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International Journal of Current Research
Vol. 10, Issue, 08, pp.72535-72543, August, 2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

FOLIAR UREA FERTILIZATION ENHANCHES MULBERRY LEAF YIELD AND COCOON PRODUCTIVITY

[1,*]Faruque Ahmed, [2]Md. Jahangir Alam and [2]Md. Toufiq Iqbal

[1]Department of Mulberry, Bangladesh Sericulture Research and Training Institute, Rajshahi 6207, Bangladesh
[2]Department of Agronomy and Agricultural Extension, University of Rajshahi, Rajshahi 6205, Bangladesh

ARTICLE INFO

Article History:
Received 19th May, 2018
Received in revised form
20th June, 2018
Accepted 17th July, 2018
Published online 30th August, 2018

Key Words:
Foliar spray, Pruning, Photosynthesis, Silkworm, Sericulture, DAP, precipitation, antagonism, Rendita.

ABSTRACT

Foliar spray of urea may improve mulberry leaf yield, quality and cocoon productivity. But, it is not clear how foliar spray of urea influence mulberry leaf yield, quality and cocoon productivity. Therefore, two years field experiments were carried out in the experimental field of Bangladesh Sericulture Research and Training Institute (BSTRI), Rajshahi, Bangladesh. The objective of this study was to quantify the effect of foliar spray of urea on mulberry plant growth, yield, leaf quality and silk cocoon productivity. This study consisted of seven treatments,T1 (Recommended Basal Dose, RBD) = 305 kg N/ha/yr, 105kg P/ha/yr and 66 kg K/ha/yr, T2 = 2.5 % urea solution 3 times foliar sprays, T3 = 3.5 % urea solution 3 times foliar sprays, T4 = 4.5 % urea solution 3 times foliar sprays,T5 = RBD + 2.5 % urea solution 3 times foliar sprays, T6 = RBD + 3.5 % urea solution 3 times foliar sprays and T7 = RBD + 4.5 % urea solution 3 times foliar spray were used for mulberry plant production. The leaf yield of mulberry plant was increased 6.26% and the crude protein, total sugar, mineral and soluble carbohydrate also increased 7.14%, 4.49%, 4.95% and 4.30% respectively as well as the silk cocoon productivity was 32.31% greater in treatment T5than to the treatment of T1.This study concluded that existing BSRT recommended basal dose (RBD) along with 3 times foliar spray of 2.5 % urea at 30 days after pruning (DAP), 45 DAP and 60 DAP respectively performed well and successfully augments the productivity and biochemical constituents of mulberry plant as well as cocoon productivity.

Citation: ***Dr. Florence K. Nyamu, Dr. Leah N. Wanjama, Rose M. Irungu and Fred N. Kariuki,*** **2018.** "Foliar urea fertilization enhanches mulberry leaf yield and cocoon productivity", *International Journal of Current Research*, 10, (08), 72535-72543.

INTRODUCTION

Mulberry (*Morus* spp.) is a perennial and high biomass producing plant, continues to grow throughout the year in tropics. The continuous production of mulberry for a long time results in gradual reduction in leaf yield and quality (Rashmi *et al*., 2009). The *Bombyxmori* is essentially monophagous and survives solely on mulberry leaves (*morus* sp.) which play an important role in the nutrition of the silkworms, and in turn cocoon and silk production (Nagaraju, 2002).Hence the silkworms should be fed with good quality mulberry leaves in abundant quantity for the successful cocoon production (Vijaya*et al.,*2009). Fertilizer is one of the basic inputs of agriculture and its timely availability is very crucial for agricultural production (Bukhari *et al*., 2015). Nitrogen being important constituents of plant cell components, like amino acid, protein and nucleic acid, required in great quantity by all crops plants. The deficiency of N is one of the greatest constraints in crop production.

Corresponding author:* **Faruque Ahmed,
Department of Mulberry, Bangladesh Sericulture Research and Training Institute, Rajshahi 6207, Bangladesh

DOI: https://doi.org/10.24941/ijcr.31496.08.2018

A close relationship was established between N and water availability (Saneoka *et al*., 2004, Shabbir *et al*., 2015). Drenovsky *et al*. (2012) stated that crop yield cannot be increased without sufficient water availability. The affirmative supply of N via roots has been clearly illuminated in relation to plant growth and its corresponding physiological process (Saneoka *et al*., 2004; Zhang *et al*., 2009; Ahmed *et al*., 2014). The chemical fertilizers are becoming costlier day by day due to escalating costs and scarce availability of commodities. Foliar feeding can provide the nutrients required for normal development of crops in cases where absorption of nutrients by the roots system is suboptimal. Foliar feeding with fully water-soluble fertilizers at critical stages dramatically increases yields, improves yield quality and also the efficiency of nutrient uptake is considered to be 8-9 folds higher when nutrients are applied to the leaves compared with nutrients applied to soil Nitrogen is one of the major plant nutrients required for plant growth. For maximizing yield of mulberry, nitrogenous fertilizer is the kingpin in mulberry farming. It is essential for the synthesis of protein, which is the constituent of protoplasm and chloroplasts. Traore (1999) found that nitrogen is a constituent of numerous important compounds found in living cells, including amino acid, protein (enzymes), nucleic acid and chlorophyll). Mae (1997) also reported that nitrogen is the most essential element in determining the yield potential of intensified agriculture system. Yeasmin *et al*., (1995) also reported that foliar application of urea and micronutrients improved the yield and quality of mulberry leaf. Recently, the foliar application of nutrients has become an important practice in the production of crops while application of fertilizers to the soil remains the basic method of feeding the majority of the crop plants. Because, foliar application overcomes soil fertilization limitations like leaching, insoluble fertilizer precipitation, antagonism between certain nutrients, heterogenic soils unsuitable for low dosages and fixation/absorption reactions like in the case of phosphorus and potassium. Jamal *et al*. (2006), also reported that the aerial spray of nutrients is preferred and gives quicker and better results than the soil application. In this aspect, the present study was, undertaken to see the effect of foliar spray urea on mulberry leaf yield and quality. It may be hypothesized that the foliar spray of urea will be enhanced the mulberry leaf yield, quality as well as improved the silk cocoon productivity.

