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Effect of Potassium Nitrate Supplementation on Economic Parameters of the Silkworm *Bombyx mori* L.

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The effect of supplementation with potassium nitrate on economic parameters was analysed following treatment of last larval stadium. The treated larvae showed a significant increase in larval weight at 500 μg/ml and silk gland weight in all the treated groups along with other enhanced larval, cocoon and adult parameters. The larval period was significantly decreased in all the treated groups with increased female and male cocoon weight, its shell weights filament lengths at 500 μg/ml. The denier was significantly decreased in all the groups. The filament weight moth emergence percentage, length of the ovariole were unaffected. However, eggs per ovariole, fecundity and hatching percentage significantly decreased compared with the corresponding parameters of the carrier control.

Key words : Silkworm, *Bombyx mori*, Potassium nitrate, Economic parameters

Introduction

The monophagous silkworm, *Bombyx mori,* takes almost all the nutrients required for its growth from the mulberry leaf. The nutritional status of the mulberry leaves can be improved by enriching them with extra nutrients which is now a major area of research in sericulture. An important aspect of nutrition in sericulture is to mulberry leaves with inorganic and organic supplements. Inorganic part of the food is composed of different minerals, and its balance in the diet plays an important role for successful development of insects (House, 1965). Japanese reares are regularly practicing indoor rearing of silk worm on artificial diets. The importance of mineral requirements of Japanese race of *B. mori* has been stressed, and quantitative decrease of potassium, calcium, magnesium and phosphorus in the diet was reported to result in decreased body weight (Iwanari, 1976). Fortification of mulberry leaves with mineral supplementation has been reported to play an important role in larval development and cocoon characters (Horie *et al.,* 1967; Ito and Niminura, 1966a, 1966b; Vishwanath and Krishnamurthy, 1982; Lokanath *et al.,* 1986).

It has been reported that in some adult insects, the requirement of salt is related to the reproductive function of female (Singh and Brown, 1957; Bracken, 1965). The Nistari race of *B. mori* fed the mulberry leaves treated with potassium nitrate and potassium iodide showed an increase in its larval weight, cocoon weight, shell weight, fecundity and reduction in the larval duration (Chakraborthi, 1977, 1978a). Similar results were obtained with low concentration of potassium iodide, but supplementation of high concentration of it decreased fecundity in the nistari race of *B. mori* (Majumdar, 1982). In addition dietary supplementation with potassium iodide, potassium sulphate and magnesium sulphate increased the economic parameters of the silk worm *B. mori* (Magdum, 1987, Padaki, 1991, Nirwani and Kaliwal, 1995). These results indicate that the economic parameters of the silk worm are affected by mulberry leaves supplemented with different salts.

It has been reported, that dietary supplementation of potassium nitrate showed an increase in body weight, silk gland weight, and protein, RNA and DNA contents in the silk gland of the Nistari race (Dasmahapatra *et al.,* 1989). But these studies did not explain the economic parameters like larval duration, cocooning percentage, cocoon weights, shell weights and its shell ratio, length, weight and denier of the filament, moth emergence, length of the ovariole, eggs per ovariole, fecundity and hatching percentage. Hence, the present investigation was undertaken to know the effect of potassium nitrate on economic param-

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eters of the multivoltine race (PM$\times$NB$_{18}$) of the domestic silkworm.

Materials and Methods

The disease free layings (DFLS) of multivoltine race (PM $\times$NB$_{18}$) of the silkworm were obtained from grainage centre Rayapur, Dharwad, Karnatak and reared in the laboratory by improved methods of silkworm rearing technique (Krishnaswami, 1978a, b). The larvae were maintained on fresh mulberry leaves (K$_2$). The fifth stadium larvae were divided into six experimental groups including controls, and every group consisted of uniformly weighed larvae in five replication each with 20 silkworms. The potassium nitrate was procured from M/s British Drug House (India) Limited. It was dissolved in small quantity of distilled water and diluted to 50, 100, 300 and 500 µg/ml by adding distilled water. The 5 ml of each potassium nitrate was uniformly sprayed per 20 g of fresh mulberry leaves and fed to the fifth instar silkworm alternatively with untreated and treated mulberry leaves : two feedings with treated leaves and the remaining two feedings with untreated leaves per day. The carrier controls were fed the leaves sprayed with distilled water and normal controls were fed untreated leaves.

