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Performance of Silkworm, *Bombyx mori* L. (FC1 X FC2) Reared on Mulberry Raised with Foliar Applied Different Volumes of Nano Nitrogen

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ABSTRACT

An experiment was carried out at Department of Sericulture, UAS, GKVK, Bengaluru to know the effect of foliar application of different volumes of nano nitrogen on growth and yield of mulberry and its subsequent effect on silkworm *Bombyx mori* L. (FC1 X FC2).The study resulted in significant improvement in silkworm (FC1 x FC2), when fed with mulberry leaves raised with different volumes of nano nitrogen fertilizer. Significantly shorter fifth instar larval duration (8.67 days), higher fifth instar larval weight (36.65 g/10 larvae) and better ERR (100 %) were observed from the silkworm batches fed with leaves harvested from mulberry plants raised with foliar application of 0.4% nano nitrogen fertilizer @ 225 ltr per acre on 25th day after pruning + 50% soil application of N, which was on par with silkworm batches fed with leaves harvested from mulberry plants raised with foliar application of 0.4% nano nitrogen fertilizer @ 200 ltr per acre on 25th day after pruning + 50% soil application of N showing shorter fifth instar larval duration (8.67 days), higher fifth instar larval weight (36.07 g/10 larvae) and better ERR (100 %). The cocoon parameters of silkworm (FC1 x FC2) viz., cocoon yield by weight (22.62 kg /10,000 worms), cocoon yield by number (10,000 / 10,000 worms), cocoon weight (2.26 g), cocoon shell weight (0.50 g), pupal weight (1.77 g), cocoon shell ratio (21.90 %) and reeling parameters viz., average filament length (1280.46 m) and non-breakable filament length (1251.01 m) were significantly superior in the silkworm groups fed with leaves harvested from mulberry plants raised with foliar application of 0.4% nano nitrogen fertilizer @ 225 ltr per acre on 25th day after pruning + 50% soil application of N, which was on par with the silkworm batches fed with leaves harvested from mulberry plants raised with foliar application of 0.4% nano nitrogen fertilizer @ 200 ltr per acre on 25th day after pruning + 50% soil application of N showing cocoon yield by weight (22.50 kg /10,000 worms), cocoon yield by number (10,000 / 10,000 worms), cocoon weight (2.25 g), cocoon shell weight (0.48 g), pupal weight (1.77 g), cocoon shell ratio (21.45 %) and reeling parameters viz., average filament length (1232.10

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m) and non-breakable filament length (1197.60 m).

Keywords Nano nitrogen, Mulberry, *B. mori*, Cocoon, Reeling parameters.

INTRODUCTION

The mulberry silkworm, *Bombyx mori* L. economically important insect, its economic significance is attributed to its silk secreting ability. The successful harvest of quality cocoons depends exclusively on the nutrition of the silkworm. Mulberry leaves serve as ideal food and provide various nutrients to carry out the physiological activities in *B. mori* L. Nutrition of silkworm is the sole factor which almost individually augments the quality and quantity of cocoon production (Kamala and Karthikeyan 2019).

Nutrition should include the essential trace elements for insect growth viz., iron, nickel, copper, manganese, potassium, zinc and iodine. Generally, vitamins present in the mulberry leaves fulfill the minimum needs of silkworms but the amount of vitamins present in mulberry leaves diverges on the basis of environmental conditions, usage of fertilizers in field and mulberry varieties and other field practices.

Enrichment of the mulberry leaves is one of the strategies by which cocoon and silk productivity can be increased and the quality can be enhanced. Feeding of nutritionally enriched leaves i.e., with ascorbic acid, folic acids, elements like Selenium and metal nanoparticles have showed better growth and development of silkworms as well as improve the economic value of cocoons. At recent, nanotechnology is being extensively used in modern agriculture to support precision agriculture with nano-particles (Duhan *et al*. 2017). Nano-particles are smaller in size, ranges from 1-100 nm and they have larger surface area, because of this unique property nano-particles might penetrate more effectively and efficiently when applied through foliar spray compared to chemical nutrients, so foliar application of these nano-nutrients can result in rapid absorption of nutrients by the plants (Qureshi *et al.* 2018).

