Roles of different fertilizer management practices on mulberry leaf yield and quality

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Abstract: Effects of fertilizer management practices on leaf yield and quality of mulberry plant are important for sustainable mulberry plant production. This study was undertaken to improve the growth, yield and biochemical contents in an instant available form in mulberry plant through different fertilizer management practices. There were four fertilizer management practices like control (CT), basal (BS), urea+magic growth (UM) and basal+urea+magic growth (BUM) were applied on mulberry plant (*Morus SPP*.). Results of this investigation revealed that among the various fertilizer treatments on the foliar application of (3 g urea + 3 mL magic growth) per liter water with BSRTI recommended BS of NPK performed well in respect of growth parameters and biochemical constituents. The highest 10 leaf area (638.64 cm^2), leaf number per branch (50), total leaf weight per plant (785.64 g), node per meter (28.67), specific leaf weight (0.005817 g/cm^2), length of longest shoot (173.25 cm) and total leaf yield per hectare per year (41 610 kg) were noticed in BUM treatment followed by UM, BS and CT treatments. Further the highest moisture (74.38%), moisture retention capacity (33.31%), total mineral (12.10%), total sugar (3.99%), reducing sugar (4.05%), crude protein (21.01%), starch (9.72%) and soluble carbohydrate (11.41%) were also recorded in BUM treatment as compare to UM, BS and CT treatments. The outcome of research implies that among the four fertilizer management practices foliar spray of (3 g urea + 3 mL magic growth) per liter water with BSRTI recommended BS dose of NPK performed well and successfully augments the productivity and biochemical constituents of mulberry plant.

Keywords: liquid fertilizer, silkworm, foliar spray, photosynthesis, pruning
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1 Introduction

Mulberry is a hardy, perennial, deep rooted plant capable of thriving under diverse agro-climatic conditions. Mulberry plant can be cultivated for several years due to its perennial characteristics. Selection of suitable land and appropriate variety can help to sustainable mulberry field. Mulberry (*Morus spp.)* plant is cultivated by farmers for its leaves, the sole food for silkworm (*Bombyx mori* L) for commercial production of raw silk in sericulture industry[1]. So it is very much needed to increase the leaf yield of mulberry plant for per unite area.

The low leaf yield of mulberry plant in Bangladesh is attributed to a number of reasons i.e., poor fertilizer management, climatic hazards, non replenishment of soil nutrient, inadequate fertilizer use, fertilizer management including setting of N_2 application etc. In Bangladesh, generally fertilizers are applied in soil. But

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in many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application[2]. Among the various cases of low mulberry production, efficient use of fertilizer seems to be important under conditions of Bangladesh.

Our previous study showed that the total weight per plant was three times higher, leaf area (cm^2) was twice and also produced highest mulberry plant production in liquid fertilizer (Magic growth) practices followed by BS, urea and CT fertilizer management practices[3]. Further study also showed that total leaf weight per plant and total shoot weight per plant were comparatively three times higher and others yield contributing characters like ten leaf area (cm^2), total branch height per plant and node per meter were also comparatively higher in basal+magic (BSM) growth fertilizer management practices as a foliar spray followed by basal+urea (BSU) fertilizer, basal and control management[4]. However, combination of basal, urea and magic growth were not applied and their effects on leaf qualities were not analyzed in our previous studies. So, therefore the present investigation was undertaken to determine the effect of various fertilizer management practices on leaf yield and its quality. The hypothesis of this study was the foliar application of liquid fertilizes (Magic Growth) with the urea and BSRTI recommended basal fertilizer dose will be the best fertilizer management practice for quality and quantity mulberry leaf production.

2 Materials and methods

2.1 Experimental site

The experiment was carried out in the experimental field of Bangladesh Sericulture Research and Training Institute (BSRTI), Rajshahi, Bangladesh (24°22′29″N and 88°37′3.84″E). On the basis of Agro-Ecological Zone (AEZ) BSRTI, Rajshahi fall under the Active Ganges Floodplain-10 and High Ganges River Floodplain-11.

2.2 Soil condition

The soil of the experimental plot was mainly loamy in nature, having normally alkaline characteristics with pH ranging from 7.2 to 7.6. As a consequence of this alkalinity, the soil is poor in potassium and available phosphorus. Both carbon and nitrogen levels are low in uncultivated as well as in the cultivated plot. Nitrogen level is not in balance with carbon. This is more prominent in the farm area where mulberry is cultivated for years. Toxic metals are present in traces but they are well below the harmful levels. The average three years basic physical and chemical properties of soils are presented in Table 1.

Table 1 Average three years data on physical and chemical properties of the experimental soil

Soil pH in H_2O	N /%	P /ppm	K /Cmol·kg^{-1}	S /ppm	Zn /ppm	Organic matter/%
8.4	0.06	13.9	0.13	12.6	0.91	1.07

2.3 Sample plant material

Mulberry plant was used as a sample planting materials for this experiment which is perennial, deep rooted and hardy in nature. Due to its perennial, deep rooting and hard habit, mulberry is grown in wide range of soil and agro-climatic conditions.

2.4 Taxonomy of mulberry plant

Mulberry plant is highly heterozygous and out breed 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. There are 25 species under the genus *Morus* L. and classified them in two sections viz. Dolichostyle and Macromorus on the basis of style length[5].

2.5 Experimental condition

For this experiment three years old high-bush mulberry plantation system was selected. According to the silkworm rearing season mulberry garden was pruned four times in a year each after 3 months interval. For this experiment the pruning was done for three year times from January, 2012 to December, 2014.

2.6 Experimental design

The experiment was laid out in a split plot design, assigning mulberry variety to the main plot and fertilizer management to the sub-plot or split-plot with three replications. Same experiment was repeated for three years time.

2.7 Treatments

There were four treatments for these experiments in the three years' time which are as follows:

CT: No any fertilizer was applied.