The larval, cocoon and adult parameters were recorded separately. The larval and silk gland weights were recorded before commencement of the spinning activity. The larval duration was recorded from the day of hatching to the completion of the spinning activity. The cocoon parameters such as female and male cocoon weights and their shell weights were recorded on the 5th day after the completion of spinning activity and filament length was recorded with epprovette by reeling 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 adult parameters such as moth emergence percentage, length of the ovariole, eggs per ovariole, fecundity and hatching percentage were recorded after the moth emergence. The cocooning, moth emergence and hatching percentage were calculated by the formulas shown in the tables. Each mean values, a record of ten observation is shown in Tables 1, 2 and 3.

The data collected were subjected to analysis of variance test to find out the significance between the parameters of treated and control groups (Raghawa Rao, 1983). The percent values of cocoon shell ratio, cocooning percentage, moth emergence percentage and hatching percentage were transformed to sine angular values for statistical analysis. The percent index was calculated for each parameters of the experimental groups over those of the corresponding parameters of the carrier control.

Results and Discussion

Larval weight

The result of the present study has shown that the larval weight was significantly increased at the dose of 500 µg/ml potassium nitrate compared with the corresponding parameters of the carrier control (Table 1). Similar results were obtained in *B. mori* treated with potassium nitrate (Dasmahapatra *et al.,* 1989). The increase in the larval weight, which may be due to the increase in the midgut enzyme activity, since copper sulphate increases the midgut enzyme activity in *Leptinotrasa. decemlineata* (Izhevskiy, 1976).

Silkgland weight

The present results show a significant increase in the silk gland weight in all the treated groups when compared with the corresponding parameters of the carrier controls. The maximum increase (18%) was observed at the dose of 500 µg/ml of potassium nitrate (Table 1). Similar results were obtained in *B. mori* treated with potassium nitrate (Dasmahapatra *et al.,* 1989).

Larval duration

The present study indicate a significant decrease in the larval duration in all the groups by the treatment of potassium nitrate when compared with the corresponding parameters of the carrier controls (Table 1). Similar results were obtained in *B. mori* fed on different mineral salts such as potassium iodide and potassium sulphate (Chakraborthi and Medda, 1978b; Majumdar, 1982; Nirwani and Kaliwal, 1996). However, it is not known why the larval duration decreased.

Cocooning percentage

Feeding with all the doses of potassium nitrate had no effect on the cocooning percentage when compared with the corresponding parameters of the carrier control (Table 1). This may indicate that the used concentrations have not adversely affected the cocooning percentage.

Cocoon weights and its shell weights

The weight of female and male cocoons increased significantly in all the treated groups with percent increase of 27 and 29 at 500 µg/ml, respectively. The shell weights of the females and males increased significantly in all the groups with percent increase of 17 and 29 at 500 µg/ml, respectively, when compared with the corresponding parameters of the carrier control (Table 2). The significant increase in female and male cocoon weight and its shell

Table 1. Effect of potassium nitrate on larval parameters of silkworm, *B. mori*

Treatment	Dose μg/ml	Larval weight (g)	Silk gland weight (g)	Larval duration (hr)	Cocooning percentage (%)
KNo_3	50	2.642	0.680*	672.6*	95.25 (77.34)**
		(102)	(110)	(98)	(99)
KNo_3	100	2.708	0.694*	672.8*	95.25 (77.34)**
		(104)	(112)	(98)	(99)
KNo_3	300	2.702	0.706*	675.0*	95.75 (78.03)**
		(104)	(114)	(98)	(99)
KNo_3	500	2.770*	0.732*	675.2*	96.00 (78.46)**
		(107)	(118)	(98)	(100)
Carrier Control	Distilled Water	2.586	0.618	684.4	96.00 (78.46)**
		(100)	(100)	(100)	(100)
Normal Control		2.604	0.624	684.4	97.50 (80.90)**
		(100)	(100)	(100)	(101)
		(S)	(S)	(S)	(NS)
S.Em ±		0.090	0.026	1.180	0.652
CD at 5%		0.177	0.052	2.419	1.351

