Research Article

Management of Macro- and Micro Nutrients in Soil and Mulberry Foliage in Peshawar, Pakistan

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Abstract | Macro- and micro nutrients were managed in soil and mulberry foliage through application of urea and diammonium phosphate (DAP). Urea at the rate of 608 kg/ha and DAP at the rate of 260 kg/ha was applied on six mulberry varieties. The results showed a deficiency in nitrogen, phosphorus, zinc and manganese in soil before the fertilizer application. Contrarily, high copper and potassium contents were found. After three weeks of fertilizer application, concentration of N, P, K and Fe in the soil almost doubled. Zinc and Cu contents decreased significantly ($p<0.01$). The highest N, P and K were found in mulberry variety PFI-1, *M. latifolia* and Karyansuban, respectively. The highest Cu and Mn were found in Kanmasi. The highest Zn and Fe were found in Husang and Karyansuban, respectively. A significant variation in uptake and retention of macro- and micro nutrients was found in the mulberry varieties after fertilizer application. The highest N was taken up by Kanmasi, while the highest P and K were taken up by Husang. Iron and Cu increased, and Zn and Mn decreased after week 3 of fertilizer application. Nitrogen was 1.5 to 2.6 times greater after week 6 of fertilizer application compared to before fertilizer application. Similarly, P and K were 4.7 to 6.6 times and 2.6 to 3.9 times greater, respectively. Based on these findings, it is concluded that urea in split doses and diammonium phosphate in single dose should be applied 3-4 weeks before the commencement of rearing of Mulberry Silkworm Moth for nutritionally rich mulberry foliage.

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Introduction

The quality of mulberry leaf plays an important role in successful rearing of the Mulberry Silkworm Moth and cocoon production (Krishnaswamy 1978; Ravikumar 1988; Choudhury et al., 1991). The quantity and quality of mulberry leaf affect larval growth rate, larval body weight, survival larvae, fecundity, developmental periods of different metamorphic stages and economic cocoon characters (Rafique and Bajwa, 2003). There are several factors which influence quantity and quality of mulberry foliage including: soil type, climate, mulberry varieties and management practices of mulberry plantation (Raman et al., 1995; Rafique and Bajwa, 2005). Among these, production of nutritionally rich mulberry foliage on sustainable basis depends on soil fertility and its management through periodical application of farm yard manure and fertilizers in required quantity (Sengupta et al., 1992; Baqual and Das, 2006).

Among fertilizers, macronutrients including: nitrogen (N), phosphorus (P) and potassium (K) play important role in foliar growth, root development, cell division, flowering, and seed and fruit formation (Brady, 1984). Similarly, micronutrients, such as, zinc (Zn), copper (Cu), iron (Fe), manganese (Mn), etc. are essential for plant growth, transportation of nutrients, cell formation, uptake and retention of other minerals, transformation of compounds, metabolism and energy cycles. Deficiency in any single micronutrient may hamper plant growth and subsequently foliage yield (Cioroi and Florea, 2003; Mousavi, 2011). The deficiency or unavailability of these micronutrients are probably the result of various factors, like calcareous nature and alkaline reaction soils, introduction of high yielding varieties and heavy imbalanced application of macronutrients and low organic matter. Among the macronutrients, excessive and indiscriminate use of P-fertilizers can affect chemical or physiological interactions in soil-plant systems. These interactions, known as phosphorus induced micronutrients disorder (Timmer and Teng, 1990) reduce solubility of micronutrients (Zn, B, Cu, Fe and Mn), which leads toward their non-availability to plants. This phosphorus induced micronutrients deficiency has been proved in various soils and crops (Wang et al., 1990; Ajouri et al., 2004).

Rational use of macronutrients (NPK) is necessary for maintaining soil fertility, as well as, ensuring solubility and availability of micronutrients. Another important factor is uptake and retention of these macro- and micro nutrients by the plant species. This could help to schedule and budget the application of NPK for managing nutritionally rich mulberry foliage. Pakistan forest Institute is maintaining five exotic and one indigenous mulberry varieties. The empirical data of, both macro- and micro nutrients in soil and mulberry foliage was not quantified. Present study was, therefore, conducted to assess (i) macro- and micro nutrients in soil and mulberry foliage, and (ii) uptake and retention of the nutrients after fertilizer application by soil and mulberry varieties.