BS: N, P and K fertilizers were applied in the form of Urea, Triple-super Phosphate (TSP) and Murat of Potash (MP) at the rate of 660 kg/ hm^2 (46% N), 330 kg/hm^2 (45%P) and 210 kg/ hm^2 (60% K) to the soil on four split doses each after three month internal in a year, which was recommend by BSRTI for mulberry cultivation.

UM: Concentration of urea namely 3 g Urea and 3 mL Magic growth (Liquid fertilizer) /1 L water was used only as foliar spray to full fill the (N) requirement on top of basal dose. Magic growth is one type of liquid Fertilizer, which contents 13 number of essential plant nutrients (N, P, K, S, Ca, Mg, Cu, Fe, Zn, B, Mn, Mo, and Cl) and others beneficiary elements.

BMU: Concentration of liquid fertilizer (LF) namely 3 mL LF + 3 g urea /1 L water was used as foliar spray to full fill the nutrients requirement with BSRTI (Bangladesh Sericulture Research and Training Institute) basal dose for mulberry cultivation.

Mass percent (%) composition of Urea, Triple Super Phosphate, Muriate of Potash and MG which were used as basal and foliar treatments are given in Table 2.

Table 2 Mass percent (%) composition of fertilizers used in this experiment

Fertilizer Name	Chemical formula	Content elements with symbol	Mass percent /%
Urea	$CO(NH_2)_2$	Carbon(C)	20.00
		Hydrogen(H)	6.66
		Nitrogen(N)	46.66
		Oxygen (O)	26.66
Triple Super Phosphate	$Ca(H_2PO_4)_2$	Calcium(Ca)	15.89
		Hydrogen(H)	2.39
		Oxygen(O)	57.13
		Phosphorus(P)	24.58
Muriate of Potash	KCl	Potassium(K)	50.00
		Chloride(Cl)	46.00
Liquid fertilizer (Magic growth)	None	*Total Nitrogen (N)	10.51
		Phosphorus (P)	5.58
		Potassium (K)	6.33
		Sulphur (S)	0.10
		Zinc (Zn)	0.16
		Copper (Cu)	0.04
		Iron (Fe)	0.0006
		Manganese (Mn)	0.006
		Boron (B)	0.25
		Calcium (Ca)	0.07
		Magnesium (Mg)	0.007

Note: Result obtained from the chemical analysis of MG was done in the Soil Resource Development Institute, Regional Research Station, Dhaka.

2.8 Experimental procedure

The treatment was randomly assigned in each sub-plot. For each year and every case according to the treatment the BS was applied 20 d after pruning (DAP) the mulberry plant when the sprouting was started. But Urea and liquid fertilizer were sprayed as a foliar spray for three times in a crop season. 1st spray was done 30 d after pruning (DAP), 2nd spray was done 45 DAP and 3rd spray was done 60 DAP. According to the treatments the tested plants were treated with the urea and magic growth 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.

2.9 Data collection

According to the treatments the data was collected 90 d after pruning for each cropping seasons, i.e. 4 times data was collected in a year. The data was collected for leaf number per branch, leaf present per branch total branch height per plant, length of longest shoot, node per meter, 10 leaf area per plant, total shoot weight per plant, specific leaf weight per plant, total leaf weight per plant and leaf yield per heaters per year.

2.10 Measurements of some important growth parameters

2.10.1 Specific Leaf Weight (SLW)

Specific leaf weight was calculated by the following formula:

$$SLW = \frac{\text{Leaf dry weight}}{\text{Leaf area}}$$

2.10.2 Ten-leaf areas

For this purpose according to the treatments randomly 10 leaves were collected for each plant and then green leaf areas were measured by the leaf area measure machine.

2.11 Methodologies for nutritional leaf quality analysis

2.11.1 Collection of mulberry leaf samples

According to the treatment 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. Leaves were shade

dried for three days and then dried in hot air oven at 700°C for one hour and were ground into powder for chemo-assay.

2.11.2 Measurement of moisture percentage (MP%) and moisture retention capacity Percentage

According to the experiments leaf samples were collected for determination of moisture percentage. After taking fresh weight, leaves were placed in open condition at room temperature for 24 h and again measured. Then dried in oven at 70°C for 48 h and made bone dried for final weight. Moisture percentage and moisture retention capacity were calculated as follows[6].

Moisture percentage =

$$\frac{\text{Fresh leaf weight} - \text{Oven dry weight}}{\text{Fresh leaf weight}} \times 100$$

Moisture retention capacity (MRC) percentage =

$$\frac{\text{Leaf weight after 24 h} - \text{Oven dry weight}}{\text{Fresh leaf weight} - \text{Oven dry weight}} \times 100$$

2.11.3 Measurement of total mineral percentage (%)

The total mineral contents of mulberry leaf for different treatments were determined[7] and percentage of mineral was calculated by the following formula:

Percentage of mineral =

$$\frac{\text{Weight of minerals obtained}}{\text{Weight of leaf powder taken}} \times 100$$

2.11.4 Measurement of protein percentage (%)

Protein contents of mulberry leaves were determinate by the Kjedhal method[8] and using the following formula:

1000 mL of IN acid = 14 g of nitrogen

Percentage of nitrogen =

$$\frac{\text{Amount of nitrogen content}}{\text{Weight of mulberry leaf}} \times 100$$

(g/100 g leaf powder)

The protein content of mulberry leaf = 6.25 × nitrogen percentage

2.11.5 Measurement of total sugar and reducing sugar

Total sugar and reducing sugar content of mulberry leaf were estimated by Dinitrosalicylic acid (DNS) method[9] and following procedure[10]. By using the stock solution and following formula the amount of total sugar and reducing sugar were calculated.

