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RESEARCH ARTICLE

INFLUENCE OF ZINC FORTIFICATION ON EGG PRODUCTION EFFICIENCY IN CSR BREEDS OF SILKWORM, *BOMBYX MORI* L.

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ABSTRACT

Raising of mulberry leaf with balanced nutrients is a pre-requisite in stabilizing the silkworm seed crops to produce quality cocoons. Zinc plays a major role in reproductive activities of silkworms. Literature available indicates that there is deficiency of Zinc in mulberry leaf required by the silkworm in tropical conditions. During present study, leaf fortification was done with Zinc in 3 doses during fifth age. Leaf was fortified once in a day with 1.5 mg (T1), 3.00 mg (T2) and 5.00 mg (T3) doses per 300 larvae dissolved in tap water. V1 mulberry variety and popular breeds CSR2 & CSR4 were used for the study. Seed crop rearing was done at standard methods. Rearing and grainage parameters were recorded and analyzed statistically. Two controls were maintained i.e. with water spray (C1) and without water spray (C2). Data revealed significant variation in larval weight (39.83g – 40.90g), ERR (90.48% - 95.63%), cocoon weight (1.62g - 1.70g), pupation (89.53% - 93.88%), moth emergence (86.32% - 91.58%) and egg recovery (55.78g - 68.32g) between control and treated batches. The seed quality was improved significantly in treated batches of T1 and T2. The study confirmed that the leaf fortification with Zinc improved seed crop performance and quality seed production.

INTRODUCTION

It is quite reasonable to attribute feed quality for healthy and vigorous growth of any insect. Being a monophagous insect reared indoors, the silkworm, *Bombyx mori* has single option for host plant selection. Hence, it is quite imperative that the raising of a healthy crop of silkworm depends largely on the quality and quantity of mulberry leaf offered as feed (Legay, 1958). Though fertility and fecundity in silkworms are very sensitive to quantitative and qualitative changes in the food, deficiency in quality affects more severely than that of quantity (Legay, 1958; Englemann, 1970). Mulberry leaves contain the adequate amounts of minerals to maintain good growth (Horie *et al.,* 1967, Ito *et al.,* 1966) except phosphorus and zinc which stands just near to the required levels of silkworm or even less. These two elements are essential to silkworm in one hand and on the other they are necessary for the reproduction (Tazima, 1978; Nakamura and Horie, 1982). Deficiency of specific nutrients in mulberry leaf viz. phosphorus, zinc and sterol will affect fertility and fecundity in silkworms (Nakamura and Horie, 1982; Horie *et al.,* 1985). Leaves (Nutrients) consumed during the entire 4th instar and 1st to 3rd day in Vth instar are utilized for the formation of eggs (Fukoda *et al*., 1963; Inagaki and Yamashita, 1983. Nutrition plays an important role in improving the growth and development of the silkworm, *Bombyx mori* L. and the silk production is dependent on the larval nutrition and nutritive value of mulberry leaves and finally in producing good quality cocoons (Etebari, 2002).

On silkworms, Zn increases the weight of the larvae and serigene gland and reduced the mortality rate and larval duration (Hugar and Kaliwal (1999), Ashfaq *et al.* (2010). Foliar spray is a type of feeding technique to the plants by applying liquid fertilizers directly to their leaves. The absorption of essential nutrients takes place largely through the stomata of leaves and through the epidermis. Mulberry (*Morus sp.*) is a deep rooted high biomass producing foliage crop cultivated as a sole food for silkworm, *Bombyx mori* L. But due to repeated harvests and soil problems, mulberry is exhibiting nutrient deficiencies in recent years (Younus Wani *et al.,* 2017). Although crops need low amounts of micronutrients (Monreal *et al.,* 2015) but still half of the cultivated world's soils are deficient in plant bioavailable micronutrients due to their slow replenishment from the weathering of soil minerals, soil cultivation for thousands of years and insufficient crop fertilization. Thus, there is a need to correct their deficiencies through use of foliar sprays. Zinc helps in synthesis of lipids, proteins, carbohydrates and helps in reducing the duration of larval and pupal stages (Bhattacharya and Medda, 1981). Always the spring leaf is superior in quality than the autumn leaf with all balanced nutrients. Supplementation to the spring leaves scarcely improved the larval survival and cocoon quality and yield under temperate conditions, while supplementation to autumn leaves or to shaded leaves had better results (Tanaka, 1964). In fact under Indian conditions, it is difficult for farmer community to grow mulberry having balanced nutrients in the leaf due to extreme climatic changes in different regions and seasons. Hence, there is need for supplementation of leaves with specific nutrients so as to enrich the leaf quality in particular for seed crop. Further, information on the requirements of nutrients for seed crop related to high egg recovery and quality is scanty. No substantial attempt was made to standardize the Zinc available in the leaf and its requirements by the silkworm. Hence, the present study has been taken up with Zinc supplementation to enrich leaf quality for raising the quality seed cocoon production and egg recovery.

