions were sprayed on fresh mulberry leaves with each concentration and then the leaves were dried and fed to the silkworm *ad libitum*. Amongst four feedings per day, feeding of treated leaves were alternated with the feeding of untreated leaves. The carrier controls were fed with distilled water sprayed mulberry leaves, while the normal controls were fed with untreated leaves.

The parameters were recorded for 10 silkworms two from each replication of treatment groups. The larval parameters were recorded before the onset of spinning activity. Cocoon parameters like male and female cocoon weight and their shell weight were recorded on the 5th day after the completion of 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 an electrical balance. The fecundity was recorded in the adult after mating. All these were calculated by the formula shown below. Each mean value recorded of 10 silkworms is shown in the Tables 1 to 9.

Statistical analysis

The data's were subjected to analysis of variance to study

Table 1. Effect of minerals mixture of nickel sulphate and potassium bromide on the larval parameters of the CSR_4 silkworm, *B. mori*

Treatment	Dose µg/ml	Larval weight (g)	Silkgland weight (g)	Larval duration (h)	Cocooning percentage (%)
Nickel sulphate + Potassium bromide	70	3.172	1.382	625*	80
					63.43**
		(101)	(98)	(99)	(103)
Nickel sulphate + Potassium bromide	110	3.280	1.612*	611	83*
					65.64**
		(104)	(114)	(96)	(107)
Nickel sulphate + Potassium bromide	160	3.290	1.534	600*	83*
					65.64**
		(105)	(108)	(95)	(107)
Carrier control	Distilled water	3.130	1.410	630	77
					61.34**
		(100)	(100)	(100)	(100)
Normal control	-	2.840	1.310	645	78
					62.02**
		(90)	(93)	(102)	(101)
		NS	S	S	S
SEM ±		0.051	0.036	8.362	1.278
C.D. at 5%		0.2043	0.1306	17.521	4.014

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

Table 2. Effect of minerals mixture of nickel sulphate and potassium bromide on the cocoon parameters of the CSR_4 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
Nickel sulphate + Potassium bromide	70	1.823*	0.358	19.732 26.37**	1.200*	0.210	17.50* 24.72**	773*	0.268*	2.652
		(125)	(94)	(86)	(106)	(98)	(92)	(75)	(83)	(95)
Nickel sulphate + Potassium bromide	110	1.551*	0.293	21.462 27.59**	1.400*	0.330*	23.56* 28.99**	950*	0.290*	2.789
		(118)	(85)	(93)	(124)	(154)	(124)	(92)	(91)	(99)
Nickel sulphate + Potassium bromide	160	1.352*	0.330	21.22 27.42**	1.210*	0.256*	21.15* 27.38**	1140*	0.336	3.119*
		(93)	(97)	(87)	(107)	(120)	(111)	(110)	(105)	(113)
Carrier control	Distilled water	1.454	0.341	22.922 28.59**	1.123	0.213	18.96 25.81**	1030	0.32	2.795
		(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Normal control	-	1.310	0.320	24.302 29.53**	0.787	0.180	22.87 28.56**	890	0.276	2.746
		(90)	(93)	(106)	(70)	(84)	(120)	(86)	(86)	(98)
		S	NS	NS	S	S	S	S	S	S
SEM ±		0.1046	0.0166	1.282	0.0042	0.01004	0.02008	2.209	0.00746	0.0658
C.D. at 5%		0.0708	0.0575	4.132	0.0088	0.0321	0.0492	6.931	0.0209	0.1943

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

Table 3. Effect of minerals mixture of nickel sulphate and potassium bromide on the adult parameters of the CSR_4 silkworm, *B. mori*

Treatment	Dose µg/ml	Moth emergence percentage (%)	Fecundity (Nos.)	Hatching percentage (%)	No. of eggs per ovariole (Nos.)	Length of the ovariole (mm)
Nickel sulphate + Potassium bromide	70	89 70.63** (102)	680* (118)	89 70.63**	59* (123)	112* (186)
Nickel sulphate + Potassium bromide	110	84 66.42** (96)	641* (111)	85 67.21** (95)	62* (129)	107* (178)
Nickel sulphate + Potassium bromide	160	83 65.64** (95)	590* (102)	84 66.42** (94)	50 (104)	100* (166)
Carrier control	Distilled water	87 68.86** (100)	576 (100)	89 70.63** (100)	48 (100)	60 (100)
Normal control	-	87 68.86** (100)	566 (98)	80 63.43** (90)	46 (96)	58 (96)
		NS	S	NS	S	S
SEM ±		1.482	2.354	1.821	1.2092	2.118
C.D. at 5%		4.570	8.560	5.618	3.740	6.822