Percentage of total sugar =

$$\frac{\text{Amount of sugar obtained}}{\text{Weight of mulberry leaf powder}} \times 100$$

Percentage of reducing sugar =

$$\frac{\text{Amount of reducing sugar}}{\text{Weight of mulberry leaf powder}} \times 100$$

(g/100 g mulberry leaf)

2.11.6 Measurement of starch percentage (%)

The starch content of mulberry leaf was determined by the[11] method and starch was calculated from the following formula:

Percentage of starch =

$$\frac{\text{Amount of starch obtained}}{\text{Weight of mulberry leaf powder}} \times 100$$

(g/100 g mulberry leaf)

2.11.7 Measurement of soluble carbohydrate percentage (%)

Carbohydrate content was estimated by Dubois et al. (1956) method and results were expressed in percentage (%).

2.11.8 Soil physical and chemical properties analysis

For this experiment the soil textural analysis was conducted through an abbreviated version of the international pipette method. Clay content was measured by a pipette method after pretreatment with H_2O_2 to remove organic matter[12]. The soil pH was determined before incubation experiment in deionizered water using a soil-to-solution ratio of 1:2.5. Organic carbon of the soil samples were determined by wet oxidation method[13]. Soil organic matter content was determined by multiplying the percent value of organic carbon with the conventional Van-Bemmelen's factor of 1.724[14] and the nitrogen content of the soil samples were determined by distilling soil with alkaline potassium permanganate solution[15]. 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)[16]. Soil available S (ppm) was determined by calcium phosphate extraction method with a spectrophotometer at 535 nm[17]. The soil available K was extracted with 1N NH_4OAC and determined by an atomic absorption spectrometer[18]. The available P of the soil was determined by spectrophotometer at a

wavelength of 890 nm. The soil sample was extracted by Olsen method with 0.5 M $NaHCO_3$ as outlined[19]. After extracting with DTPA the Zn in the soil sample was measured by an atomic absorption spectrophotometer (AAS)[20].

2.11.9 Statistical analysis

Mulberry plant growth and composition data were analyzed by a one-way analysis of variance for the main effects of mulberry plant growth. All statistical analysis was conducted using Genstat 12.1th ed^{n} for Windows (Lawes Agricultural Trust, UK). SigmaPlot 12.5 version was used for representing results as a figure form.

3 Results

3.1 Effects of fertilizer management practices on mulberry plant growth

3.1.1 Total branch height per plant

The maximum total branch height per plant was found in combination of BUM treatment which was 1395.33 cm followed by the UM, BS and CT treatments respectively (Figure 1).

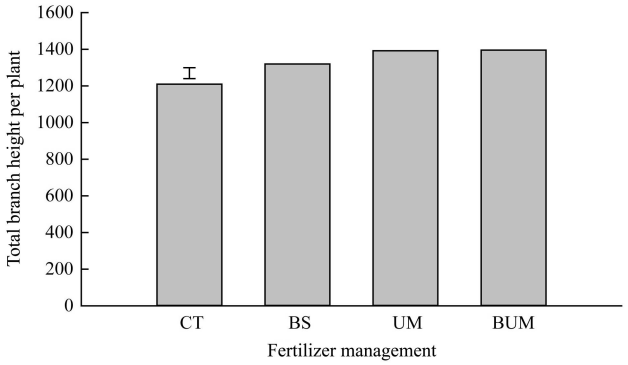

Figure 1 Effects of fertilizer management practices on total branch height per plant (cm) of mulberry (*Morus spp.)* plant. Vertical bar represent LSD (p= 0.05) for various fertilizer management

3.1.2 Leaf number per branch

The leaf number per branch was significantly (p≥0.05) varied by the treatments (Table 3), where the maximum leaf number per branch was 50 in BUM treated plot followed by the UM, BS and CT treatments respectively (Figure 2).

Table 3 Significance levels from the analysis of variance for the main effects of growth and yield parameters among various combined fertilizers management

Source of variation	Leaf number per branch	Ten leaf area	Leaf present per branch	Total leaf yield per hm^2 per yr	Specific leaf weight	Total leaf weight per plant	Total shoot weight per plant	Total branch height per plant	Node per meter	Length of longest shoot
Combined fertilizer treatment	*	***	*	***	***	***.	***	*	*	***

Note: Where *, ** and *** represent probability of >0.05, ≤0.05, ≤0.01 and ≤0.001. Values were means of three replicates.

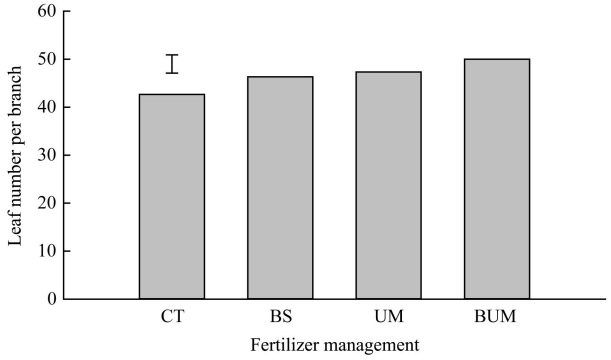

Figure 2 Effects of fertilizer management practices on leaf number per brance of mulberry (*Morus spp.*) plant. Vertical bar represent LSD (p= 0.05) for various fertilizer management

3.1.3 Ten Leaf areas

The 10 leaf area is an essential parameter. Interestingly, the maximum leaf area 638.64 cm^2 was obtained in combination of BUM fertilizer treated plant followed by the UM, BS and CT treatments (Table 3: Figure 3).

3.1.4 Leaf present per branch

There were significant (p≥0.05) variations observed for the mean leaf present per branch (Table 3). The highest mean leaf present was noticed in BUM fertilizer treated plant which was 35.67 (Figure 4).