MATERIALS AND METHODS

Experimental Area: A field study was conducted at the research area of Bangladesh Sericulture Research and Training Institute (BSRTI), Rajshahi, Bangladesh (24°22′29″N and 88°37′3.84″E) and the Agro-Ecological Zone (AEZ), Active Ganges Floodplain-10 and High Ganges River Floodplain-11 for three consecutive years.

Sample Material: The mulberry plant was used as sample materials for this study, which is perennial, deep rooted and woody in nature. Due to its perennial, deep rooting and hard habit, it is grown in wide range of soil and agro-climatic conditions. Mulberry is cultivated in various agro-climatic conditions ranging from temperate to tropical conditions (Rangaswami *et al.,* 1976).

Taxonomy of Mulberry: Mulberry is highly heterozygous and out breed in nature, producing natural hybrids with wide range of variation in morphological characters which creates problem for classification and in identification of actual number of species under the genus *Morus* L. Linnaeus (1953) established the genus *Morus* with 5 species and Koidzumi (1917, 1923) recognized 35 species under the genus *Morus*.

Experimental Design: The experiment was carried out in a split plot design, with three replications. The assigning mulberry variety was the main plot and fertilizer management to the sub-plot or split-plot and same experiment was repeated for three years.

Experimental Condition: The mulberry variety BM-9 and high bush plantation system were used for this study. On the basis of silkworm rearing season mulberry garden was pruned four times in a year each after 3 months interval during January, 2016 to December, 2017.

Treatments: In this study the following concentrations of urea were tested through foliar spray method**:**

T_1 (RBD) = 305 kg/ha/yr, 105kg/ha/yr and 66 kg/ha/yr NPK respectively with four split doses each after three months interval were used as the recommend basal dose (RBD) of NPK of BSRTI for mulberry production.

T_2 = 3 times foliar sprays of 2.5 % urea30 days after pruning (DAP), 45 DAP and 60 DAP respectively.
T_3 = 3 times foliar sprays of 3.5% urea 30 days after pruning (DAP), 45 DAP and 60 DAP respectively.
T_4 = 3 times foliar sprays of 4.5 % urea 30 days after pruning (DAP), 45 DAP and 60 DAP respectively.
T_5= RBD + 3 times foliar sprays of 2.5% urea 30 days after pruning (DAP), 45 DAP and 60 DAP respectively.
T_6 = RBD + 3 times foliar sprays of 3.5% urea 30 days after pruning (DAP), 45 DAP and 60 DAP respectively.
T_7 = RBD + 3 times foliar sprays of 4.5 % urea 30 days after pruning (DAP), 45 DAP and 60 DAP.

Experimental Procedure

The treatment was assigned in each sub-plot for each year and every case according to the treatment the RBD was applied to the soil 20 days after pruning (DAP) of the mulberry plant when sprouting was started. But the urea solutions were sprayed as a foliar spray for three times for each crop. 1st spray was done 30 DAP, 2nd spray was done 45DAPand 3rd spray was done 60DAP. According to the treatments the tested plants were treated with the urea solutions that were made up with distilled water and spraying with hand-held sprayer. Other Cultural practices like irrigation, digging cum weeding and insect-pest management were done as per requirement for each year.

Data Collection

The data was collected 90 DAP for each cropping seasons, i.e. 4 times data was collected in a year for the leaf yield and yield contributing parameters and also on the leaf quality. In case of leaf yield and yield contributing characters: total branch number/plant, total branch height/plant (cm), length of longest shoot/plant (cm), total leaf number per/plant, 10 leaf area/plant (cm^2), ten leaf weight (g)/ plant, total leaf weight/plant (g) and leaf yield/heaters/year (metric ton) were recorded. On the other hand in case of leaf quality: moisture (%), moisture retention capacity (%), Crude protein (%), total sugar (%), reducing sugar (%), mineral (%) and Soluble carbohydrate (%) parameters were recorded.

Methodologies of Leaf Quality Analysis

The mulberry leaf samples at different heights of the plant (top, middle and bottom) were collected in paper bags at 75 d after pruning and composite leaf samples were made. Then the leaves sample were shade dried for three days and again then dried in hot air oven at700°C for one hour and were ground into powder for chemo-assay. The moisture (%) and moisture retention capacity were determined by followed the Vijayan *et al*., (1996), total mineral (%) followed the AOAC (1980), protein (%) followed by the Kjeldahl's method (Wong, 1923), total sugar and reducing sugar (%) followed by the Miller (1972) and Loomis et al., (1937) procedure and methods, starch (%) by the Morse (1947) method and soluble carbohydrate (%) followed by Dubois *et al*. (1956) method.