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

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

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

$$\text{Denier of the filament} = \frac{\text{Single cocoon filament weight}}{\text{Single cocoon filament length}} \times 9000$$

$$\text{Moth emergence percentage} = \frac{\text{No. of Moth emerged}}{\text{No. of cocoon kept}} \times 100$$

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

the significance among the treatment groups. To determine the least significant difference test (Lsd) was carried out. The present values of cocooning percentage and hatching percentage were transferred into sine angular values (Raghava Rao, 1983).

Results and Discussion

The effect of minerals mixture of potassium bromide and nickel sulphate on larval, cocoon and post cocoon parameters were summarized in the Tables 1 to 9.

Larval weight

The results of the present study have indicated that the larval weight was significantly increased in all the treated groups of CSR_2 race, with 70 and 110 µg/ml treated groups of $CSR_2 \times CSR_4$ crossbreed race whereas there was no significant change in CSR_2 race treated with minerals mixture of potassium bromide and nickel sulphate when compared with that of the carrier control. Similar increase in larval weight have been reported in the silkworm, *B.mori* with cobalt and nickel (Masui and Matsubara, 1983), copper sulphate (Magadum *et al.*, 1992), magnesium sulphate, ferrous sulphate and potassium sulphate (Nirwani and Kaliwal, 1995, 1996), nickel chloride (Hugar *et al.*, 1997), zinc chloride (Hugar and Kaliwal, 1999), and potassium permanganate (Bhattacharya and Kaliwal, 2003). The significant increase in the larval

Table 4. Effect of minerals mixture of nickel sulphate and potassium bromide on the larval parameters of the CSR_2 silkworm, *B. mori*

Treatment	Dose µg/ml	Larval weight (g)	Silkgland weight (g)	Larval duration (h)	Cocooning percentage (%)
Nickel sulphate + Potassium bromide	70	3.152*	1.324	623	89* 70.63**
		(120)	(113)	(98)	(107)
Nickel sulphate + Potassium bromide	110	3.206*	1.250	615	84 66.42**
		(122)	(107)	(97)	(101)
Nickel sulphate + Potassium bromide	160	3.002*	1.227	608	87 68.86**
		(114)	(105)	(96)	(104)
Carrier control	Distilled water	2.617	1.162	631	83 65.64**
		(100)	(100)	(100)	(100)
Normal control	-	2.904	1.226	628	82 64.89**
		(110)	(105)	(99)	(98)
		S	NS	NS	S
SEM ±		0.0808	0.055	11.321	1.485
C.D. at 5%		0.236	0.168	23.420	4.829

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

weight with minerals mixture of potassium bromide and nickel sulphate treated groups may be due to growth stimulating effect and increase in mid gut enzyme activity, since copper sulphate increases the mid gut enzyme activity in *L. decemlineata* (Izhevskiy, 1976). These results also indicated that the larval weight of CSR_4 race did not showed any response to the minerals compare to CSR_2 and $CSR_2 \times CSR_4$ crossbreed of the silkworm, *B. mori.*

Silkgland weight

There was significant increase in silkgland weight in CSR_4 treated with 110 µg/ml minerals mixture of potassium bromide and nickel sulphate and there was no significant change in CSR_2 and $CSR_2 \times CSR_4$ crossbreed when compared with that of carrier control. Similar results were found after supplementation the feed with potassium nitrate in the nistari race of the silkworm, *B. mori* (Dasmahapatra *et al.*, 1989) biosalt mixture of calcium, magnesium and natrum phosphates (Subburathianam and Sulochana Chetty, 1991) ferrous and magnesium sulphate (Nirwani and Kaliwal, 1995) nickel chloride (Hugar and Kaliwal, 1997) and potassium nitrate (Goudar and Kaliwal, 2000). Recently, it has been reported that supplementing the feed with potassium permanganate increased the silkgland weight (Bhattacharya and Kaliwal, 2003). The increased silkgland weight obtained in the present study might be due to the stimulatory effect of these mineral salts on the metabolic activity of the silkgland only in CSR_4 race of the silkworm, *B. mori.*