Materials and Methods

Macro- and micro nutrients in soil and six mulberry varieties were assessed during 2014-15 at Pakistan Forest Institute, Peshawar. Both, soil and mulberry foliage were analyzed for total Nitrogen, AB-DTPA extractible Phosphorus, Potassium, Zinc, Copper, Iron and Manganese before and after fertilizer application.

Fertilizer application and sampling

Urea and diammonium phosphate at the rate of 608 kg/ha and 260 kg/ha were applied, respectively. The fertilization followed by irrigation. Full dose of DAP and half dose of Urea were applied after collecting the samples, while the remaining half dose of Urea was applied four weeks after 1st fertilizer application. The plot area per treatment was 225 m^2, while the plant to plant and row to distance each was 1.5 m.

Composite soil sample at a depth of 0-20 cm was collected from the field of mulberry plants, while leaf samples from six mulberry varieties belonging to two species, *Morus alba* including: Husang (Chinese), Kanmasi (Japanese), Karyansuban (Korean), PFI-1 (Pakistani) and Qumji (Korean), and species *Morus latifolia* (Japanese) were collected.

Nitrogen assessment

The total N was assessed using the Kjeldahl method as described by Bremner and Mulvaney (1982). Soil sample and plant leaves were air dried and 0.5 g from each sample were taken, ground finely and were digested with 3.0 ml concentrated H_2SO_4 on block digester at low temperature and then at 350°C with 1.1 g digestion mixture ($CuSO_4$, K_2SO_4 and Se) until the digest became clear. Four milliliter of 40% NaOH was added to the digested material and distilled into 5.0 ml boric acid mixed indicator solution. The mixture was titrated against 0.005 N HCl. Total nitrogen was calculated using following formula:

$$Total\ Nitrogen\ (\%) = \frac{(mL\ sample - blank)\ x\ N\ of\ HCl\ x\ meg\ of\ N\ x\ dilution\ x\ 100}{Weight\ of\ plant/soil\ sample\ (g)\ x\ Volume\ taken\ for\ distillation\ (mL)}$$

Where:
N of HCl = 0.005 N
meq of N = 0.014
Volume of digestion = 100 ml
Weight of sample = 0.5 g
Volume taken for distillation = 20 ml (soil sample), and 10 ml (plant sample)

Phosphorus assessment

AB-DTPA (Ammonium bicarbonate-Diethylene Tri-amine penta acetic acid) extractable Phosphorus was extracted by the procedure as described by Soltanpour and Schawab (1977). Fifteen gram soil sample was added with 30 ml AB-DTPA (1:2) solution having pH 7.56. The suspension was shaken on gentle reciprocating shaker for 30 minutes in open-mouthed 250 ml conical flasks and then filtered through Whatmann no. 42. P in the sample was determined through NH_4-molybdate complex method. One milliliter of the extract was added with 4 ml distilled water and 5 ml ascorbic acid having P mixed reagent. The volume made up to 25 ml adding distilled water. Blank and five standards of 2, 4, 6 and 8 ml P per liter were also prepared with the same procedure to get standard absorption curve on spectrophotometer at 880 nm wavelengths. P contents were estimated in soil on dry weight basis using the standard absorption curve using following formula:

$$P\ (mgkge^{-1}) = Reading \times \frac{Volume\ of\ Extract\ taken}{Weight\ of\ sample}$$

In mulberry foliage, P contents were estimated through wet digestion method as described by Benton et al. (1991). An amount of 0.5 g of the dried ground leaf sample was treated with 10 ml concentrated HNO_3 for 24 h followed addition of 4 ml concentrated $HClO_4$. The mixture was heated until it became colourless. The mixture was cooled, filtered and diluted to 100 ml. P was estimated by standard absorption curve on spectrophotometer at 880 nm wavelengths. P was estimated using following formula:

$$P\ (mgkge^{-1}) = Reading \times \frac{Volume\ of\ Extract\ taken}{Weight\ of\ sample}$$

Potassium assessment

Potassium in the soil was determined by AB-DTPA extracting solution as described by Soltanpour and Schawab (1977) using Flame Photometer. The Potassium in mulberry foliage was estimated through wet digestion of the sample as suggested by Benton et al. (1991). An amount of 0.5 g dried ground mulberry leaves was treated with 10 ml concentrated HNO_3 for 24 h, added 4 ml concentrated $HClO_4$. The mixture was heated until it became colourless. After cooling it was filtered and diluted to 100 ml. The samples were run for K analysis through Flame Photometer. Potassium was estimated using following formula:

$$K\ (mgkge^{-1}) = Reading \times \frac{Volume\ of\ Extract\ taken}{Weight\ of\ sample}$$