Patil *et al.* (2016) concluded that, the larval traits of mulberry silkworm were superior when silkworms were fed with nanoparticles treated mulberry leaves. Some researchers showed that nano-fertilizer released nutrients up to 1200 hr while conventional fertilizer could support only for less than 500 hr (Selva Preetha and Balakrishnan 2017). Pooja *et al.* (2022) studied the efficacy of nano nitrogen foliar application to mulberry on larval parameters of silkworm, *Bombyx mori* L. (FC1 x FC2). Significantly shorter larval duration (4.73, 8.69 and 24.42 days for fourth instar, fifth instar and total larval durations, respectively), maximum fifth instar larval weight (36.66 g /10 larvae) and better ERR (97.78 %) were noticed in silkworms fed with leaves of mulberry with foliar application of 0.4% nano nitrogen fertilizer on 25th day after pruning. Also they formed significantly maximum cocoon yield by weight (26.36 kg / 10,000 worms), cocoon yield by number (9777 / 10,000 worms), single cocoon weight (2.69 g), single cocoon shell weight (0.63 g) and cocoon shell ratio (23.28 %) were noticed in the silkworms fed with leaves of mulberry plants with foliar application of 0.4% nano nitrogen fertilizer.

Keeping in view of the above aspects and importance of nano-fertilizers, the present work was planned to study the standardization of different volumes of foliar spray nano nitrogen fertilizer to mulberry and its subsequent effect on silkworm, *Bombyx mori* L. (FC1x FC2).

MATERIALS AND METHODS

The experiment was laid out in a well established V-1 mulberry garden at Department of Sericulture, College of Agriculture, UAS, Bengaluru following Randomized Complete Block Design (RCBD) with 10 treatments and each replicated thrice. The commercial bivoltine double hybrid silkworms (FC1 x FC2) were used for study.

Before the commencement of silkworm rearing, the appliances were sun dried and rearing room, rearing trays and other appliances were thoroughly cleaned and washed using two per cent bleaching powder solution. Then entire rearing room was disinfected by following standard procedures (Dandin and Giridhar 2014). The larvae were provided with chopped mulberry leaves of required quantity and

quality. After second moult, silkworms were separated and 50 silkworms were maintained in experimental tray for each replication. In order to assess the efficacy of different volumes of nano nitrogen foliar application to mulberry on larval traits of silkworm, the silkworm rearing was carried out and fed with mulberry leaves as per the following treatment details.

Treatment details

T_1 : Foliar application of 0.4 % nano N at 150 ltr per acre+50 % N soil application.

T_2 : Foliar application of 0.4 % nano N at 175 ltr per acre+50 % N soil application.

T_3 : Foliar application of 0.4 % nano N at 200 ltr per acre+50 % N soil application.

T_4 : Foliar application of 0.4 % nano N at 225 ltr per acre+50 % N soil application.

T_5 : Foliar application of 2 % urea at 150 ltr per acre+50 % N soil application.

T_6 : Foliar application of 2 % urea at 175 ltr per acre+50 % N soil application.

T_7 : Foliar application of 2 % urea at 200 ltr per acre+ 50 % N soil application.

T_8 : Foliar application of 2 % urea at 225 ltr per acre+50 % N soil application.

T_9 : Control (Recommended PoP).

T_{10} : Absolute control.

Note: The above-mentioned treatments were given on 25th day after pruning and 100% P and K +Farm yard manure were applied commonly through soil application for all the treatments except absolute control.

PoP: Package of Practice

Silk worm parameters: Observations such as fourth instar larval duration (days), fifth instar larval duration (days), fifth instar larval weight (g / 10 larvae), effective rearing rate (ERR) (%), cocoon yield by weight (kg / 10,000 worms), cocoon yield by number (No. / 10,000 worms), cocoon weight (g), cocoon shell weight (g), cocoon shell ratio (%), pupal weight (g), average filament length (m) and non breakable filament length (m) were recorded. The data recorded on various parameters were subjected to fisher's method of Analysis of Variance (ANOVA) and interpreted according to Sundararaj *et al.* (1972). The level of significance used in F and t-tests was P = 0.05 for RCBD. The critical difference (CD) values were computed where the F test was found significant.

RESULTS AND DISCUSSION

Larval duration (days)

There was no significant difference in fourth instar larval duration due to foliar application of different volume of nano nitrogen on mulberry. However, the shortest fourth instar duration of 4.72 days was recorded in treatments T_4, T_3, T_2 and T_1 followed by T_5, T_6, T_7, T_8, T_9 and T_{10}(4.73 days). The application of different volume of nano nitrogen foliar spray on mulberry altered the fifth instar larval duration significantly. The shortest fifth instar larval duration of 8.67 days was recorded in batches of silkworm fed on leaves harvested from 0.4% nano N @ 225 ltr per acre which was on par with 0.4% nano N @ 200 ltr per acre 8.67 days followed by 0.4% nano N @ 175 ltr per acre (8.68 days). The silkworms reared on mulberry leaves of absolute control resulted in longest fifth instar larval duration (8.74 days) (Table 1).