* -Significant increase/decrease at 5%
** -Angular transformed values
S.Em ± -Standard error mean
CD -Critical difference
NS -Non Significant
S -Significant
Percentage increase/decrease over that of the carrier controls in parenthesis.

$$\text{Cocooning percentage} = \frac{\text{No. of cocoon formed}}{\text{Total No. of larvae kept}} \times 100$$

weight is preceded by increase in silk gland weight. Similar results have been reported with feeding of potassium iodide and potassium sulphate on *B. mori* (Majumdar, 1982; Nirwani and Kaliwal, 1995).

Silk filament length, weight and denier

There was significant increase in the filament length at 500 μg/ml treated group. However, the denier was significantly decreased in all the treated groups when compared with the corresponding parameters of the carrier control (Table 2).

Moth emergence percentage

There was no significant change in the moth emergence percentage in all the treated groups when compared with the corresponding parameters of the carrier control (Table 3). This indicate that these concentration range of potassium nitrate has no toxic effect on the cocoon crop.

Length of the ovariole and eggs per ovariole

There was no significant change in the length of the ovariole in all the treated groups. However, eggs per ovariole showed significant decrease in all the treated groups when compared with the corresponding parameters of the carrier control (Table 3). This indicate that these concentration range of potassium nitrate has toxic effect on the silkworm ovary.

Fecundity

There was a significant decrease in the fecundity in the groups treated with 300 and 500 μg/ml of potassium nitrate when compared with the corresponding parameters of the carrier controls (Table 3). However, it has been reported that supplementation of potassium nitrate and

Table 2. Effect of potassium nitrate on cocoon parameters of the silkworm, *B. mori*

Treatment	Dose µg/ml	Female			Male			Felament Length (mts)	Filament Weight (g)	Denier
		Cocoon Weight (g)	Cocoon Shell weight (g)	Cocoon Shell ratio (%)	Cocoon Weight (g)	Cocoon Shell weight (g)	Cocoon Shell ratio (%)			
KNo$_3$	50	1.400*	0.210*	15.23 (22.95)**	1.296*	0.213*	16.45 (23.89)**	633.58	0.193	2.800*
		(117)	(109)	(94)	(112)	(109)	(97)	(105)	(101)	(91)
KNo$_3$	100	1.408*	0.215*	15.52 (23.19)**	1.314*	0.214*	16.82 (24.20)**	649.74	0.193	2.656*
		(118)	(111)	(96)	(114)	(110)	(100)	(108)	(101)	(86)
KNo$_3$	300	1.438*	0.216*	15.12 (22.87)**	1.372	0.222*	16.23 (23.73)**	700.00	0.200	2.326*
		(120)	(112)	(93)	(119)	(115)	(96)	(117)	(105)	(75)
KNo$_3$	500	1.517*	0.225*	14.90* (22.71)**	1.482*	0.250*	16.89 (24.20)**	723.66*	0.206	2.572*
		(127)	(117)	(92)	(129)	(129)	(100)	(120)	(108)	(83)
Carrier control	Acetone	1.193	0.192	16.13 (23.66)**	1.148	0.193	16.80 (24.20)**	598.29	0.190	3.073
		(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Normal Control	-	1.380*	0.208	15.62 (23.26)	1.191	0.188	15.85 (23.42)**	600.58	0.173	2.159*
		(115)	(108)	(96)	(103)	(97)	(94)	(100)	(91)	(70)
		S	S	NS	S	S	NS	S	NS	S
S.Em±		0.083	0.009	0.7532	0.075	0.010	0.659	52.143	0.015	0.072
C.D.at 5%		0.163	0.017	1.477	0.147	0.020	1.293	110.023	0.032	0.161