The Soil Condition and Methodologies of Soil Physical and Chemical Properties Analysis: The soil of the experimental plot was sandy clay loam in nature with pH ranges from 7.54 to

Table 1. Average fertility status of the experimental plot used for study

Soil pH in H2O	N/%	P/ppm	K /Cmol·kg-1	S /ppm	Zn /ppm	Organic matter/%	Textural Class
7.69	0.07	13.7	0.15	12.53	0.95	0.91	Sandy clay loam

Table 2. Significance levels from for the main and interactive effect on treatments for growth and yield contributing characteristics of mulberry plant

Source of variation	Total branch number per plant	Total branch height per plant (cm)	Length of longest shoot (cm)	Total leaf number per plant	Ten leaf area (cm^2)	10 leaf weight per plant (gm)	Total leaf weight per plant (gm)	Total leaf yield/ ha/yr (mt.)
Treatments	*	***	***	***	***	**	**	**

7.68. The soil was poor in potassium and available phosphorus. Both carbon and nitrogen levels were low in uncultivated as well as in the cultivated plot. Nitrogen level was not in balance with carbon. The pH of soil paste was measured by the method of Mclean (1982).the nitrogen content of the soil samples were determined by distilling soil with alkaline potassium permanganate solution (Subbiah *et al*., (1956) and the distillate was collected in 20 mL of 2% boric acid solution with methylred and bromocresol green indicator and titrated with 0.02 N sulphuric acid (H_2SO_4) Podder *et al*., (2012).Soil organic matter contents were estimated following the described method of Walkley (1947), which involves reduction of potassium dichromate by organic carbon compounds. The potassium was determined on flame photometer (Rowell, 1994) while phosphorus was measured on spectrophotometer at 880 nmusing sodium bicarbonate extraction (Rowell, 1994). The soil available S (ppm) was determined by calcium phosphate extraction method with a spectrophotometer at 535 nm Petersen (1996) and textural class by using hydrometer method (Bouyoucos, 1962). The pooled soil analysis data of the field is given in Table 1.

RESULTS

Foliar Spray of Urea, Growth and Leaf Yield of Mulberry Plant

Total Branch Number per Plant: The total branch number per plant was significantly influenced ($P \leq 0.05$) by the fertilizer treatments (Table 2). The greater total branch number per plant (13.42) was found for the treatment of T_5(Combined application of RBD + 3 times foliar spray of2.5 % urea). The lowest total branch number (10.58) was recorded in treatment T_2 (3 times foliar spray of2.5 % urea only)(Figure I; Table III and Table IV).

Total Branch Height per Plant (cm)

The total branch height per plant was significantly differ by the treatments. The highest total branch height per plant (932.0 cm) was recorded in treatment T_5(Combined application of RBD + 3 times foliar spray of2.5 %) which was significantly greater ($P \leq 0.05$) than the other treatments(Figure II; Table III and Table IV).

Length of Longest Shoot (cm) per Plant

The length of longest shoot was significantly influenced ($P \leq 0.05$) by the fertilizer treatment. The highest length of longest shoot 88.40 cm was obtained for the treatment of T_5 (Combined application of RBD + 3 times foliar spray of2.5 % urea) (Figure III; Table III and Table IV).

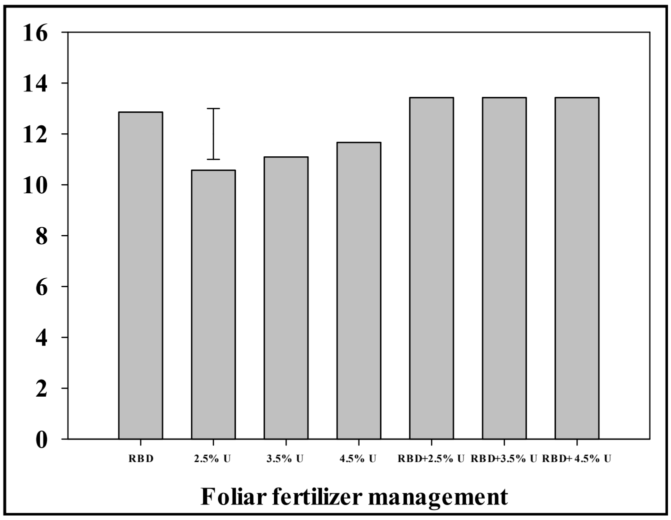

Figure 1. Total branch number per plant under several foliar fertilizer management. Vertical bar represents LSD ($P \geq 0.05$) for treatments interaction

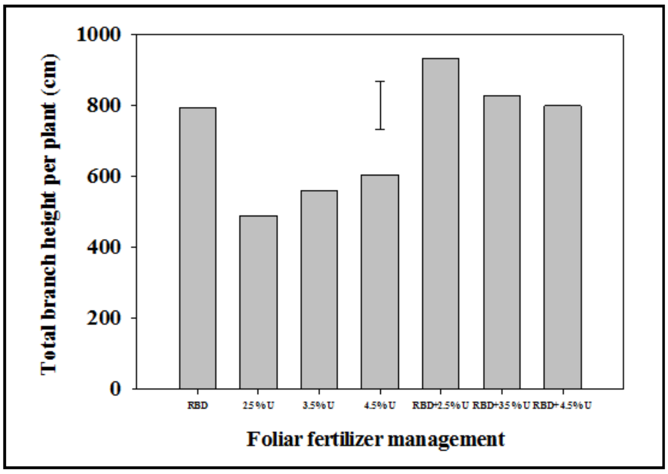

Figure 2. Total branch height per plant (cm) under several foliar fertilizer management. Vertical bar represents LSD ($P \geq 0.05$) for treatments interaction

Total Leaf Number per Plant

The total leaf number per plant was significantly differ by the treatments. The maximum total leaf number per plant (343.78) was recorded in treatment of T_5 (Combined application of RBD + 3 times foliar spray of2.5 % urea)which was significantly greater ($P \leq 0.05$) than the others. The lowest total leaf number per plant was found 225.50 in treatment T_2 (3 times foliar spray of 2.5 % urea only) (Figure III; Table III and Table IV).