Micronutrient assessment

Zn, Cu, Fe and Mn were estimated, both in soil and mulberry foliage through Atomic Absorption Spectrophotometer (AAS) following procedure as described earlier. The wavelength used for detection of micronutrients included: 248.3 nm, 213.8 nm, 324.8 nm and 279.5 nm for Fe, Zn, Cu, and Mn, respectively.

The experiment was conducted in randomized complete block design in four replications. The data was analyzed using 1-Way analysis of variance, while difference among the treatments was tested applying Least Significance Difference test (p=0.05).

Results and Discussion

Soil nutrients

The macro- and micro nutrients in soil showed variable temporal levels. The soil was found deficient in N, P, Zn and Mn. Fe was at marginal level. Contrarily, Cu and K were found at high level (Table 1). After fertilizer application, concentration of N and P, K and Fe increased significantly ($p<0.01$). Contrarily, Zn and Cu decreased significantly ($p<0.01$). The level of N, P and K was still greater after week 6 of fertilizer application compared to the level of N, P and K before the fertilizer application. However, N, P and K reduced significantly ($p<0.01$) after week 6 of fertilizer application compared to week 3. Zinc increased significantly after week 6 of fertilizer application. Fe and Mn before and after week 6 of fertilizer application remained almost same (Table 1).

Mulberry foliage nutrients

The results showed highly significant ($p<0.01$) variation in macro- and micro nutrients in different mulberry varieties. The highest N was found in PFI-1 followed by Karyansuban, while the lowest N was found in Kanmasi (Table 2). The difference in N between Husang and Qumji was not significant ($p>0.05$). The highest P was found in *M. latifolia*, while the lowest P was found in Husang. The difference in P among *M. latifolia*, Karyansuban, PFI-1 and Qumji was not significant. The highest K was found in Karyansuban, while the lowest K was found in PFI-1. The difference in K between *M. latifolia* and Qumji was not significant. The highest Zn was found in Husang, while the lowest Zn was found in Qumji. The highest Cu was estimated in Kanmasi. The difference in Cu among Karyansuban, PFI-1, *M. latifolia* and Qumji was not significant. The highest Fe was found in Karyansuban, followed by Husang and PFI-1. The lowest Fe was found in Qumji. The highest Mn was estimated in Kanmasi, while the lowest Mn was estimated in PFI-1. The Cu and Mn indicated similar pattern in different mulberry varieties (Table 2).

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Table 1: *Macro/micro nutrients in soil before and after fertilizer application*

Sampling time	N (%)	P (mg/kg)	K (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)
Before FA	0.075*± 0.021 b	0.740*± 0.012 c	86.725*± 0.993 c	0.6950*± 0.010 b	1.2375*± 0.018 a	2.8900*± 0.026 b	0.3950*± 0.013 b
After 1st FA	0.160± 0.002 a	1.423± 0.018 a	160.00± 1.581 a	0.3610± 0.023 c	0.6325± 0.023 b	5.4775± 0.071 a	0.5125± 0.015 a
After 2nd FA	0.109± 0.004 b	0.948± 0.009 b	102.250± 1.493 b	1.8888± 0.037a	0.4050± 0.021 c	2.9175± 0.283 b	0.2925± 0.022 c
CV	0.0429	0.029	5.4594	0.1068	0.0806	0.6402	0.0518

**Significant at 99% level; Figures in a column sharing same alphabet (s) are not significant (p=0.05; Least Significant Difference test); FA=Fertilizer application*

Table 2: *Macro/micro nutrients in mulberry foliage before fertilizer application*