MATERIAL AND METHODS

Silkworm rearing was conducted in the laboratory as per the standard rearing procedure (Krishnaswami, 1986). Mulberry shoots were fortified with Zinc (Zn SO4) and fed to silkworms during 5th age. Leaf was fortified once in a day with 1.5 mg (T1), 3.00 mg (T2) and 5.00 mg (T3) doses per 300 larvae in three replications dissolved in tap water. V1 mulberry variety and popular breeds of CSR2 & CSR4 were used for the study. Rearing and grainage parameters were recorded and analyzed statistically. Two controls were maintained i.e. with water spray (C1) and without water spray (C2).

RESULTS AND DISCUSSION

Data pertaining to the Zinc fortification of mulberry leaves and its effects on seed crop performance and egg production are presented in table 1 and 2. There was significant difference in larval weight, ERR, cocoon characters, cocoon yield and pupation rate between treatments, breeds and race x treatments and their interaction indicating the Zinc influence in enhancing the larval growth, developmental activities and their survival rate. Significantly high larval weight (41.28 g), ERR (95.63%), cocoon weight (1.70 g), pupation (93.88%), moth emergence (91.58%), laying recovery (37.86%), egg recovery (68.32 g) and fecundity (541) were recovered recorded in treated batches indicating influence of Zinc on developmental activities, survival and increased reproductive efficiency. Mihai Bentea *et al.* (2012) studied the effect of zinc supplementation and reported that the use of Zinc in silkworms has improved larval weight, serigene gland weight, cocoon weight and shell weight. The maximum dose of administration did not have any negative effects. Geetha *et al.* (2017) conducted the combined foliar spray of micronutrients ($ZnSO_4$, $FeSO_4$, $MnSO_4$ and citric acid) on 5th instar larvae and reported that the significant increase might be due to increased DNA synthesis in the silk gland or may be due to the general growth stimulatory effect of those chemicals on silk glands as indicated by Manimala (1995). The importance of these elements were indicated by Ito and Niminura (1966) as well as Horie *et al.* (1967) where they reported that it accelerated the growth of larvae. Hugar *et al.* (1999) and Ashfaq *et al.* (2010) reported that Zn increases the weight of the larvae and sericine gland and reduced the mortality rate and the larval duration. During present study increase of larval weight was observed in treated batches compared to control batches. The data on moth emergence revealed that the cocoon melting was less in Zinc treated batches (4.65 to 4.88% in CSR2 and 4.52 to 4.92% in CSR4) than the controls (6.88 to 6.92% in CSR2 and 7.50 to 7.82% in CSR4) during cocoon preservation. This is evident that the egg production efficiency in loose eggs was also increased 12 - 15% in Zinc treated CSR breeds. There was an improvement in quality of seed produced in treated batches with increase of egg recovery and reduced incidence of unfertilized eggs which may be due to the Zinc fortification. In spite of less difference in the cocoon weights, it can be envisaged that the reproductive efficiency of the treated moths has improved over the controls through the Zinc influenced metabolic activities related to the egg maturation and oviposition. Bose *et al.* (1995) reported that succulent mulberry leaves with less fibre and higher mineral contents presumably stimulated the metabolic activities in silkworm resulting in qualitative improvement of cocoon and silk. The production of cocoons is highly influenced by the quality mulberry leaf as reported by Aruga (1994). The quality of leaf being fortified with additional inputs by application of micronutrients either at soil or at foliar level has an impact on the floss production (Dutta *et al.,* 2007). Tanaka (1964) reported that the spring leaf is always superior in quality than the autumn leaf with all balanced nutrients. Supplementation to the spring leaves scarcely improved the larval survival and cocoon quality and yield under temperate conditions, while supplementation to autumn leaves or to shaded leaves had better results. It is envisaging that leaf from tropical areas may require additional supplementation to overcome mineral deficient. In the present study Zinc supplementation to overcome the deficiency of Zinc in leaf for seed crop improvement was confirmed as the survival rate and the egg production was significantly improved over non supplemented batches. Further, determination of dosage was taken care by considering the Zinc quantity available in the leaf and its requirement by the larva in reproduction.

The role of mineral nutrition, more particularly that of Zinc, needs to be ascertained as it is known to play a vital role in the synthesis of lipids, proteins and carbohydrates and in reducing the duration of larval and pupal stages (Bhattacharya and Kaliwal, 2005). Such studies provide substantial evidences for practical application of Zinc and other microelements for qualitative and quantitative improvements in silk production. Chamundeswari and Radhakrishnaiah, (1994) reported the increase of cocoon weight, when the silkworm larvae were fed with zinc and nickel fortified mulberry leaves. Parameters such as raw silk, filament length, reliability, denier and shell ratio were found to be good considerably in the case of cocoons reared by feeding mulberry leaves treated with Zinc, Pyridoxine and Methoprene and with mixed dose. In the Zinc treated group the economic traits elevated significantly. The mineral availabilities in insects were reviewed by Muniandy *et al.* (2001). In *Bombyx mori*, the assimilation efficiencies ranged from negative values to 51% (Zn), with that for Phosphorus at 27% (Horie *et al.,* 1985). Studies of Valle, (1976) suggest that proteins involved in controlling such processes would be regulated directly by zinc. Foliar spray of Zn as (ZnSO4) increases the moisture content in mulberry leaves (Lokanath 1981) The moisture content determines the nutritive quality of leaves and plays an important role in the production of quality cocoons (Dandin and Kumar, 1989). Foliar spray of Zinc helps in retaining the leaf freshness for longer periods. During present study larval weight, effective rate of rearing (ERR), cocoon parameters and grainage parameters were studied. The data showed significant difference between breeds, treatments and their interaction in all the parameters. The larval weight ranged from 39.43 g to 41.28 g. The maximum larval weight was recorded in T3 batch of CSR4 and minimum in control 2 of CSR2. Mihai Bentea *et al*. (2012) reported superior performance in Zn treated batches