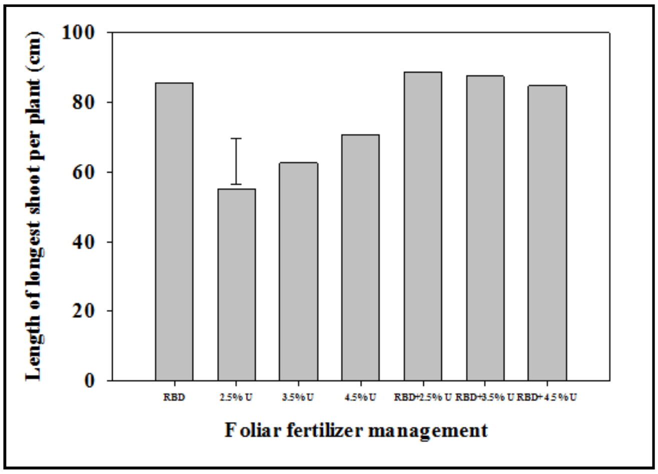

Figure 3. Length of longest shoot (cm) per plant under several foliar fertilizer management. Vertical bar represents LSD ($P \geq 0.05$) for treatments interaction

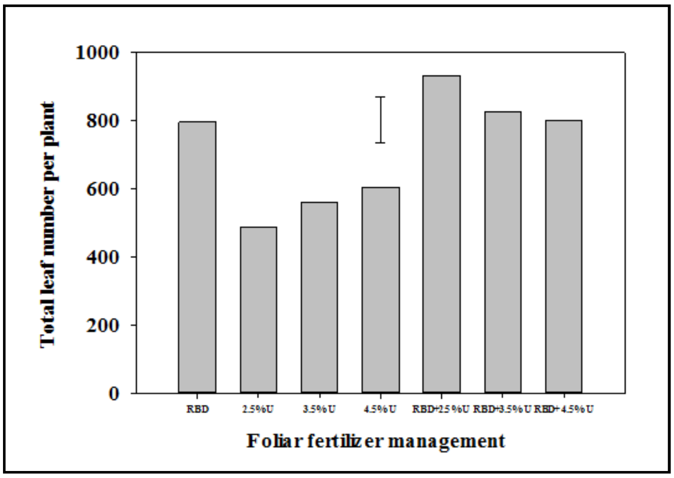

Figure 4. Total leaf number per plant under several foliar fertilizer management. Vertical bar represents LSD ($P \geq 0.05$) for treatments interaction

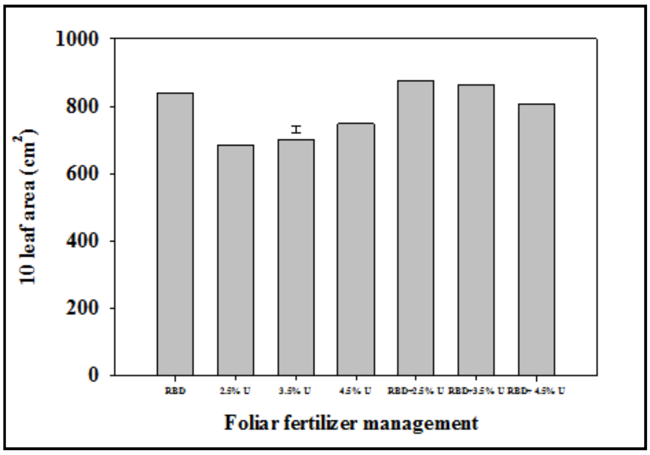

Figure 5. Ten leaf area (cm^2) per plant under several foliar fertilizer management. Vertical bar represents LSD ($P \geq 0.05$) for treatments interaction

Ten Leaf Area (cm^2) per Plant: The ten leaf area was significantly differ by the treatments. The highest ten leaf area (875.10 cm^2) was recorded in the treatment of T_5 (Combined application of RBD + 3 times foliar spray of2.5 % urea) which was significantly greater ($P \leq 0.05$) than the other treatments (Figure III; Table III and Table IV).

Ten Leaf Weight (gm) per Plant

The ten leaf weight was significantly influenced ($P \leq 0.05$) by the fertilizer treatments. The maximum ten leaf weight (46.51 g) was obtained for the treatment of T_5 (Combined application of RBD + 3 times foliar spray of2.5 % urea) which was significantly greater than the others. The lowest ten leaf weight per plant 32.92 g was recorded for the treatment of T_2 (3 times foliar spray of 2.5 % urea only) (Figure III; Table III and Table IV).

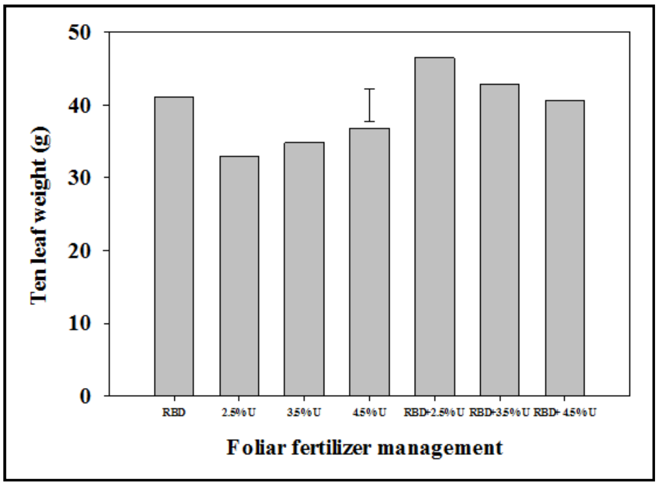

Figure 6. Ten leaf weight (g) per plant under several foliar fertilizer management. Vertical bar represents LSD ($P \geq 0.05$) for treatments interaction

Total Leaf Weight per Plant (gm)

The total leaf weight per plant was significantly differ by the treatments. The total leaf weight per plant inT_5 (Combined application of RBD + 3 times foliar spray of2.5 % urea) treatment (735 g) was significantly greater than the others (Figure III; Table III and Table IV).