3.1.5 Total Leaf weight per plant

The total leaf weight per plant was significantly (p≥0.05) varied among various fertilizer combinations (Table 3). The maximum total leaf weight per plant was observed in BUM fertilizer treated plant followed by UB, BS and CT treatments respectively (Figure 5).

3.1.6 Node per meter

In our study the maximum number node per meter was found 28.67 in BUM fertilizer treated plot. But in case of UM, BS and CT treatments the node per meter were 27, 26 and 22.33, respectively (Figure 6).

3.1.7 Total shoot weight per plant

The highest total shoot weight per plant was obtained in combination of BUM fertilizers treatments followed by UM, BS and CT treatments. The total shoot weights per

plant were 981.433 g, 912.59 g, 755.53 g, and 486.56 g, respectively (Figure 7).

3.1.8 Specific leaf weight

The maximum specific leaf weight was measured for the BUM treatment which was 0.005817 g/cm^2. On the other hand for the UM, BS and CT treatments the specific leaf weight were 0.00537 g/cm^2, 0.00514 g/cm^2 and 0.00441 g/cm^2 (Figure 8).

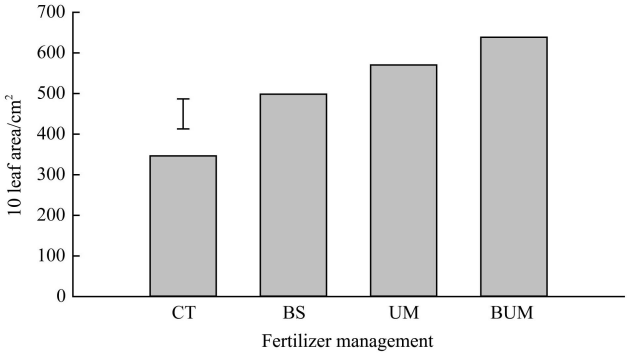

Figure 3 Effects of fertilizer management practices on 10 leaf area of mulberry plant (*Morus spp*.). Vertical bar represent LSD (p= 0.05) for various fertilizer management

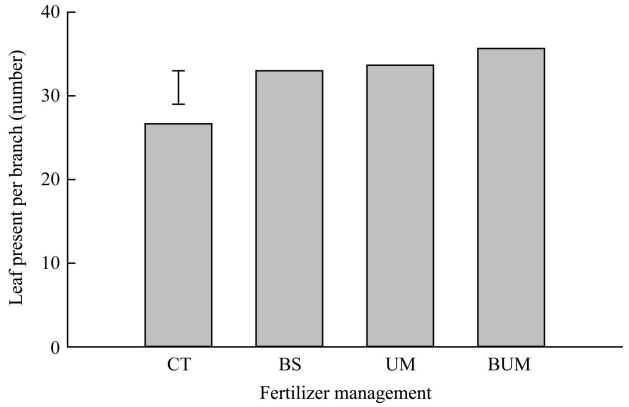

Figure 4 Effects of fertilizer management practices on leaf present per branch of mulberry (*Morus spp*.) plant. Vertical bar represent LSD (p= 0.05) for various fertilizer management

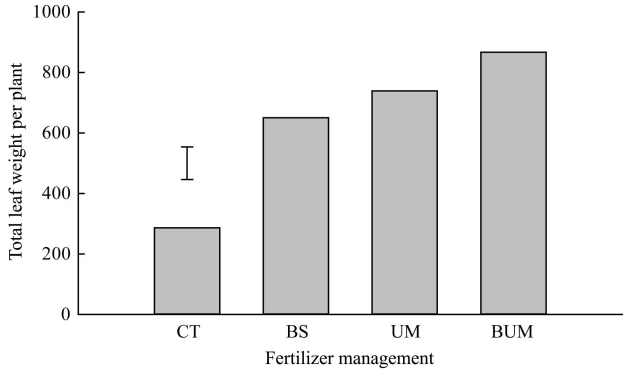

Figure 5 Effects of fertilizer management practices on total leaf weight of per plant. Vertical bar represent LSD (p= 0.05) for various fertilizer management

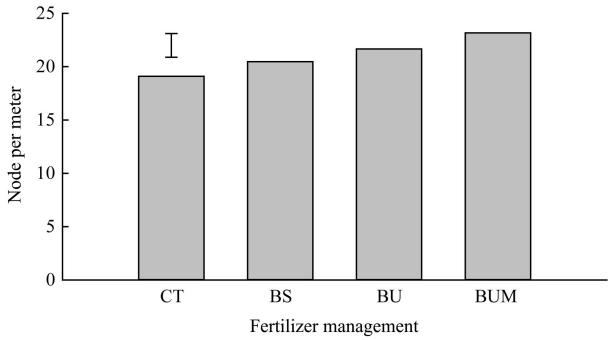

Figure 6 Effects of fertilizer management practices on node per meter of mulberry (*Morus spp.)* plant. Vertical bar represent LSD (p= 0.05) for various fertilizer management

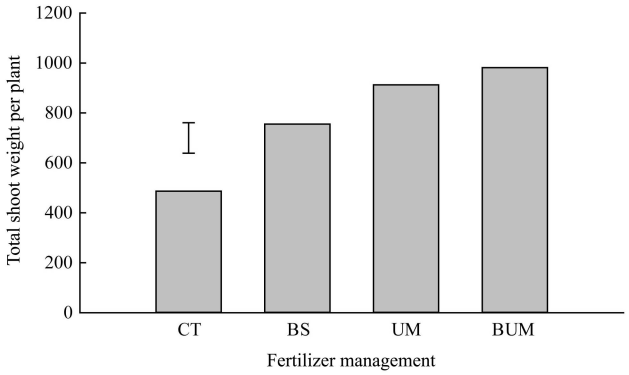

Figure 7 Effects of fertilizer management practices on total shoot weight per plant. Vertical bar represent LSD (p= 0.05) for various fertilizer management