* - Significant increase/decrease at 5%
** -Angular transfer values
S.Em± -Standard error mean
CD -Critical difference
NS -Non significant
S -Significant
Percentage increase/decrease over that of the carrier controls in paranthesis

$$\text{Female/male cocooning shell ratio} = \frac{\text{Cocoon shell weight (g)}}{\text{Cocoon weight (g)}} \times 100$$

$$\text{Denier} = \frac{\text{Single cocoon shell weight (g)}}{\text{Single cocoon filament length (mt)}} \times 100$$

potassium sulphate to silkworm, *B. mori,* increased the fecundity (Chakraborthi and Medda, 1977; Nirwani and Kaliwal, 1995). Hence, further investigation is essential in this regard.

Egg hatching percentage

The results suggest that the egg hatching percentage significantly decreased in all the treated groups except for the group treated with 50 µg/ml of potassium nitrate when compared with that of the carrier control (Table 3). This indicates that these concentration of potassium nitrate has toxic effect on the silkworm embryo.

Insects, like vertebrate, require a variety of minerals, for certainly mineral elements cannot be biosynthesized. So complex salt mixtures are essential components always included in insect diets. Insects probably require almost all the elements required by vertebrates. In fact, potassium nitrate and potassium iodide have been shown to increase economic parameters of the silkworm, *B. mori* (Chakraborthi and Medda, 1977, 1978a; Majumdar, 1982; Dasmahapatra *et al.,* 1989), since the physiological processes and economic parameters are dependent on the dose, way of administration, duration of treatment and race of the insects. The precise mechanism of action of exogenous supplementation of minerals in insects is still abscare.

In conclusion, the results of the present study show that the potassium nitrate enhances the silk yield such as silk gland weight, female and male cocoon weights and its shell weights. However, potassium nitrate has toxic effect on the reproductive performance like eggs per ovariole, fecundity and hatching percentage. Additional studies using other races of silkworm and a variety of exercise paradigms will be necessary to determine the physiological significance and generalization of the present results.

Table 3. Effect of potassium nitrate on adult parameters of the silkworm, *B. mori*

Treatment	Dose μg/ml	Moth emergence percentage (%)	Length of the ovariole (mm)	Eggs per ovariole (No)	Fecundity (No)	Egg hatching Percentage (%)
KNo_3	50	97.75 (81.28)**	134.00	83.5*	674.0	89.8 (71.37)**
		(99)	(97)	(95)	(98)	(99)
KNo_3	100	97.75 (81.28)**	134.3	82.3*	680.0	87.0* (68.87)**
		(99)	(97)	(94)	(98)	(96)
KNo_3	300	97.75 (81.28)**	132.8	79.8*	670.6*	85.0* (67.21)**
		(99)	(96)	(91)	(97)	(94)
KNo_3	500	97.00 (80.02)**	133.1	80.1*	657.6*	84.8* (67.05)**
		(98)	(97)	(91)	(95)	(94)
Carrier Control	Distilled Water	98.50 (82.96)**	137.2	87.2	687.0	90.0 (71.56)**
		(100)	(100)	(100)	(100)	(100)
Normal Control		98.50 (82.96)**	141.2	89.2*	705.8*	90.2 (71.76)**
		(100)	(102)	(102)	(102)	(100)
		(NS)	(NS)	(S)	(S)	(S)
S.Em ±		0.571	2.112	0.835	5.436	0.871
CD at 5%		1.182	4.140	1.636	11.145	1.745

* -Significant increase/decrease at 5%
** - ngular transformed values
S.Em ± -Standard error mean
CD -Critical difference
NS -Non Significant
S -Significant
Percentage increase/decrease over that of the carrier controls in parenthesis.

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

$$\text{Hatching percentage} = \frac{\text{Total No. of eggs hatched}}{\text{Total No. of eggs laid}} \times 100$$

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References

Bracken, G. K. (1965) Effects of dietary components of fecundity of the parastioid *Exerists comstockii* (Hymenoptera: Ichnecmonidae). *Can. Entomol.* **97**, 1037-1041.