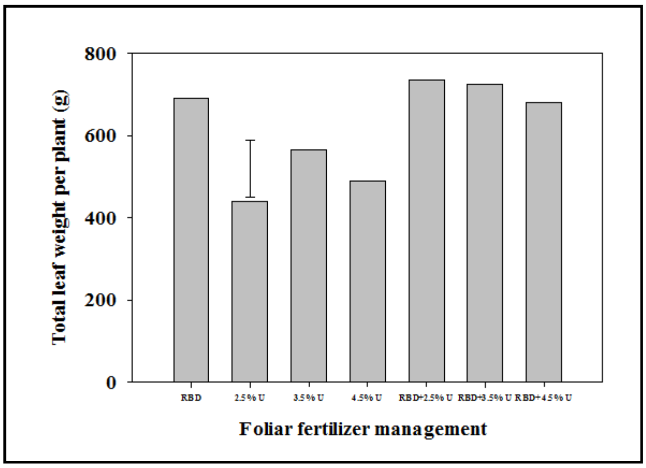

Figure 7. Total leaf weight (g) per plant under several foliar fertilizer management. Vertical bar represents LSD ($P \geq 0.05$) for treatments interaction

Total Leaf Yield/ Hectare/Year (metric ton): The foliar application of urea had a significant ($P \leq 0.01$) effect onthe total leaf yield of mulberry plant. The highest total leaf yield/hectare/ year35.29 metric ton was recorded for the

Table 3. Effects of foliar spray of urea on leaf quality of mulberry

Treatments	Mean leaf quality performance for different fertilizer treatments						
	Moisture (%)	Moisture Retention Capacity (%)	Crude Protein (%)	Total Sugar (%)	Reducing Sugar (%)	Mineral (%)	Soluble Carbohydrate (%)
T_1	75.60^{ab}	52.07^{c}	18.06^{c}	6.01ab	3.20b	12.11bc	10.24bc
T_2	69.61^{e}	48.81^{e}	16.28^{e}	5.21c	2.73c	10.57e	9.43d
T_3	71.45^{d}	50.22^{d}	$16.54d^{e}$	5.41c	2.79c	11.12d	9.52d
T_4	73.04^{c}	51.137^{cd}	17.02d	5.93b	2.93c	11.10c	9.95c
T_5	76.17^{a}	55.04^{a}	19.35a	6.28a	3.34b	12.71a	10.68a
T_6	74.46^{b}	51.97^{c}	19.07ab	6.21a	3.58a	12.66a	10.57ab
T_7	76.31^{a}	53.73^{b}	18.58bc	6.16a	3.68a	12.42ab	10.58ab

In a column, means followed by common letter are not significantly different at the 5% level by DMRT.

Table 4. Effects of foliar spray of urea on silkworm rearing performance

Treatments	Weight of 10 Matured Larve (g)	Effective Rate of Rearing by Number	Single Cocoon Weight (g)	Single Shell Weight (g)	Cocoon Shell Ratio	Highest Filament Length (m)	Rendita	Cocoon Production/100dfls (kg)
T_1	31.29a	7926.3d	1.35c	0.23b	15.18d	856.68c	12.96c	52.21d
T_2	27.7a	7364.0g	1.17f	0.20d	12.39g	801.49f	14.65a	48.28f
T_3	28.09a	7544.9f	1.20e	0.21cd	13.56f	809.23e	13.89b	49.36ef
T_4	28.30a	7583.6e	1.26d	0.22bc	13.71e	816.86d	13.96b	50.36e
T_5	33.27a	8892.4a	1.58a	0.25a	17.33a	972.34a	10.93f	69.08a
T_6	32.54a	8766.0b	1.42b	0.22bc	15.61b	920.52b	11.87e	64.29b
T_7	31.33a	8696.1c	1.34c	0.2cd	15.39c	919.91b	12.26d	61.29c

treatment ofT_5 (Combined application of RBD + 3 times foliar spray of2.5 % urea) which was significantly greater than the other treatments. The lowest total leaf yield per hectare per year 21.15 metric ton was obtained for the treatment of T_2 (3 times foliar spray of 2.5 % urea only)(Figure III; Table III and Table IV).

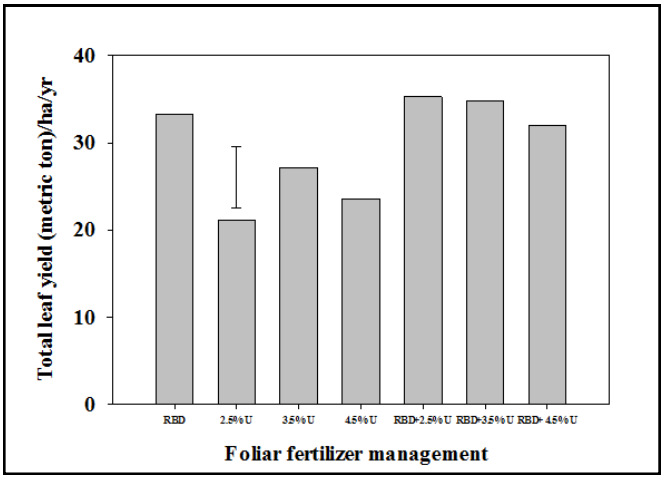

Figure 8. Total leaf yield (metric ton) per hectare per year under several foliar fertilizer management. Vertical bar represents LSD ($P \geq 0.05$) for treatments interaction

Foliar Spray of Urea and Leaf Quality of Mulberry Plant

This study pertained to assess the biochemical changes in mulberry leaf under foliar spray of urea fertilizer. For this purpose the coarse leaves were analyzed and the founding results are presented in below:

Moisture (%): The maximum moisture (76.31%)was observed for the treatment of T_7(Combined application of RBD + 3 times foliar spray of4.5 % urea) which was statistically similar with the treatments of T_5(Combined application of RBD + 3 times foliar spray of2.5 % urea) and T_1 (RBD of NPK only). But it was statistically differ with rest of the treatments and the minimum moisture (69.61%) was recorded for the treatment of T_2 (3 times foliar sprays of 2.5% ureaonly) (Table-3).