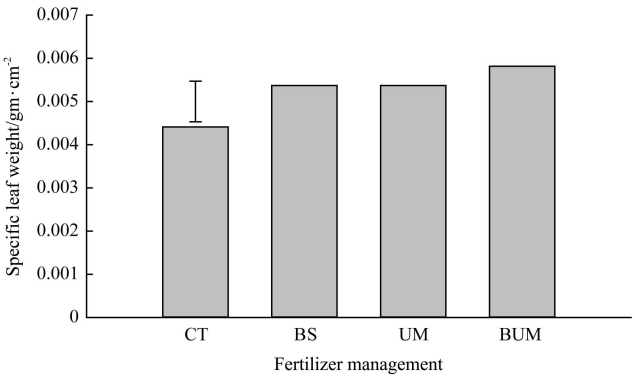

Figure 8 Effects of fertilizer management practices on specific leaf weight of mulberry (*Morus spp.*) plant. Vertical bar represent LSD (p= 0.05) for various fertilizer management

3.1.9 Length of longest shoot per plant

The maximum length of longest shoot was 173.25 cm in combination of BUM fertilizer treatment followed by UM (169.34 cm), BS (164.78 cm) and CT (160.0767 cm) treatments respectively (Figure 9).

3.1.10 Total leaf yield per heater per year

The total leaf yield was significantly (p≥0.05) influenced by the treatments (Table 3). The maximum leaf yield was 41,610 kg/ha/yr in BUM treatment followed by the UM, BS and CT treatments respectively

(Figure 10).

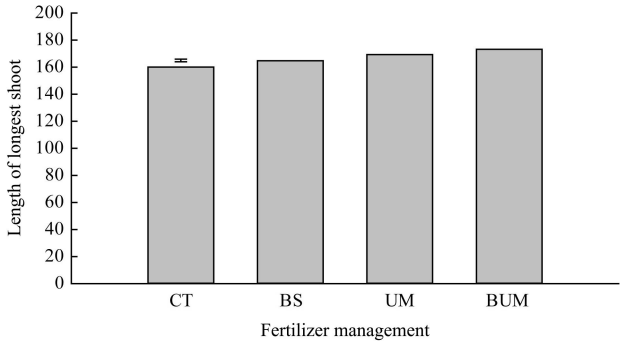

Figure 9 Effects of fertilizer management practices on length of longest shoot per plant. Vertical bar represent LSD (p= 0.05) for various fertilizer management

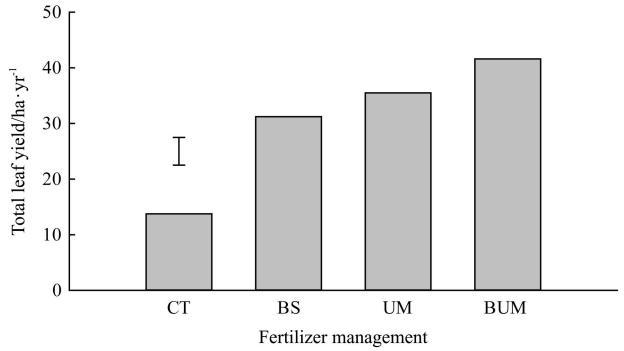

Figure 10 Effects of fertilizer management practices on total leaf yield per heacter per year of mulberry (*Morus spp*.) plant. Vertical bar represent LSD (p= 0.05) for various fertilizer management

3.2 Effects of fertilizer management practices on leaf quality

This study pertained to assess the biochemical changes in mulberry leaf under different treatments like CT, BS, UM, and BUM. For this purpose the coarse leaves were analyzed and the founding results are presented below:

3.2.1 Moisture (%)

The results of the present investigations indicated that the moisture percentage of coarse leaf for combined application of BUM treatment was maximum, which 74.38% as compared to UM, BS and CT treatments respectively (Table 4).

3.2.2 Moisture Retention capacity (%)

The maximum leaf Moisture Retention capacity (%) was 33.31 for the BUM treatment. On the other hand the minimum leaf Moisture Retention capacity (%) were accordingly UM (31.74%), BS (31.17%) and CT (27.40%) respectively (Table 4).

3.2.3 Total Mineral (%)

The present observation revealed that the highest total mineral (%) of leaf was 12.10, which obtained in combination of BUM treatment followed by UM, BS and CT treatments (Table 4).

3.2.4 Total Sugar (%)

Among the four fertilizer treatments the maximum total sugar (%) was 3.99 found in BUM treated plot followed by the UM, BS and CT treatments (Table 4).

3.2.5 Reducing Sugar (%)

The foliar spray of BUM treated mulberry leaf was recorded maximum reducing sugar % was 4.05 followed by UM 3.16 %, BS (2.99%) and CT (1.64%) treatments (Table 4).

3.2.6 Crude protein (%)

Our present investigation revealed that the highest crude protein (%) was 21.06 for combined application of BUM treatment. But in case of UM, BS and CT treatments crude protein % were 17.47, 16.33 and 13.19 respectively (Table 4).

3.2.7 Starch (%)

Starch is also important parameters for determination of mulberry leaf quality. The highest starch % was 9.72 in BUM treatment followed by UM, BS and CT treatments (Table 4).

3.2.8 Soluble Carbohydrate (%)

The highest Soluble Carbohydrate (%) was recorded for BUM treatment also, which was 11.42 followed by the UM, BS and CT treatments respectively (Table 4).