Larval duration

Larval duration was significantly decreased in CSR_4 and there was no change in larval duration in CSR_2 and $CSR_2 \times CSR_4$ crossbreed treated with minerals mixture of potassium bromide and nickel sulphate when compared with that of carrier control. It was also reported that the decrease in the larval duration after supplementation with potassium iodide to the silkworm, *B. mori* (Majumdar, 1982; Nirwani and Kaliwal, 1996; Goudar and Kaliwal, 2000). Recently, it has been reported that potassium permanganate had no effect on the larval duration (Bhattacharya and Kaliwal, 2003). However, it is not known the mechanism involved in decrease of the larval duration only in CSR_4 race of the silkworm, *B. mori.*

Table 5. Effect of minerals mixture of nickel sulphate and potassium bromide on the cocoon parameters of the CSR_2 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
Nickel sulphate + Potassium bromide	70	0.992*	0.198*	20.08* 26.62**	0.960	0.232	24.16* 29.44**	1093	0.320	2.674
		(80)	(62)	(75)	(101)	(115)	(113)	(98)	(100)	(98)
Nickel sulphate + Potassium bromide	110	1.526*	0.400*	26.352 30.85**	1.256*	0.300	23.86* 29.23**	1110	0.329*	2.811
		(123)	(125)	(99)	(133)	(149)	(111)	(100)	(103)	(103)
Nickel sulphate + Potassium bromide	160	1.473*	0.342	23.164 28.72**	1.280*	0.340*	26.60* 31.04**	845*	0.264*	2.598*
		(119)	(106)	(87)	(135)	(169)	(145)	(76)	(82)	(98)
Carrier control	Distilled water	1.234	0.320	26.666 31.04**	0.943	0.201	21.31 27.49**	1108	0.320	2.726
		(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Normal control	-	1.142	0.280	24.59 29.66**	0.900	0.181	20.11 26.64**	990	0.300	2.636
		(92)	(87)	(92)	(95)	(90)	(94)	(89)	(94)	(96)
		S	S	S	S	S	S	S	S	S
SEM ±		0.0274	0.0186	1.805	0.0081	0.0107	0.0224	6.2088	0.0045	0.0381
C.D. at 5%		0.096	0.0559	5.577	0.0297	0.1086	0.0622	29.3199	0.00844	0.1191

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

Table 6. Effect of minerals mixture of nickel sulphate and potassium bromide on the adult parameters of the CSR_2 silkworm, *B. mori*

Treatment	Dose µg/ml	Moth emergence percentage (%)	Fecundity (Nos.)	Hatching percentage (%)	No. of eggs per ovariole (Nos.)	Length of the ovariole (mm)
Nickel sulphate + Potassium bromide	70	76 60.66** (101)	584* (105)	90 71.56** (101)	89* (118)	133* (123)
Nickel sulphate + Potassium bromide	110	80* 63.43** (106)	601* (108)	88 69.73** (99)	75 (100)	104 (96)
Nickel sulphate + Potassium bromide	160	86* 68.02** (114)	652* (117)	86 68.02** (96)	78 (104)	108 (100)
Carrier control	Distilled water	75 60.00** (100)	556 (100)	89 70.63** (100)	75 (100)	108 (100)
Normal control	-	78 62.02** (104)	554 (99)	88 69.73** (99)	69 (92)	107 (99)
		S	S	NS	S	S
SEM ±		1.437	1.6318	1.4056	1.215	1.3822
C.D. at 5%		4.570	4.918	4.367	4.988	4.359

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

Survival percentage

The results of the present study showed significant increase in the survival percentage in all the races of the silkworm, treated with minerals when compared with that of the carrier control. Nirwani and Kaliwal (1996) have also reported that the supplementation with potassium sulphate significantly increased the survival percentage in the silkworm, *B. mori.* This may indicate that the used concentrations have stimulatory effect on survival percentage in all the three races of the silkworm, *B. mori.*

Filament length, weight and denier

There was significant increase in the filament length in CSR_4 treated with 160 µg/ml, denier in CSR_2 and CSR_4 in 110 µg/ml, filament length in $CSR_2 \times CSR_4$ crossbreed with 70 and 110 µg/ml minerals mixture of potassium bromide and nickel sulphate treated groups when compared with that of the carrier control. The increase in filament length and weight has been reported after supplementing the feed with zinc and nickel chloride in the silkworm, *B. mori* (Chamundeshwari and Radhakrishnaiah, 1994; Hugar and Kaliwal, 1997). The significant increase in the denier may be due to increased fineness of the silk filament. The increase in length of the filament may be due to stimulatory activity on silkgland by these minerals in all the three races of the silkworm, *B. mori.* Contrast to our findings it has been reported that there was a significant decrease in the filament length and weight with magnesium sulphate and potassium nitrate treated groups to the silkworm, *B. mori* (Goudar and Kaliwal, 2001).