Moisture Retention Capacity (%): The maximum moisture retention capacity (55.04%) was recorded for the treatment of T_5 (Combined application of RBD + 3 times foliar spray of2.5 % urea) which was statistically differ than the other treatments. The minimum moisture retention capacity (48.81%) was observed for the treatment of T_2 (3 times foliar sprays of 2.5% ureaonly) (Table 3).

Crude Protein (%): The maximum crude protein (19.35%) was noted for the treatment of RBD of T_5(Combined application of RBD + 3 times foliar spray of2.5 % urea) which was statistically significant than the all treatments except treatment T_6(Combined application of RBD + 3 times foliar spray of3.5 % urea) The lowest crude protein (16.28%) was observed for the treatment of T_2 (3 times foliar sprays of 2.5% ureaonly) (Table 3).

Total Sugar (%): The total sugar (%) was statistically differ only the T_2, T_3 and T_4 respectively. The maximum total sugar (6.28%) was observed in the treatment of T_5(Combined application of RBD + 3 times foliar spray of2.5 % urea). The minimum total sugar (5.21 %) was recorded in treatment of T_2 (3 times foliar sprays of 2.5% ureaonly) (Table 3).

Reducing Sugar (%): The reducing sugar (%) was statistically differ with all the treatments except T_6 (Combined application of RBD + 3 times foliar sprays of 4.5% ureaonly) (Table 3). The highest reducing sugar (3.68%) was recorded for the treatment of T_7 (Combined application of RBD + 3 times foliar sprays of 4.5% ureaonly) which was statistically similar with the treatment of T_6 (Combined application of RBD + 3 times foliar sprays of 4.5% ureaonly). The minimum reducing sugar

(2.73%) was obtained for the treatment of T_2 (3 times foliar sprays of 2.5% ureaonly).

Mineral (%): The maximum mineral (12.71%) was noted in the treatment of T_5 (Combined application of RBD + 3 times foliar spray of2.5 % urea) which was statistically significant than the all treatments except treatments T_6 and T_7 respectively. The minimum mineral (10.57%) was recorded for the treatment of T_2 (3 times foliar sprays of 2.5% ureaonly).

Soluble Carbohydrate (%): The highest soluble carbohydrate (10.68%) was recorded for the treatment of T_5(Combined application of RBD + 3 times foliar spray of2.5 % urea) which was statistically differ than the all treatments except T_6 and T_7.The lowest soluble carbohydrate (9.43%) was recorded for the treatment of T_2 (3 times foliar sprays of 2.5% ureaonly).

Foliar Spray of Ureaon Mulberry Leaf and Silkworm Rearing Performance

Among the different concentration of urea solution, foliar spray of 2.5% urea with RBD of NPK were recorded notable response on.

The effective rate of rearing by number, single cocoon weight (g), single shell weight (g), shell ratio, highest filament length (m), rendita and Cocoon production/100dfls (kg) except weight of 10 matured larve (g) were statistically differ for the treatment of T_5(Combined application of RBD + 3 times foliar spray of2.5 % urea) (Table 4).The highest effective rate of rearing by number, single cocoon weight (g), single shell weight (g), cocoon shell ratio, highest filament length (m), rendita and cocoon production/100dfls (kg) were 8892.4, 1.58 9 (g), 0.25 (g), 17.33, 972.34 (m),10.93 and 69.08 (kg) respectively. The highest weight of 10 matured larve 33.27 (g) also noted for the treatment T_5 (Combined application of RBD + 3 times foliar spray of2.5 % urea) (Table 4).

DISCUSSION

Foliar Spray of Urea Enhance Growth and Yield of Mulberry Plant

Foliar spray of different concentration of urea enhance mulberry yield. Total branch number per plant in ($P \leq 0.1$), ten leaf weight (g) per plant, total leaf weight per plant (g) and total leaf yield/ha/yr (metric ton) were significant ($P \leq 0.01$) for combined application of RBD + 3 times foliar spray of 2.5 % urea among the other treatments. Similarly, total branch height per plant (cm), length of longest shoot (cm) per plant, total leaf number per plant, ten leaf area (cm^2) per plant were highly significant ($P \leq 0.001$)for the same treatment. Previously, Qayyum *et al.,* (1991) were studied on the foliar spray of urea solution for mulberry plant. They used four concentrations of urea like without urea, 0.5% urea, 1% urea and 2% urea respectively and found that the foliar spray of 0.5 % urea increase the mulberry leaf yield 27.63% over the control, which is closely related with our results. Likewise, Quader *et al.,* (1990) were also found that the foliar spray of urea along with different doses of NPK fertilizers significantly increase the mulberry leaf yield. They used eight doses of NPK with 0.5% foliar application of urea and found that the combined application of 250kgN, 125kgP and 100kgK per hectare per year with 0.5% foliar spray of urea solution was provided the higher leaf yield in mulberry plant.

Our study investigated that the foliar spray of 2.5 % urea with RBD of NPK significantly increased the mulberry leaf yield than the other treatment which is lined with the findings of Witte *et al.,* (2002), because they found that the mulberry leaf yield depends on the length of longest shoot, inter nodal distance, number of total leaf per plant and weight of total leaf per plant.