Table 4 Mean value of nutrient content in leaf for various treatments

%

Treatment	Moisture	Moisture retention capacity	Crude protein	Reducing sugar	Soluble carbohydrate	Starch	Total mineral	Total sugar
CT	67.31 (±0.36)	27.40 (±0.38)	13.19 (±0.19)	1.64(±0.28)	7.73 (±0.31)	6.81(±0.13)	7.55(±0.28)	2.52(±0.18)
BS	71.68 (±0.36)	31.18(±0.11)	16.33(±0.23)	2.99(±0.07)	9.32 (±0.17)	8.26 (±0.31)	10.63(±0.34)	3.28(±0.17)
UM	73.34 (±0.41)	31.74(±0.31)	17.47(±0.34)	3.16(±0.11)	10.45(±0.26)	8.32(±0.06)	10.95(±0.16)	3.85(±0.07)
BUM	74.38 (±0.33)	33.31(±0.19)	21.01(±0.39)	4.05(±0.04)	11.41 (±0.33)	9.72 (±0.24)	12.10(±0.07)	3.99(±0.05)

Note: The values within parenthesis indicates that the standard errors of three means in each treatments.

4 Discussion

4.1 Effects of combined fertilizer management on mulberry leaf yield

Three years data was recorded on different plant growth attributing characteristics of mulberry plant and revealed that 10 leaf area per plant, total leaf weight per plant, specific leaf weight per plant, total shoot weight per plant, length of longest shoot per plant and total leaf yield per heater per year in ($p \leq 0.001$) level, leaf number per branch per plant, total branch height per plant, leaf present per branch and node per meter per plant in ($p \leq 0.05$) level were significantly highest by the combination of BUM treatment followed by the UM, BS and CT treatment (Figures 1-10; Table 3).

Due to the local production of magic growth we are not able to validate our findings with other studies. However, our previous study also showed that magic growth treat was best among all fertilizer management practices[3,4].

There are several reasons may be activated for this results. Like our applied liquid fertilizer (Magic growth) contents most of the macro and micro nutrients in balanced proportion and application method was foliar spray. So that the growth response of mulberry plant may be in a balanced way. Our concept line with the other findings. They reported that micronutrients always play a major role in mulberry cultivation therefore; foliar sprays of micronutrients are known to influence the growth, quality and yield of mulberry crop[21]. The importance of NPK fertilizers for both increased productivity and improved quality of mulberry leaves has been well recognized which was also similar with the other observations. He concluded that by the application of N, P, and K fertilizers at the rate of 400 kg N, 200 kg P, and 150 kg K/hm^2·a, leaf yield was increased by 77.92% over the control[22]. In another study found that addition of N foliar spray (1% urea) gave significant increase of yield components in wheat, which are also; confirm our experimental result[23]. In our experiment it was found that the all yield contributing parameters are positively increased, which may be due to the reasons of timely, quickly, balanced proportion, specific form and availability of the supply of essential nutrients. These opinions also line with the other experimental results. They confirmed that every plant requires specific amount of certain nutrients in specific form at appropriate time, for their growth and development[24]. Besides in other findings concluded that due to the stimulating effect of urea through improving the physiological performance of plants and multiple advantage of foliar application method such rapid and efficient response to plant needs, less product needed and independence of soil conditions[25]. It was speculated that high penetration rate is one of the pre requisites for efficient utilization of nutrition in foliar application method. Generally it was proved that nutrients such as calcium (essential part of plant cell-wall structure, provides for normal transport and retention of other elements as well as strength in the plant), magnesium (plays vital role in photosynthesis and activate many plant enzymes which are needed for growth), iron (actively participate in transformation of carbohydrates and regulators consumption of sugars) are most important nutrients for mulberry[26]. It was found that mulberry leaf yield depends on the number and length of the shoots, intermodal distance and number and weight of leaves per plant[27]. Another findings also reported that inter nodal distance is an important genotypic attribute for influencing the total foliage produced by a plant and lesser inter nodal distance more will be the number of the inter nodes per plant and in turn more number of leaves per plant[28] which are closely related with our experimental results. In the present study the highest leaf area was recorded under BUM treatment, which is due to increased of photosynthesis leading to enhanced leaf area and as well as better utilization of stored carbohydrates. The results are in accordance with the other study, who viewed that foliar spray of different levels salicylic acid perform better with respect to number of leaves and lamina, which might be due to increase of photosynthesis leading to enhanced leaf area index[29]. However, from the above discussion we can be concluded that as our applied magic growth (liquid fertilizer) contents 13 number of plant nutrients, recommended basal dose contents (N, P,

K) and application method was foliar feedings, so the photosynthesis rate, consumption of sugars, transformation of carbohydrates, regulates of growth substances etc are positively influenced. As a result the growth of mulberry plant in balanced way and ultimately the yield of mulberry plant were significantly increased.

4.2 Effect of combined fertilizer application on mulberry leaf quality

In the present study the foliar spray of urea + magic growth with basal dose (N, P, K) recommended by BSRTI was found influencing results on nutritive quality of mulberry leaves. Among the various leaf quality characters like moisture, moisture retention capacity, crude protein, reducing sugar, soluble carbohydrate, starch, total mineral and total sugar were comparatively higher in combination of BUM treatment followed by the UM, BS and CT treatment (Table 4). A study investigated that foliar application of phosphorus through Single Super Phosphate (SSP) and Di-ammonium Phosphate (DAP) enhanced the leaf moisture percentage, total chlorophyll, crude protein, total carbohydrates and plant nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium and sulphur content[31]. These findings are positively related with our experimental results. Other studies found that foliar spray of urea along with different doses of N P K fertilizers significantly increase leaf yield and nutrients like moisture content, protein, sugar, reducing sugar and starch in both tender and matured leaves[32-34] that was similar with our observation. However, the highest moisture content was 74.38 % in combination of BUM treatment in foliar application method followed by UM, BS and CT treatments respectively. These findings more or less similar with the observation conducted by other researchers[35-37]. They found that Bio-foliar (Spirulina : Soybean : Vermiwash 3 : 2 : 1) spray contributed well for leaf moisture when treated with 45 μg m/L concentration. The higher moisture content in the leaves of AR-14 mulberry variety was found 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 percentage (21.06%) was recorded in our observation for the combination of BUM treatment which is similar with other study[38]. They reported that the total protein contents were increased in mulberry plant through the folia spray of urea[39]. The progressive increase in the leaf protein content percentage by the combined application of recommended basal dose of N P K with foliar spray of magic growth and urea may be due to higher absorption of nitrogen, phosphorous and other micro nutrients in available forms in soil and also in leaf cells, which is more or less similar with the experimental results of the other findings. They found that the progressive increase in the leaf protein content through combined dose of biofertilizer and chemical fertilizer may be due to higher absorption of nitrogen and phosphorus from soil by crop plants due to their availability under the influence of application of biofertilizer[40,41].