Chakraborthi, M. K. and A. K. Medda (1977) Effect of calcium and potassium nitrate feeding on silkworm (*B. mori* L.). *Ind. J. Physiol. Appl. Sci.* **31(3)**, 98-105.

Chakraborthi, M. K. and A. K Medda (1978a) Effect of potassium iodide on silkworm (*B. mori* L.) Nistari race. *Sci. & Cult.* **44**, 231-233.

Chakraborthi, M. K. and A. K. Medda (1978b) Effect of cobalt chloride on silkworm (*B. mori* L.) Nistari race. *Sci. & Cult.* **44**, 406-408.

Dasmahapatra A. K., M. K. Chakraborthi and A. K. Medda (1989) Effect of potassium iodide, cobalt chloride, calcium chloride and potassium nitrate on protein, RNA and DNA content of silk gland of silkworm (*B. mori* L.) Nistari race. *Sericologia* **29(3)**, 355 - 359.

House, H. L. (1965) Insect nutrition digestion. in *The physiology of insecta 2.* M. Rockstein (ed.), pp. 769-858, Academic Press, New York.

Horie, Y., K. Watanabe and T. Ito (1967) Nutrition of silkworm *B. mori* XVIII. Quantitative requirements for potassium phosphorus, magnessium and zinc. *Bull. Sericul. Expt. Sta.* **22 (2)**, 181-193.

Ito, T. and M. Niminura (1966a) Nutrition of silkworm *B. mori.* Its specific requirements and its nutrition in relation the mineral nutrition of its host plant mulberry, *Morus indica* L. *Indian J. Exptl. Biol.* **4**, 31-36.

Ito, T. and M. Niminura (1966b) Nutrition of silkworm *B. mori.* XII Nutritive effects of minerals. *Bull. Sericul. Expt. Sta.* **20**, 373.

Iwananari, Y (1976) Bull Farms, Tokyo Univ, *Agr. Tech,* **7**, 62.

Izhevskiy, S. S. (1976) The physiological effects of mineral salts on *Leptinotrsa decemlineata* (Coleoptera: Chrysomelidae). *Ecologia* **4**, 90-92.

Krishnaswami, S. (1978a) New technology of silkworm rearing, Bulletin No.2, CSRTI, Mysore, 3-24.

Krishnaswami, S. (1978b) Improved method of rearing young age (Chawki) silkworms. Bulletin No.3, CSRTI, Mysore, 1-27.

Lokanath, R., K. Shivashankar and K. Kasivishwanathan (1986) Effect of foliar application of magnesium and micronutrients to mulberry on quality and production of cocoons. *Indian J. Seric.* **25**, 40-41.

Majumdar A. C. (1982) Note on the physiological effects on the growth and reproduction of silkworm fed on mulberry leaves soaked in potassium iodide. *Indian J. Agri. Sci.* **52**, 250-252.

Magadum, S. B. (1987) Studies on the effect of some chemicals and hormones on the gonad and the life cycle of the silkworm, *B. mori* L. Ph.D. Thesis, Karnatak University, pp. 1-30, Dharwad, India.

Nirwani, R. B. and B. B. Kaliwal (1995) Effect of ferrous and magnesium sulphate supplementation on some commercial characters of *B. mori* L. *Bull. Seric. Res.* **6**, 21-28.

Padaki, P. R. (1991) Some aspects of physiology of the eri silkworm *Philosamia ricini*, Ph.D. Thesis, Karnatak University, pp. 48-161, Dharwad, India.

Raghawa Rao, D. (1983) Statistical Techniques in Agricultural and Biological Research, Oxford and IBH Publishing Co., New Delhi.

Singh, K. R. P. and A. W. A. Brown (1957) Nutritional requirements of *Aedes aegypti* L. *J. Insect. Physiol.* **1**, 199-220.

Vishwanath, A. P. and K. Krishnamurthy (1982) Effect of foliar spray of micronutrients on the larval developments and cocoon characters of the silk worm B. mori L. *Indian J. Seric.* **2**, 26.