Fifth instar larval weight (g /10 larvae)

There was significant difference among the treatments with respect to larval weight due to foliar application of different volumes of nano nitrogen on mulberry. The grown-up larval weight was recorded on fifth day of fifth instar. Significantly maximum larval weight (36.65 g per 10 larvae) was recorded when silkworms were fed with mulberry leaves treated with 0.4% nano N @ 225 ltr per acre which was on par with 0.4% nano N @ 200 ltr per acre (36.07 g per 10 larvae) followed by T_2 (35.66 g per 10 larvae). Significantly, minimum larval weight was recorded in batches of silkworm fed on leaves from absolute control (28.37 g per 10 larvae) (Table 1).

Table 1. Performance larval traits of silkworm, *Bombyx mori* L. (FC1 x FC2) reared on mulberry with foliar applied different volumes of nano nitrogen.

Treatments	Larval duration (days)		Larval weight	ERR
	Fourth instar	Fifth instar	(g/10 larvae)	(%)
T_1 : Foliar application of 0.4 % nano N at 150 ltr per acre	4.72	8.69	35.30	100.00
T_2 : Foliar application of 0.4 % nano N at 175ltr per acre	4.72	8.68	35.66	100.00
T_3 : Foliar application of 0.4 % nano N at 200 ltr per acre	4.72	8.67	36.07	100.00
T_4 : Foliar application of 0.4 % nano N at 225 ltr per acre	4.72	8.67	36.65	100.00
T_5 : Foliar application of 2 % urea at 150 ltr per acre	4.73	8.72	32.18	100.00
T_6 : Foliar application of 2 % urea at 175 ltr per acre	4.73	8.72	32.28	99.89
T_7 : Foliar application of 2 % urea at 200 ltr per acre	4.73	8.71	33.89	100.00
T_8 : Foliar application of 2 % urea at 225 ltr per acre	4.73	8.69	34.92	100.00
T_9 : Control (Recommended PoP)	4.73	8.73	31.95	100.00
T_{10} : Absolute control	4.73	8.74	28.37	99.67
F-test	NS	*	*	NS
SEm±	-	0.003	0.586	-
CD@ 5%		0.010	1.742	
CV	3.13	5.12	4.89	2.42

*Significant at 5%, NS- Non significant, PoP: Package of Practice.

Table 2. Performance on cocoon yield of silkworm, *Bombyx mori* L. (FC1 x FC2) reared on mulberry with foliar applied different volumes of nano nitrogen.

Treatments	Cocoon yield (No./ 10,000 worms)	Cocoon yield (kg/10,000 cocoons)
T_1 : Foliar application of 0.4 % nano N at 150 ltr per acre	10000.00	21.68
T_2 : Foliar application of 0.4 % nano N at 175 ltr per acre	10000.00	21.97
T_3 : Foliar application of 0.4 % nano N at 200 ltr per acre	10000.00	22.50
T_4 :Foliar application of 0.4 % nano N at 225 ltr per acre	10000.00	22.62
T_5 : Foliar application of 2 % urea at 150 ltr per acre	10000.00	20.08
T_6 : Foliar application of 2 % urea at 175 ltr per acre	9988.89	20.48
T_7 : Foliar application of 2 % urea at 200 ltr per acre	10000.00	20.88
T_8 : Foliar application of 2 % urea at 225 ltr per acre	10000.00	21.28
T_9 : Control (Recommended PoP)	10000.00	19.70
T_{10} : Absolute control	9966.67	15.78
F-test	NS	*
SEm±	-	0.17
CD@ 5%	-	0.504
CV	3.42	5.12

*Significant at 5%, NS- Non significant, PoP: Package of Practice.