Variety	N± SE (%)	P± SE (%)	K± SE (%)	Zn± SE (%)	Cu± SE (%)	Fe± SE (%)	Mn± SE (%)
Husang	1.068**± 0.021 c	0.094*± 0.001 c	1.038**± 0.008 d	0.0032**± 0.000 a	0.0023**± 0.000 b	0.0086**± 0.000 b	0.0243**± 0.001 b
Kanmasi	0.630± 0.003 e	0.114± 0.007 bc	1.199± 0.008 b	0.0029± 0.000 b	0.0039± 0.00 a	0.0066± 0.000 c	0.0305± 0.002 a
Karyansuban	1.173± 0.013 b	0.124± 0.002 ab	1.328± 0.007 a	0.0029± 0.000 b	0.0011± 0.000 c	0.0122± 0.000 a	0.0056± 0.000 e
M. latifolia	0.953± 0.011 d	0.140± 0.018 a	1.141± 0.002 c	0.0016± 0.000 c	0.0012± 0.000 c	0.0062± 0.000 c	0.0101± 0.001 d
PFI-1	1.275± 0.010 a	0.127± 0.002 ab	0.950± 0.021 e	0.0015± 0.000 c	0.0007± 0.000 d	0.0086± 0.000 b	0.0035± 0.000 f
Qumji	1.095± 0.017 c	0.125± 0.001 ab	1.146± 0.002 c	0.0013± 0.000 c	0.0007± 0.000 d	0.0056± 0.000 d	0.0146± 0.000 c
CV	0.039	0.024	0.032	0.0003	0.0004	0.0004	0.002

** Significant at 95% level; ** Significant at 99% level; Figures in a column sharing same alphabet (s) are not significant (p=0.05; Least Significant Difference test)*

Table 3: *Macro/micro nutrients in mulberry foliage after 3 week of fertilizer application*

Variety	N± SE (%)	P± SE (%)	K± SE (%)	Zn± SE (%)	Cu± SE (%)	Fe± SE (%)	Mn± SE (%)
Husang	1.235**± 0.021 bc	0.158ns± 0.011 a	3.995**± 0.021 b	0.0008**± 0.000 bc	0.0023*± 0.000 b	0.0293**± 0.001 d	0.0013**± 0.000 d
Kanmasi	0.898± 0.039 e	0.133± 0.011 b	4.265± 0.017 a	0.0018± 0.000 a	0.0016± 0.000 b	0.0650± 0.001 b	0.0223± 0.001 a
Karyansuban	1.328± 0.021 ab	0.143± 0.002 ab	3.743± 0.039 c	0.0007± 0.000 c	0.0018± 0.000 b	0.0245± 0.001 e	0.0009± 0.000 d
M. latifolia	1.083± 0.028 d	0.145± 0.002 ab	3.183± 0.017 d	0.0006± 0.000 c	0.012± 0.006 a	0.0433± 0.001 c	0.0180± 0.001 b
PFI-1	1.395± 0.024 a	0.149± 0.002 ab	2.515± 0.016 f	0.0007± 0.000 c	0.0008± 0.000 b	0.0655± 0.002 b	0.0023± 0.000 d
Qumji	1.175± 0.033 cd	0.140± 0.002 ab	2.625± 0.017 e	0.0010± 0.000 c	0.0013± 0.000 b	0.1140± 0.001 a	0.0064± 0.000 c
CV	0.093	0.021	0.065	0.0002	0.007	0.004	0.002

** Significant at 95% level; ** Significant at 99% level; ns non-significant; Figures in a column sharing same alphabet (s) are not significant (p=0.05; Least Significant Difference test)*

After week 3 of fertilizer application, different level of absorption and retention of macro- and micro nutrients was found in the mulberry varieties (Table 3). Nitrogen increased significantly ($p<0.01$) in all mulberry

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varieties. The highest N was found in PFI-1, while the lowest N was found in Kanmasi. The difference in N between PFI-1 and Karyansuban was not significant (p>0.05). Similarly, the difference between Husang and Karyansuban; Husang and Qumji; Qumji and *M. latifolia* was not significant. The highest P was recorded in Husang, while the lowest P was recorded in Kanmasi. The difference in P among Husang, Karyansuban, PFI-1, Qumji and *M. latifolia* was not significant. The highest K, Zn and Mn were taken up and retained by Kanmasi. The lowest K was taken up and retained by PFI-1. Copper increased in Karyansuban and *M. latifolia* after fertilizer application, while Cu decreased in Kanmasi. Iron increased significantly in mulberry varieties after the fertilizer application. The highest Fe was found in Qumji, while the lowest Fe was found in Karyansuban. The difference in Fe between Kanmasi and PFI-1 was not significant. In general, Mn decreased in mulberry foliage after week 3 of fertilizer application compared to before fertilizer application.