Cocoon weight, cocoon shell weight and cocoon shell ratio

There was significant increase in cocoon weight, cocoon shell weight and cocoon shell ratio in CSR_4, CSR_2 and $CSR_2 \times CSR_4$ crossbreed races of the silkworm treated with minerals mixture of potassium bromide and nickel sulphate when compared with that of carrier control. The significant increase in cocoon weight and its shell weight is preceded by increase in silkgland weight of the silkworm, *B. mori.* Similar results have been reported with feeding of potassium iodide and potassium sulphate on *B. mori* (Majumdar, 1982; Chamundeswari and Radhakrishnaiah, 1994; Balamani *et al.*, 1995; Nirwani and Kaliwal,

Table 7. Effect of minerals mixture of nickel sulphate and potassium bromide on the larval parameters of the $CSR_2 \times CSR_4$ crossbreed silkworm, *B. mori*

Treatment	Dose µg/ml	Larval weight (g)	Silkgland weight (g)	Larval duration (h)	Cocooning percentage (%)
Nickel sulphate + Potassium bromide	70	3.37*	1.162	629	81 64.15**
		(118)	(103)	(98)	(102)
Nickel sulphate + Potassium bromide	110	3.20*	1.266	640	80 63.43**
		(112)	(112)	(100)	(101)
Nickel sulphate + Potassium bromide	160	3.00	1.112	645	85* 67.21**
		(105)	(99)	(101)	(107)
Carrier control	Distilled water	2.84	1.120	638	79 62.72**
		(100)	(100)	(100)	(100)
Normal control	-	2.56	1.09	635	78 62.02**
		(90)	(97)	(99)	(98)
		S	NS	NS	S
SEM ±		0.085	0.0442	10.320	1.468
C.D. at 5%		0.254	0.269	21.415	4.577

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

1995; Saha and Khan, 1996). Recently, it has been reported that supplementation with potassium permanganate was more effective in increasing cocoon weight and its shell weight (Bhattacharya and Kaliwal, 2003).

Moth emergence percentage

Moth emergence percentage in CSR_2 showed significant increase where as $CSR_2 \times CSR_4$ crossbreed showed significant decrease, but there was no change in CSR_2 race treated with minerals mixture of potassium bromide and nickel sulphate when compared with that of the carrier control. Similar results have been reported in increase in the moth emergence percentage in the bivoltine silkworm, *B. mori* after treating with potassium sulphate and zinc chloride (Nirwani and Kaliwal, 1995). In contrast to our results it has been reported that there was a significant decrease in the moth emergence percentage with magnesium sulphate and potassium nitrate treated groups of the silkworm, *B. mori* (Goudar and Kaliwal, 2001). This indicates that the concentrations of mineral mixtures of potassium bromide and nickel sulphate used in the present study on CSR_2 race did not have any lethal effect but in $CSR_2 \times CSR_4$ crossbreed showed lethal effect on the pupae and cocoon crop of the silkworm, *B. mori.*

Length of the ovariole and number of eggs per ovariole

There was significant increase in number of eggs per ovariole in CSR_2 in all the groups, in CSR_4 with 70 and 110 µg/ml, in $CSR_2 \times CSR_4$ crossbreed with 70 µg/ml treated group when compared with that of the carrier control. It was reported that there was a significant increase in the length of the ovariole and a significant decrease in the number of eggs per ovariole in the silkworm, *B. mori* treated with potassium nitrate and potassium permanganate (Goudar and Kaliwal, 2000; Bhattacharya and Kaliwal, 2003).