This might be due to the combined application of RBD of NPK in soil + 3 times foliar sprays of 2.5 % urea dose were comparatively appropriate, specific forms, balanced proportion and available for mulberry plant uptake. As a results the nutrients utilization by the plant was maximum both in the soil and leaf cells, penetration &uptake rates higher, efficiently and quickly in terms increase the photosynthesis rates, dry matter produces and other physiological functions of the plant, which enhance the growth parameters as well as increase the leaf yield of mulberry plant. Kaushal *et al.*, (2014) reported that nutrient uptake is 8-9 folds higher when nutrients are applied to the leaves than the soil, more that 90% of the fertilizers is utilized in foliar spray, where 10% utilized in soil applied fertilizers, foliar applied fertilizers are up to 20 times more effective than the soil applied, which is lined with the above assumption. Our speculation is as urea was applied both the foliar and soil applied methods consequentially, N uptake by the mulberry plant was optimum which influences the growth and leaf yield production in mulberry. Because integrated nutrients especially N uptake by the crops is directly related with crop production. These speculation is closely related with the previous findings of Khan *et al.,* (2009).They found that the crop yield is often associated with optimum nutrient uptake particularly N uptake and also found that the integrated application of N through soil and foliage facilitated the higher N uptake by the plant. Further speculations were due to the foliar spray of urea N deficiency was minimized, stimulating effects of urea progress the photosynthesis rate, photosynthesis related parameters and other physiological functions of mulberry plant as well as mulberry plant productivity was maximum through combined application of RBD of NPK in soil + 3 times foliar sprays of 2.5 % urea than the others. There may be possibility that the improvements in physiological indices with foliar spray of nutrients that are attributed due to their effective role in enhancing physiological processes involved in plant growth and delayed plant leaves senescence as well as increasing photosynthetic activity.

We also used the other concentration of urea with RBD of NPK namely, RBD of NPK in soil + 3 times foliar sprays of 3.5% urea and RBD of NPK in soil + 3 times foliar sprays of 4.5% urea. But the performance of these treatments were not satisfactory compared to RBD of NPK in soil + 3 sprays of 2.5% urea treatment. It may be due to the phyto-toxicity of higher concentration of urea, plants were not uptake the N required quantity and also leaves could not perform its functional activities properly, as a results the growth and yield performance of these treatments were comparatively low. These finding are more or less closely related with the finding of Vagen (2003), who found that the higher concentration of urea (10%) significantly reduced N uptake due to the phyto-toxicity of urea and leaves could not function properly thus the additional N uptake was inhibited. Similarly, Khan *et al.*, (2009) were used six concentration of urea i.e. 0, 2, 4, 6, 8 and 10 % as foliar spray with 60 and 120 kg N/ha in wheat crops and they found the significant plant height, spike length, number of grains/spike, 1000 grain weight, biological yield, grain yield and N uptake by the crop in 4% urea solution spray. Therefore, foliar spray of 2.5% urea along with RBD of NPK was a effective doses, so the mulberry plant uptake the nutrients especially N in promptly, maximum quantity and balanced proportion, which interns positively enhanced the photosynthesis rate, photosynthesis related parameters, physiological activities, growth regulates etc. of the mulberry plant. As a result the growth of mulberry plant was in balanced proportion and ultimately the leaf yield and yield contributing characters were significantly greater.