Table 1. Effect of Zinc fortification on seed crop rearing performance of CSR breeds (Mean of three trials)

Race	Parameters	Larval Wt. (g)	ERR (%)	SCW (g)	SSW (g)	Shell (%)	Cocoons/ kg (No)	Melting (%)	Cocoon yield/ 100 dfls (Kg)
	T1	40.03	95.48	1.67	0.37	22.11	597	4.65	79.98
	T2	40.47	93.44	1.68	0.36	21.83	600	4.85	77.61
CSR2	T3	40.89	95.63	1.65	0.37	22.28	607	4.88	78.97
	Ctrl 1	39.62	92.25	1.63	0.35	21.59	612	6.92	75.44
	Ctrl 2	39.43	90.55	1.63	0.35	21.22	611	6.88	74.91
	T1	40.81	94.44	1.69	0.37	21.84	590	4.52	79.70
	T2	40.90	93.66	1.69	0.36	21.41	588	4.68	79.45
CSR4	T3	41.28	93.88	1.70	0.37	21.72	586	4.92	79.92
	Ctrl 1	39.98	90.74	1.62	0.35	21.35	615	7.82	73.92
	Ctrl 2	39.80	90.48	1.64	0.36	21.86	611	7.50	74.08
CD@5%	Race	0.280	0.390	0.011	NS	NS	1.989	0.102	NS
	Tmt	0.400	0.556	0.016	0.009	NS	2.813	0.114	0.612
	Trial	0.209	0.333	0.006	0.004	NS	1.182	0.127	0.491
	R x Tmt	0.679	1.050	0.018	NS	NS	5.801	0.282	0.567
	R x Tmt x Tri	0.468	0.740	0.015	NS	NS	2.643	0.193	1.098

R – Race, Tmt – Treatment, Tri – Trial

Table 2. Effect of Zinc fortification on seed production in CSR breeds (Mean of three trials)

Race	Para-meters	Pupation (%)	Moth emergence (%)	Layings (%)	Egg recovery (g/kg cocoons)	Eggs/g (No)	Dead eggs (%)	UF eggs (%)	Fecundity (No)	Hatch (%)
CSR2	T1	93.31	91.58	37.33	67.80	1789	0.60	2.11	541	96.70
	T2	92.66	90.67	37.86	68.15	1792	0.58	1.77	541	97.06
	T3	93.88	90.81	35.85	65.52	1791	0.64	2.10	536	96.15
	Ctrl 1	91.36	87.22	30.68	55.78	1790	0.61	2.25	528	96.27
	Ctrl 2	91.55	85.97	31.35	57.79	1793	0.61	2.20	537	96.44
CSR4	T1	91.87	90.14	35.37	64.30	1742	0.60	2.00	539	97.28
	T2	93.18	91.40	37.76	68.32	1741	0.52	1.96	540	96.19
	T3	92.94	91.03	36.18	65.33	1737	0.79	2.17	538	96.28
	Ctrl 1	89.53	86.32	29.53	56.21	1729	0.73	2.84	524	95.56
	Ctrl 2	90.58	86.57	29.91	56.45	1728	1.00	2.48	530	95.74
CD@5%	Race	0.303	NS	0.393	0.246	17.970	0.018	0.083	3.042	0.389
	Tmt	0.429	0.602	0.556	0.343	NS	0.026	0.118	4.303	0.550
	Trial	0.315	0.374	0.289	0.333	8.993	0.019	0.049	1.605	0.335
	R x Tmt	0.519	0.587	0.610	0.421	NS	0.026	0.129	5.582	0.663
	R x Tmt x Tri	0.706	0.836	0.646	0.746	NS	0.043	0.109	3.590	0.748

compared to control in body mass of silkworm larvae. Geetha *et al.* (2017) conducted the combined foliar spray of micronutrients (Zn SO4, FeSO4, MnSO4,and citric acid on 5th instar larvae and reported that the significant increase might be due to increased DNA synthesis in the silk gland or may be due to the general growth stimulatory effect of those chemicals on silk glands as indicated by Manimala (1995). The increase or decrease in the mineral contents affects the growth and development of silkworms which consequently alerts the quality of silk produced (Ito and Nimura, 1966) .Thus mineral nutrition of mulberry foliage has a decisive role in the production of good quality cocoons. Growth and development of silkworms depend on the nutritive status of leaves. If there is an imbalance in elemental contents (mineral nutrition) the leaf quality is severely deteriorated. This could be detrimental to silkworms.

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