After week 6 of fertilizer application, a great variation in retention capacity of macro- and micro nutrients was found in mulberry varieties (Table 4). Macronutrients in mulberry foliage increased variably compared to week 3 of fertilizer application. The highest N and P were found in PFI-1, while the lowest N and P were found in Qumji. The difference in N between Karyansuban and *Morus latifolia;* Husang and Kanmasi; Kanmasi and Qumji was not significant. The variation in P in the mulberry varieties was not significant (p>0.05). The highest K was found in Kanmasi, while the lowest K was found in PFI-1. The difference in K between Karyansuban and *Morus latifolia*; PFI-1 and Qumji was not significant. Zinc and Cu decreased considerably in almost all mulberry varieties compared to week 3 of fertilizer application. The highest Zn was found in Kanmasi. The highest Cu was found in *M. latifolia*. The highest Fe was found in Qumji, while the lowest Fe was found in Karyansuban. The difference in Fe between Husang and *M. latifolia*; Husang and Karyansuban was not significant. The highest Mn was found in *M. latifolia*. The difference in Mn among Husang, Kanmasi and Karyansuban was not significant.

The present results show deficiency of macronutrients in soil. Application of urea increases concentration of N in soil which is also responded positively by the mulberry varieties. The soil deficiency of N may be due to the parent material and the alkaline calcareous nature of soil. In Pakistan, N deficiency in soil due to the parent material and soil nature has been reported earlier by Shah et al. (2012). Present findings of positive response of soil towards application of urea and consequently removing deficiency of N are in conformity with Ehsanullah et al. (2012) and Ali and Noorka (2013).

Phosphorus concentration in soil is ranged between low to moderate level. This deficiency of P in soil may be attributed to alkaline calcareous nature of soil as P makes insoluble compounds with calcium and

Table 4: *Macro/micro nutrients in mulberry foliage after 6 week of fertilizer application*

Variety	N± SE (%)	P± SE (%)	K± SE (%)	Zn± SE (%)	Cu± SE (%)	Fe± SE (%)	Mn± SE (%)
Husang	1.668**± 0.021 c	0.620ns± 0.020	4.072**± 0.000 b	0.00047*± 0.000 c	0.0012**± 0.000 b	0.017**± 0.000 de	0.0001**± 0.000 d
Kanmasi	1.628± 0.011 cd	0.632± 0.013	4.475± 0.011 a	0.0012± 0.000 a	0.00017± 0.000 e	0.046± 0.002 b	0.0015± 0.000 d
Karyansuban	1.800± 0.018 b	0.620± 0.027	3.792± 0.000 c	0.00022± 0.000 d	0.00021± 0.000 e	0.014± 0.000 e	0.0001± 0.000 d
M. latifolia	1.773± 0.022 b	0.635± 0.011	3.640± 0.000 c	0.0003± 0.000 cd	0.0042± 0.000 a	0.020± 0.001 d	0.030± 0.002 a
PFI-1	1.900± 0.020 a	0.778± 0.030	2.777± 0.000 d	0.00037± 0.000 c	0.00044± 0.000 d	0.040± 0.001 c	0.006± 0.000 c
Qumji	1.605± 0.014 d	0.585± 0.019	2.942± 0.000 d	0.00056± 0.000 b	0.00099± 0.000 c	0.054± 0.001 a	0.014± 0.000 b
CV	0.0568	0.2373	0.2798	0.00012	0.00022	0.0033	0.0025

** Significant at 95% level; ** Significant at 99% level; ns non-significant; Figures in a column sharing same alphabet (s) are not significant (p=0.05; Least Significant Difference test)* magnesium in alkaline calcareous soils. In Pakistan, about 90% soils are deficient in P due to its widespread calcareous nature (Sattar, 2011). In calcareous soil, recovery of phosphate fertilizer is low as 5-9% remains water soluble, while 15-25% is recovered by plants. Remaining part of phosphate fertilizer is converted to unavailable calcium and magnesium phosphates (Ahmad et al. 1992).