The foliar spray of BUM treatment the higher percentage of Soluble Carbohydrate (11.42%) was obtained followed the other treatments which are closely conformity with the findings of another study. They reported that soil application of DAP to mulberry, with foliar application of seriboost to mulberry increased the total carbohydrates[42]. The higher level of total sugar content in mulberry leaves is probably due to transportation of soluble sugar from the flowering parts are used by the developing leaves of the crop plants. Improved level of sugar in the leaves of crop plants under combined application of BUM can be attributed towards growth retardant cycocel which may have stimulated the rate of photosynthesis leading to higher rate of production of photosynthate in the leaves along with adequate supply of nutrients. Our findings were closely similar with the earlier findings on *Siderites montana*[43,44]. Besides the foliar spray of UM with BS dose of NPK enhance the biochemical components of mulberry leaf are also closely related with the findings of reference [45]. They found that plant growth promoting bacterium applied as foliar spray on *Lycopersicon esculentum* and *Cucumis sativus* increased biochemical contents and growth parameters of plants.

5 Conclusions

This study demonstrated that the combined foliar spray of magic growth (LF) and urea with soil applied BSRTI recommended basal dose of N P K fertilizers can improve mulberry leaf productivity and quality. The finding of the present study indicate that foliar spray of magic growth (LF) and urea with BSRTI recommended basal dose of N P K fertilizers would be an advisable treatment that produces higher leaf yield and improves the leaf quality in mulberry plant. This could be due to the availability and rapidly absorption of both micro and macro nutrients, improved photosynthesis rate and plant physiological activities of the mulberry plant.

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[References]

[1] Rajaram S, Nongrang K, Mandal S K, Ghosh M K, Bindroo B B. Azotobacter Chroococcum Mass Culture for Production of BioFertilizer, Its Sustained Efficacy on Nitrogen Fixation and Crop Productivity in Mulberry Garden. International Journal of Computational Engineering Research, 2013; 3(3): 332–340.

[2] Jamal Z, Hamayun M, Ahmad N, Chaudhary M F. Effect of soil and foliar application of different concentrations of NPK and foliar application of $(NH_4)_2SO_4$ on different parameters in wheat. J. Agron., 2006; 5(2): 251–256.

[3] Ahmed F, Ahmed O, Iqbal M T. Advanced fertilizer management practices for mulberry (*Morus spp.*) plant production. J. Basic and Applied Research International, 2015; 9(2): 111–122.

[4] Ahmed F, Ahmed O, Iqbal M T. Integrated chemical fertilizer management for mulberry (*Morus spp.*) plant production. J. International Journal of Tropical Agriculture, 2015; 2: 13–20.

[5] Koidzumi G. Morus in contributions and floral asiae orientales. The Botanical Magazine, Tokyo, 1917; 31: 31–41.

[6] Vijayan K, Tikader A, Das K K, Roy B N, Pavan K T. Genotypic influence on leaf moisture content and moisture retention capacity in mulberry (*Morus spp.*). Bull. Sericultt. Res, 1996; 7: 95–98.

[7] AOAC. Association of official analytical chemists. Method of Analysis. 13thedition. Washington, DC, USA, 1980; 13044.

[8] Wong S Y. The use of persulfate in the estimation of nitrogen by the arnold-gunning modification of kjeldahl's method. Journal of Biological Chemistry, 1923; 55: 427.

[9] Miller L G. Use of dinitrosalicylic acid reagent for determination of reducing sugar. Analytical Chemistry, 1972; 426–428.

[10] Loomis E W, Shull A C. Meethods in plant physiology. McGraw- Hill Book Company, New York, 1937.

[11] Morse E E, Anthrone in estimating low concentration of sucrose. Analytical Chemistry, 1947; 19: 10–12.

[12] Gee G W, Bauder J W. Particle-size analysis. *In* A. Klute (ed.) Methods of soil analysis. Part 1. 2nd ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI. p. 1986; 383–411.

[13] Walkley I and Black A. An examination Degtijareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science, 1934; 37: 29–38.

[14] Piper C S. Soil and plant analysis. Adelaide University. Hassel Press, Australia.368p, 1950.

[15] Subbiah V B, Asija G L. A rapid procedure for estimation of available nitrogen in soils. Current Science, 1956; 25: 259–260.

[16] Podder M, Akter M, Saifullah M S A, Roy S. Impacts of plough pan on physical and chemical properties of soil. Journal of Environmental Science & Natural Resources, 2012; 5(1): 289–294.

[17] Petersen L. Soil analytical methods soil testing Management and development. Soil Resources Development Institute, Dhaka, Bangladesh, 1996; pp.1–28.

[18] Biswas A, Alamgir M, Haque S M S, Osman K T. Study on soils under shifting cultivation and other land use categories in Chittagong Hill Tracts. Bangladesh. Journal of Forestry Research, 2012; 23(2): 261–265.

[19] Huq I M S, Alam M D. A Handbook on analyses of soil, plant and water. BACER-DU, University of Dhaka, Bangladesh, 2005; pp.13–40.

[20] Soltanpour P N, Workman S. Modification of the NH_4HCO_3-DTPA soil test to omit carbon black. Communications in Soil Science and Plant Analysis, 1979; 10: 1411–1420.