Effective rate of rearing (ERR) (%)

There was non-significant difference among the treatments with respect to ERR due to foliar application of different volumes of nano nitrogen on mulberry (Table 1). Mulberry silkworms being reared completely as domestic insect, besides other factors, feeding the quality leaves is important for growth of silkworm and production of silk. The nutritive feed especially with nitrogen would act as a stimulant for rapid growth of silkworms. Silkworm groups which were reared on mulberry leaves sprayed with different volumes of nano nitrogen fertilizer showed significantly improved rearing parameters. Mulberry leaves that have been sprayed with nano nitrogen fertilizer have considerably enhanced leaf nutrient content, crude protein, carbohydrate and crude fiber content further resulting in better growth of silkworm.

Cocoon yield by number (No. /10,000 worms)

No significant differences in the cocoon yield by number of FC1 × FC2 hybrid was evident with mulberry leaves raised through foliar application of different volumes of nano nitrogen (Table 2).

Cocoon yield by weight (kg / 10,000 worms)

Significant influence was exerted on cocoon weight by feeding silk worms on mulberry leaves obtained through foliar application of different volumes of nano nitrogen. The maximum cocoon yield by weight

Table 3. Performance on cocoon parameters of silkworm, *Bombyx mori* L. (FC 1 x FC 2) reared on mulberry with foliar applied different volumes of nano nitrogen.

Treatments	Cocoon weight (g)	Cocoon shell weight (g)	Cocoon shell ratio (%)	Pupal weight (g)
T_1 : Foliar application of 0.4 % nano N at 150 ltr per acre	2.17	0.44	20.23	1.73
T_2 : Foliar application of 0.4 % nano N at 175 ltr per acre	2.20	0.46	21.27	1.73
T_3 : Foliar application of 0.4 % nano N at 200 ltr per acre	2.25	0.48	21.45	1.77
T_4 : Foliar application of 0.4 % nano N at 225 ltr per acre	2.26	0.50	21.90	1.77
T_5 : Foliar application of 2 % urea at 150 ltr per acre	2.01	0.36	17.90	1.65
T_6 : Foliar application of 2 % urea at 175 ltr per acre	2.05	0.38	18.53	1.67
T_7 : Foliar application of 2 % urea at 200 ltr per acre	2.09	0.40	19.14	1.69
T_8 : Foliar application of 2 % urea at 225 ltr per acre	2.13	0.42	19.72	1.71
T_9 : Control (Recommended PoP)	1.97	0.35	17.74	1.62
T_{10} : Absolute control	1.58	0.28	15.83	1.30
F-test	*	*	*	*
SEm±	0.003	0.005	0.190	0.001
CD@ 5%	0.01	0.014	0.563	0.003
CV	5.34	3.98	1.95	5.13

*Significant at 5 %, PoP: Package of Practice.

(22.62 kg per 10000 cocoons) was recorded from 0.4% nano N @ 225 ltr per acre which was on par with 0.4% nano N @ 200 ltr per acre (22.50 kg per 10000 cocoons) followed by 0.4% nano N @ 175 ltr per acre (21.97 kg per 10000 cocoons). Whereas, minimum cocoon weight (15.78 kg per 10000 cocoon) was recorded in absolute control (Table 2).

Cocoon weight (g)

Significant influence was exerted on single cocoon weight when silkworms were reared on mulberry leaves treated with foliar application of different volume of nano nitrogen. Among different treatments, significantly highest cocoon weight was recorded in the cocoons harvested from T_4 (2.26g) which was on par with T_3 (2.25 g) followed by T_2 (2.20 g)and T_1 (2.17g). Significantly lowest cocoon weight was observed in cocoons harvested from absolute control (1.58 g) (Table 3).

Shell weight (g)

Significantly maximum cocoon shell weight was recorded for the cocoons spun by double hybrid silkworm FC1 × FC2 (0.50 g) in batches of cocoons harvested from treatment T_4 which was on par with T_3 (0.48 g) followed by T_2 (0.46). While, the minimum shell weight (0.28 g) was obtained in batches of cocoons harvested from the absolute control T_{10} (Table 3).

Cocoon shell ratio (%)

Significant difference in cocoon shell ratio of FC1 × FC2 double hybrid was evident with mulberry leaves raised through foliar application of different volumes of nano nitrogen. Significantly higher cocoon shell ratio (21.90 %) was recorded in the cocoons harvested from batches of silkworm fed on leaves obtained by the application of 0.4% nano N @ 225 ltr per acre which was on par with 0.4% nano N @ 200 ltr per acre 21.45% followed by T_2 (21.27 %). The per cent cocoon shell ratio was least in batches of cocoons obtained from the absolute control treatment (15.83 %) (Table 3).