The present findings reveal further that Zn and Mn are deficient in soil, while Cu and Fe are present in greater concentration. Low levels of Zn and Mn, while insoluble form of Fe may be assigned to alkaline reaction of the soil. Previously, it has been found that calcareous soils may contain high levels of total Fe, but in forms unavailable to plants. This insolubility of Fe disorder in calcareous soils is not always attributable to Fe deficiency (Obreza et al., 1993). The increase in P and K, after week 6 of fertilizer application further shows that second application of urea has a synergistic effect on these macronutrients. Increase in macronutrients in mulberry foliage substantiated uptake of these nutrients by the mulberry varieties. The uptake of macronutrients by the mulberry foliage likely enhances growth performance of the mulberry varieties, vis-à-vis foliage productivity. The positive correlation between uptake of macronutrients and growth parameters of mulberry has been substantiated earlier by Baqual and Das (2006).

The decrease in Zn and Cu, both in soil and mulberry leaves after fertilizer application indicates negative interactions between macronutrients, and Zn and Cu. Moreover, increase in Fe and Mn shows positive interactions of these micronutrients with the macronutrients. The application of P as phosphatic fertilizer reduces the pH of soil and has favorable effect on the solubility of Fe and Mn in the alkaline-calcareous soils. The antagonistic effect of P on Zn and Cu, and synergistic effect of P on Fe and Mn in crops have been reported earlier by Ali et al. (2014). The synergetic effect may be due to positive interaction with applied phosphorus during incubation period. The decrease in Zn may be assigned to low absorption of Zn in presence of applied phosphorus. The antagonistic phenomenon, especially in soils with low carbonate contents has been reported by Mousavi (2011).

The present findings show positive response of mulberry varieties to the fertilizer application. However, level of uptake of macro- and micro nutrients and their retention in foliage depends on mulberry variety. PFI-1 is the most efficient variety for absorbing and retaining nitrogen. Husang has potential to absorb P quickly but cannot retain over a longer period of time. PFI-1 retains P for a longer period of time. Kanmasi uptakes greater quantity of K compared to other mulberry varieties, however, *M. latifolia* retains K for a longer period of time. The positive response of mulberry varieties towards nitrogenous and phosphatic fertilizers is in conformity with Baqual and Das (2006). Similarly, variety-specific nutrients uptake and retention response is in corroboration with Kumar et al. (2012). The increased K in foliage of different mulberry varieties may be due to increased N in foliage. The synergetic effect of increased N in foliage on K has been reported earlier by Shankar et al. (1994).

Among the micronutrients, Zn reduces after fertilizer application in all mulberry varieties. This trend continues after week 6 of fertilizer application. Kanmasi contains the highest Cu in foliage before fertilizer application, however, synergic effect is revealed in Cu uptake and fertilizer application in *M. latifolia.* Similar interaction exists between Fe and Qumji. Kanmasi is quick to uptake Mn but *M. latifolia* retains Mn over a longer period of time. Micronutrients are important like macronutrients as each micronutrient plays a significant specific role in physiological and biochemical processes of mulberry (Gowda et al., 2000). This variation in uptake and retention of micronutrients by the mulberry varieties may affect growth and quality of mulberry foliage. In other studies, micronutrients were found to influence qualitative and quantitative growth parameters of mulberry (Kumar et al., 2012). Among the micronutrients, Mn and Zn are important for normal growth of the plants. Zinc has a vital role in enzymes structure like dehydrogenases, aldolase and isomerases and also effective in energy production and Krebs cycle (Mousavi, 2011), while Mn is necessary for metabolic activities. Similarly, Fe is an essential micronutrient for transformation of carbohydrates and regulating consumption of sugars (Kumar et al., 2012). The present application of urea and phosphate has improved the uptake and level of micronutrients in the mulberry foliage.

Conclusions

Based on present findings it is concluded that soil in Peshawar is deficient in nitrogen and some nutrients. The soil can be enriched through fertilizer application.

Different mulberry varieties have variable capacity for uptake and retention of macro- and micro nutrients. Overall mulberry foliage can retain macro- and micro nutrients after week 6 of fertilizer application. Full dose of DAP at the rate 260 kg/ha and urea at the rate of 608 kg/ha, the later in two equal split doses should be applied 3-4 weeks before the commencement of rearing of Mulberry Silkworm Moth for maintaining macro- and micro nutrients in the mulberry foliage.

Authors Contributions

Ghulam Ali Bajwa (GAB) developed the concept of the research. GAB and Muhammad Arshad khan (MAK) designed the experiments. Both of the authors conducted the trials, analytical analysis of macro and micro nutrients and analyzed the research data. GAB prepared the manuscript draft for submission.

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