[21] Chikkaswamy K B, Paramanik C R, Gopinath M S and Shivashankar M. Effect of foliar nutrients on the growth, quality and yield of mulberry. Proceeding of the National Seminar on Soil Health and Water Management for Sustainable Sericulture. Bangalore, India, 2006; 95p.

[22] Soylu S B, Sade A, Topal N, Akgun and Gezgin S. Responses of irrigated durum and bread wheat cultivars to boron application in low boron calcareous soil. Turk. J. Agric., 2005; 29: 275–286.

[23] Miah B M A. Studies on the growth and yield of mulberry *(Morus alba* L.). PhD thesis. University of Rajshahi, Bangladesh, 1989.

[24] Yassen A, A. A. E, Abou El- Nour and Shedeed S. Response of Wheat to Foliar Spray with urea and Micronutrients. J. of American Science, 2010; 6(9): 1–5.

[25] Sajid A, Khan A R, Mairaj G, Fida M and Bibi S. Assessment of different crop nutrient management practices for yield improvement. Australia J of Crop Science, 2008; 2(3): 150–157.

[26] Yildirim E, Guvenc M, Turan M, Karatas A. Effect of foliar urea application on quality, growth, mineral uptake and yield of broccoli (*Brassica oleracea* L. var. italica). Plant Soil Environ, 2007; 53(3): 120–128.

[27] Witte P C, Tiller A S, Taylor M A, Davies H V. Leaf urea metabolism in potato. Urease activity profile and patterns of recovery distribution of 15N after foliar urea application in wild-type and urease-anti-sense transgenics. Plant Physiol., 2002; 128: 1129–1136.

[28] Yokoyama T. Text book of Tropical sericulture. *Japan Overseas Cooperation Volunteers*, 1st end, Tokyo, 1975.

[29] Fotadar R K, Ahsan N M, Dhar L K, Bhakuni S B. Evaluation and utilization of genetic variability in mulberry. Ind. J. sericulture, 1989; 28: 50–158.

[30] Watson D J. The physiological basis of variation in yield. Adv. Agron, 1952; 4: 101–145. DOI: 10.1016/S0065-2113(08)60307-7.

[31] Trivedy K, Nair S K, Ramesh M, Gopal N and Kumar N S. New Semi- synthetic diet, Nutrid- A technology forbrearing young instar silkworm in India. Indian J. Sericul., 2003; 42: 158–161.

[32] Gooding M J, Davies P W. Foliar urea fertilization of cereals, A review, Nutr. Cycl. Agroecosyst, 1992; 32: 209–222.

[33] Readman R J, Kettlewell S P, Beckwith P C. Application of N as urea solution: N recovery and N use efficiency. Aspects App. Biol, 1997; 50: 125–132.

[34] Quader M A, Qayyum M A, Sarkar A A, Rab M A, Ahmed S U. Varietal response to NPK-fertilizers in combination with foliar spray of urea on leaf yield and quality of mulberry. Bull. Sericult. Res., 1992; 3: 54–66.

[35] Tari I, Csiszar J, Gabriella S, Horvath F, Pecsvaradi A, Acclimation of tomato plants to salinity stress after a salicylic acid pretreatment. Acta Biol. Szegediensis, 2002; 46: 55–56.

[36] Szepesi A, Csiszar J, Bajkan S, Gemes K, Horvath F, Erde L, et al. Role of salicylic acid pre-treatment on the acclimation of tomato plants to salt- and osmotic stress. Acta Biologica Szegediensis, 2005; 49: 123–125.

[37] Yildirim E, Turan M, Guvenc I. Effect of foliar salicylic acid applications on growth, chlorophyll and mineral content of cucumber (*Cucumis sativus* L.) grown under salt stress. J. Plant Nutr., 2008; 31: 593–612. DOI: 10.1080/01904160801895118.

[38] Han Z, Zeng X, Wang F. Effect of autumn foliar application of 15 N- urea of nitrogen storage & reuse in apple. Journal of plant nutrition, 1989; 12(6): 675–685.

[39] Teotia S R, Choudhary K S, Chinya K P. Studies on effect of CAN & urea on growth and leaf yield of mulberry in acidic soil. Indian Journal of sericulture, 1992; 31(1): 31–36.

[40] Chela G S, Tiwana M S, Thind I S, P K, Puri P K, Kaur K. Effect of bacterial cultures and nitrogen fertility on the yield and quantity of maize fodder (*Zea mays* L). Annals of Biology, 1999; 9: 83–86.

[41] Uyanoz R. The effects of different bioorganic, chemical fertilizers and combination on yield macro and micronutrition content on dry bean (*Phaseolus vulgaris* L). International Journal of Agricultural Research, 2007; 2(2): 115–125.

[42] Gowda R, Sundar P, Raghu V B. Foliar spray of seriboost on mulberry and its impact on cocoon production. Proc. Natl. Seminar Tropical Sericulture, Bangalore, 2000; 2: 163–167.

[43] Ram Rao D M, Kodandaramaiah J, Reddy M P, Katiyar R S, Rahmathulla K V. Effect of VAM fungi and bacterial biofertilizers on mulberry leaf quality and silkworm cocoon characteristics under semiarid condition. Caspian Journal of Environmental Sciences, 2007; 5(2): 111–117.

[44] Ali F A. The role of organic manure and some growth regulators on growth, flowering and bulb production and chemical composition of Iris plants. The 6th Arab Conf. Hort., Islamia, Egypt, Orman No, 2005; 90.

[45] Dursun A, Ekinci M, Donmez F M. Effect of foliar application of plant growth promoting bacterium on chemical contents, yield and growth of tomato (*Lycopersicon esculentum*) and cucumber (*Cucumis sativus*), Pak. J.Bot., 2010; 42: 3349–3356.