Fecundity

The fecundity significantly increased in CSR_4, CSR_2 and $CSR_2 \times CSR_4$ crossbreed treated with minerals mixture of potassium bromide and nickel sulphate treated groups when compared with that of the carrier control. Similar increase in fecundity was reported after supplementing the feed with potassium iodide in nistari race of the silkworm,

Table 8. Effect of minerals mixture of nickel sulphate and potassium bromide on the cocoon parameters of the $CSR_2 \times CSR_4$ crossbreed 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
Nickel sulphate + Potassium bromide	70	1.528*	0.338	22.104 28.04**	1.08	0.260*	31.02* 33.84**	1044*	0.344*	3.167
		(108)	(119)	(112)	(92)	(88)	(122)	(113)	(111)	(104)
Nickel sulphate + Potassium bromide	110	1.323*	0.300	31.488* 34.189**	1.25	0.300*	24.07* 29.33**	934*	0.300	3.132
		(93)	(106)	(159)	(107)	(102)	(95)	(101)	(97)	(103)
Nickel sulphate + Potassium bromide	160	0.612*	0.190*	22.730 28.47**	0.68*	0.211*	24.00* 29.33**	727*	0.256*	2.963
		(43)	(67)	(115)	(58)	(71)	(77)	(79)	(83)	(98)
Carrier control	Distilled water	1.418	0.283	19.720 26.36**	1.162	0.294	25.30 30.19**	916	0.308	3.025
		(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Normal control	-	1.161	0.234	19.828 26.44**	0.950	0.320	33.656 35.45**	712	0.248	2.890
		(82)	(82)	(101)	(82)	(108)	(133)	(78)	(80)	(95)
		S	S	S	S	S	S	S	S	NS
SEM ±		0.0112	0.0196	1.987	0.0374	0.0057	0.0204	2.232	0.0059	0.575
C.D. at 5%		0.0295	0.0685	7.113	0.1596	0.0156	0.0208	6.669	0.00865	0.1823

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

Table 9. Effect of minerals mixture of nickel sulphate and potassium bromide on the adult parameters of the $CSR_2 \times CSR_4$ crossbreed silkworm, *B. mori*

Treatment	Dose µg/ml	Moth emergence percentage (%)	Fecundity (Nos.)	Hatching percentage (%)	No. of eggs per ovariole (Nos.)	Length of the ovariole (mm)
Nickel sulphate + Potassium bromide	70	83* 65.64** (94)	680* (118)	93* 74.65** (104)	87* (126)	120 (103)
Nickel sulphate + Potassium bromide	110	80 63.43** (91)	590* (102)	88 69.73** (99)	86 (124)	118 (102)
Nickel sulphate + Potassium bromide	160	92 73.57** (104)	641* (111)	88 69.73** (98)	81 (117)	112 (96)
Carrier control	Distilled water	88 69.73** (100)	576 (100)	89 70.63** (100)	69 (100)	116 (100)
Normal control	-	84 66.42** (95)	566 (98)	85 67.21** (95)	58 (84)	104 (89)
		S	S	S	S	NS
SEM ±		1.335	2.354	1.0408	1.889	2.325
C.D. at 5%		4.023	8.560	3.133	10.380	8.060

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

B. mori (Majumdar, 1982), a pure Mysore breed (Magdum, 1987), with rainwater and minerals in *B.mori* (Thangavelu and Bania, 1990; Subburathinam and Chetty, 1991), ferrous and magnesium sulphate (Nirwani and Kaliwal, 1995) and zinc chloride (Hugar and Kaliwal, 2003). This indicates that the used concentrations of minerals have stimulating effect on the fecundity in all the three races of the silkworm, *B. mori.*

Hatching percentage

The results of the present study suggests that the dietary supplementation with minerals mixture of potassium bromide and nickel sulphate showed significant increase in hatching percentage only in $CSR_2 \times CSR_4$ crossbreed race with 70 µg/ml treated group. Recently, similar results have been obtained with the dietary supplementation of zinc chloride in the silkworm, *B. mori* (Hugar and Kaliwal, 2003). This indicates that the used concentrations had of minerals in crossbreed stimulatory effect than in CSR4 and CSR2 races on the egg hatching percentage. In conclusion, the results of the present study showed that the minerals mixture of potassium bromide and nickel sulphate increases the larval weight, silkgland weight, cocoons weight and their shell weight, filament length weight and denier and reproductive performance like eggs ovariole, fecundity and hatching percentage. Since, the minerals mixture of potassium bromide and nickel sulphate has stimulatory effect on silk yield and reproductive performance. The results also indicated that all the three races of the silkworm, *B. mori* showed good response to minerals mixture of potassium bromide and nickel sulphate.

Acknowledgement

The authors express their sincere thanks to Prof. R. D. Kanamadi Chairman, P. G., Department of studies in Zoology, Karnatak University, Dharwad for providing financial assistance and necessary facilities.

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