Foliar Spray of Urea Enhance leaf quality of mulberry: Mulberry leaf quality improved due to foliar nitrogen application. The average nutritive quality of matured mulberry leaf was comparatively better in 3 times foliar spray of 2.5% urea in 30 DAP, 45 DAP and 60 DAP respectively along with RBD of NPK. The leaf quality characters viz. moisture retention capacity (%), crude protein (%), soluble carbohydrate (%), total mineral (%) and total sugar (%) except moisture% and reducing sugar (%) were highest in the treatment ofT_5 (RBD of NPK + 3 times foliar sprays of 2.5% urea)among the other treatments (Table 4). These findings are closely linked with the previous findings of Gooding *et al.,* (1992), who found that the foliar spray of urea along with NPK fertilizers improve the nutritive quality namely, moisture content, protein, sugar, reducing sugar and starch both in tender and matured leaves of mulberry plant. Similarly, Quader *et al.,* (1990) also found that the foliar spray of 0.5% urea along with 250 kg N, 125 kg P and 100 kg K significantly increased the total leaf yield, moisture, protein, total sugar, reducing sugar, starch and carbohydrate contents over the control in mulberry plant. However, the maximum moisture 76.31% was found in the combination of RBD of NPK + 3 times foliar sprays of 2.5% urea treated plot than the others. These findings are more or less similar with the findings of Yildirim*et al.*, (2008). He found that the Bio-foliar spray of (Spirulina: Soybean: Vermiwash 3: 2 : 1) improve the leaf moisture when treated with 45 μg m/L concentration. The highest moisture content was in AR-14 mulberry variety for the additional supply of nutrition (Bio-foliar) to the leaves and also withstanding the moisture for longer duration. This phenomenon attributed to the fact that bio-foliar application can increase the leaf diffusive resistance and lower transpiration rates. The maximum crude protein content 19.35%was also recorded for the treatment of RBD of NPK + 3 times foliar sprays of 2.5% urea which is similar with the findings of Han *et al.,* (1989), who reported that the total protein contents were increased in mulberry plant through the foliar spray of urea. The progressive increase in the leaf protein content percentage by the combined application of recommended basal dose of NPK with foliar spray of 2.5% urea may be due to the higher absorption of nitrogen, phosphorous and potassium in available forms both in soil and also in leaf cells, which is more or less similar with the findings of Chela et al. (1999) and Uyanoz (2007). They reported that the leaf protein content progressively increased due to the availability and higher absorption of nitrogen and phosphorus from soil by crop plants under the influence of combined application of biofertilizer and chemical fertilizer. Our another assumption is due to the foliar spray of urea with RBD of NPK nutrient absorbed by the foliage rapidly and evidently the plant metabolism/ assimilation might have been activated which contributing the healthy green foliage resulting in synthesis of organic contents. Similar observations were reported by Singhvi *et al*., (2000) and Manchashetty (1979). Singhvi *et al*., (2000) reported that the foliar application of Seri boost and Manchashetty (1979) reported that the application of NPK to soil as well as foliar spray of nitrogen @ 0.5 per cent increased the crude protein content in mulberry leaves. The highest soluble Carbohydrate 10.68% was recorded also for the treatment of T_5 (RBD of NPK + 3 time's foliar spray of 2.5% urea) which is more or less lined with the findings of Gowda *et al*., (2000). They reported that soil application of Di Ammonium Phosphate (DAP) to mulberry, with foliar application of seriboostin creased the total carbohydrates%. The higher level of total sugar content 6.28% was recorded in mulberry leaves treated by the RBD of NPK with 3 times foliar spray of 2.5% urea treated plot. The total sugar content was increased in foliar spray of urea along with RBD of NPK most probably due to the transportation of soluble sugar from the flowering parts of mulberry plant which were used by the developing leaves of the plants. In addition the enhanced total sugar content in mulberry leaf was attributed due to the improved of mineralization which enhanced the production of plant growth substances and enzyme activity in mulberry. These results are in close conformity with the findings of Vijaya *et al*.,(2009), who reported that the application of recommended dose of NPK to soil with 2% foliar nutrition increased the total sugars content in mulberry leaves due to the improvement of mineralization attribute resulting in enhanced production of plant growth substances and enzyme activity in mulberry. Besides the level of sugar contents in the leaves of mulberry plants under combined application of RBD of NPK with 3 times foliar spray of 2.5% urea can be attributed towards growth retardant cycocel which may have stimulated the rate of photosynthesis leading to higher rate of photosynthate production in the leaves along with adequate supply of nutrients particularly N. However, the foliar spray of 2.5% urea with RBD dose of NPK enhance the biochemical components of mulberry leaf are also more or less confirmed by the previous findings of Dursum *et al*., (2010). They found that the foliar spray of plant growth promoting bacterium increased the biochemical contents of *Lycopersiconesculentum* and *Cucumissativus.* The above findings are also agreement with the previous findings of Faruque *et al*., (2017), where we found that the combined application of (3gm urea + 3ml LF) with RBD of NPK significantly increased the moisture%, moisture retention capacity%, total mineral%, total sugar%, reducing sugar%, crude protein%, starch % and soluble carbohydrate%.

Impact of Foliar Spray of Urea Enhance Silkworm Rearing Performance: Urea foliar sprayed on mulberry leaf has positive impact for silkworm rearing performance. The foliar spray of 2.5% urea solution along with RBD of NPK also improved the rearing performance of silkworm. Our experimental results showed that the rearing parameters viz. effective rate of rearing by number, single cocoon weight (g), single shell weight (g), shell ratio, highest filament length (m) and yields/100dfls (kg) were statistically greater for the silkworm feed on the 3 times foliar spray of 2.5% urea + RBD of NPK treated mulberry leaf. The rearing performance as well as cocoon productivity was increased may be attributed to enrichment in elemental composition of mulberry leaves due to foliar spray of additional urea with soil applied RBD of NPK, which in turn had stimulated the metabolic activities in silkworm thus fulfilling the requirement of nutrients both qualitatively and quantitatively. These results corroborates with the findings of Ashfaq *et al.,* (1998) and Rasool (1995), who concluded that silkworm larvae fed on leaves treated with different nutrients gained significantly more weight. This could be due to reason that applied 2.5% urea along with RBD of NPK enhanced the leaf quality, succulence, less fiber content and absorption of essential mineral form the soil, which apparently stimulated the metabolic actives of silkworm resulting improve the cocoon characters as well as increased the cocoon productivity. Likewise, Bose et al. (1995) also reported that succulent mulberry leaves with less fiber and higher mineral contents presumably stimulated the metabolic activities in silkworm resulting in qualitative improvement of cocoon and silk. However, our speculation was that the silkworm was reared by the quality mulberry leaf which was treated by2.5% urea + RBD of NPK as a results the rearing performance as well as the cocoon productivity was greater than the others. Because quality mulberry leaf is a single factor which contributes about 38.2% for the success of silkworm crop production (Miyashita, 1986).

Conclusion

This study concluded that the fertilizer dose of 3 times foliar spray of 2.5% urea with soil applied BSRTI recommended basal dose of NPK was superior fertilizer treatments with respect of mulberry leaf yield, quality and cocoon productivity. This occurred due to the availability, maximum and quickly absorption of NPK especially of N by the mulberry plant, improved photosynthesis rate, plant physiological activities as well as improved the silkworm metabolic activities. This study concluded that the additionally foliar spray of a small amount of urea with RBD of NPK might be increased the mulberry leaf yield, quality and silk cocoon productivity.

Acknowledgement

Researchers indebted to the Director of Bangladesh Sericulture Research and Training Institute, Rajshahi, for valuable help and providing laboratory facilities for analytical analysis in regarding the experiment. Researchers also would like to thanks the technical staffs of Soil Resources Development Institute (SRDI), Rajshahi, Bangladesh for their constructive suggestion regarding soil samples collection and analysis. Finally, we wish to extend our thanks to the technical staff of Bangladesh Sericulture Research and Training Institute, Rajshahi, Bangladesh for their help regarding the experiment.

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