Pupal weight (g)

Significantly higher single pupal weight was recorded for the cocoons spun by double hybrid silkworm FC1 × FC2 (1.77 g) in batches of cocoons harvested from treatment T_4 which was on par with T_3 (1.77) followed by T_2 (1.73) and T_1 (1.73). While, the minimum pupal weight (1.30 g) was obtained in batches of cocoons harvested from the absolute control (Table 3).

Cocoon parameters of silkworm fed with leaves from mulberry plants sprayed with different volumes of nano nitrogen fertilizer differed significantly. The better larval growth and development with qualitatively enriched leaves of mulberry also resulted in larvae spinning good quality cocoons exerted good cocoon weight, cocoon shell weight, pupal weight and cocoon shell ratio.

Table 4. Performance on reeling parameters of silkworm, *Bombyx mori* L. (FC1 x FC2) reared on mulberry with foliar applied different volumes of nano nitrogen.

Treatments	Average filament length (m)	Non- breakable filament length (m)
T_1: Foliar application of 0.4 % nano N at 150 ltr per acre	1125.87	1066.73
T_2: Foliar application of 0.4 % nano N at 175 ltr per acre	1162.02	1095.58
T_3: Foliar application of 0.4 % nano N at 200 ltr per acre	1232.10	1197.60
T_4: Foliar application of 0.4 % nano N at 225 ltr per acre	1280.46	1251.01
T_5: Foliar application of 2 % urea at 150 ltr per acre	1086.19	932.85
T_6: Foliar application of 2 % urea at 175 ltr per acre	1100.16	938.65
T_7: Foliar application of 2 % urea at 200 ltr per acre	1132.48	1105.94
T_8: Foliar application of 2 % urea at 225 ltr per acre	1147.16	1118.71
T_9: Control (Recommended PoP)	1071.08	1060.67
T_{10}: Absolute control	908.43	659.95
F-test	*	*
SEm±	24.967	18.103
CD @ 5%	74.181	53.786
CV	3.09	4.12

*Significant at 5 %, PoP: Package of Practice.

Nano particles improved the feeding efficacy of silkworms, also might have stimulated the metabolic activity in silkworms leading to the improved cocoon quality. Prabu *et al.* (2011) and Patil *et al.* (2016) reported that silkworms fed with mulberry leaves sprayed with nano-particles showed significantly highest cocoon weight. Pramila *et al.* (2019) nano micronutrients might have stimulated the metabolic activities in silkworm resulting in better growth and development, resulting in production of good quality cocoon.

Average filament length (m)

There was a significant difference among the treatments with respect to filament length with the foliar application of different volume of nano nitrogen to mulberry. Significantly longest filament length (1280.46 m) was recorded in the cocoons harvested from 0.4% nano N @ 225 ltr per acre which was on par with T_3 (1232.10 m) followed by T_2 (1162.02 m). Significantly shorter (908.43 m) filament length was recorded in batches of cocoons obtained from treatment absolute control (Table 4).

Non-breakable filament length (m)

Significantly longest non-breakable filament length was recorded in the cocoons spun by the silkworms fed on leaves harvested from 0.4% nano N @ 225 ltr per acre (1251.01 m) which was on par with T_3 (1197.60 m) followed by T_2 (1095.58 m) and T_1 (1066.73 m), significantly shortest filament length was noticed in the batches of cocoons obtained from the silkworms fed with absolute control leaves (T_{10}) (659.95 m) (Table 4).

Feeding quality leaves is important for growth of silkworm and production of silk. However, leaves of nano nitrogen fertilizer sprayed mulberry plants were formed nutritionally superior and the larvae fed with those leaves exerted better growth and development and spun good quality cocoons. The nutritive feed especially with nitrogen would act as a stimulant for rapid growth of silkworm resulting better silk production.

Nano particles which improve the feed efficacy of silkworms as they might have stimulated the metabolic activity in silkworms leading in improving the rearing performance, intern enhanced the reeling parameters.

CONCLUSION

Though the performance of double hybrid silkworm (FC1 X FC2) was formed better in T_4 when fed with mulberry sprayed at 225 ltr / acre volume of nano nitrogen fertilizer with 50 % N as soil application was not significantly differed from T_3 i.e., mulberry sprayed at 200 ltr / acre volume of nano nitrogen fertilizer with 50 % N as soil application. Hence, recommending the nano nitrogen fertilizer foliar spray at 200 ltr / acre along with 50 % N as soil application is quite possible which need to be studied at larger scale.

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