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Seasonal Variation in Macro Nutrient Contents of Mulberry (Morus Alba) Leaves under Temperate Climatic Conditions of Kashmir

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***Abstract* – Foliar analysis conducted during 1st phase (prior to pruning on May 1, May 15 and June 1) and 2nd phase (after pruning on August 1, August 15, September 1, September 15 and October 1) on eight sampling dates revealed that nitrogen, phosphorus, potassium and sulphur contents in leaf decreased with advancement of age, while as calcium and magnesium accumulated in leaves with maturity. Nutrient status of leaves depicted that during 1st phase level of all the three major nutrients NPK was higher as compared to the 2nd phase necessitating the augmentation of the deficit through application of fertiliser. Almost all the nutrients exhibited highest concentration in leaf on 1st of August and the period between 1st and 15th of August has been found to be stable period for most of the nutrients during 2nd phase, thereby, envisaging August 1 as the suitable date of brushing for taking up 2nd commercial silkworm rearing on June pruned plots.**

***Keywords* – Mulberry, NPK, Season, Split Application, Uptake, Yield.**

I. Introduction

Under tropical conditions of India, sericulture is practised throughout the year by harvesting as many as five to six crops, whereas in temperate areas only one rearing is practised under natural conditions in a year. Jammu and Kashmir state is bestowed with a climate well suited for the production of the bivoltine silk of international quality having scope for taking 2 crops in a year from May to September from same plantation but farmers are reluctant to take second cocoon rearing mainly because of poor quality of leaf available during summer/autumn seasons that obviously affects the health of silkworms and cocoon crop. Significant correlations have been reported between chemical composition of mulberry leaf and cocoon characters. Quality of leaf influences the healthy growth of silkworm larvae and thereby the quality of cocoons (Hajare *et al*., 2008) [1].

Foliar nutrient concentrations display appreciable changes during growing seasons due to reasons such as dilution factor, leaching of nutrients by rainfall, transport with in plant and also due to tendency of back translocation towards leaf abscission (Guha and Mitchell,1966)[2]. Leaf quality variations in mulberry at different maturity levels/growth periods are of special importance to silkworm (*Bombyx mori* L.).

In the event of some minor changes in the climate and rearing practice, the quality of leaf acts as buffer and helps in getting good cocoon crop. As the concentration of nutrients goes on changing with the maturity it is of utmost importance to find out the most suitable time for synchronising the availability of nutrients in the leaf with the requirement of the silkworm at different ages of its larval growth.

Although considerable work has been done in India on the nutrient contents of the mulberry leaves in response to seasons under tropical conditions, hardly any work has been done on these aspects under temperate climatic conditions of Kashmir Therefore, in view of the scanty information available on the subject and with a view to make sericulture more remunerative by exploring the possibility of multiple rearing on the basis of leaf nutrient status at different maturity levels, the present investigation was undertaken.

II. Material And Methods

The present investigation was carried out at the experimental farm of Temperate Sericulture Research Institute (located at 34°.17′ N latitude, 74°.17′ E longitude and at an altitude of 1585 meters above mean sea level) during the year 2009 and 2010. Chemo-assay of the mulberry genotype was carried out at the Division of Soil Science SKUAST-K Shalimar. The material and methods used for the study are presented under the following heads:

III. Study Material

Established mulberry plantation of Goshoerami (the most popular variety of mulberry used for commercial rearing in the region) with uniform growth and vigour was used for the study. The plantation was maintained as dwarf at 6´x6´ spacing. Cultural operations were followed as per the package of practices recommended by the Temperate Sericulture Research Institute Mirgund (Anonymous, 2003)[3] except for the application of chemical fertiliser which was done in a more split manner.

IV. Layout of the Experiment

Experiment was laid down in RBD comprising of 104 treatment combinations with thirteen fertiliser combinations including control (control 1&2) and eight number of leaf sampling dates. Three replications were maintained per treatment and number of plants per treatment/per replication was five.

Fertiliser was applied in two splits, first in the first week of April and the second split in the last week of June after harvesting first crop. Nitrogen was applied in three levels viz., N1, N2 and N3 (150 +150; 180 + 120 and 120 + 180 kg/ha/yr), phosphorus in two levels viz., P1 and P2 (120 + 00 and 60 + 60 kg/ha/yr) and potassium was also applied in two levels K1 and K2 (120 + 00 and 60 + 60 kg/ha/yr) respectively.

V. Fertiliser Combinations

F_1- $N_0P_0K_0$ (control 1); F_2- $N_1P_1K_1$ Recommended dose (control 2); F_3-$N_1P_1K_2$; F_4-$N_1P_2K_1$; F_5- $N_1P_2K_2$; F_6- $N_2P_1K_1$; F_7- $N_2P_1K_2$; F_8 -$N_2P_2K_1$; F_9 - $N_2P_2K_2$; F_{10} -$N_3P_1K_1$; F_{11} - $N_3P_1K_2$; F_{12} - $N_3P_2K_1$; F_{13} - $N_3P_2K_2$.

VI. Leaf Analysis

Composite leaf samples comprising of coarse, medium and tender leaves were collected from all the four sides of the plant as described by Nakashima (1931)[4]. Samples were collected on May 1, May 15, June 1, August 1, August 15, September 1, September 15 and October 1during both the years of study.

Leaf samples after collection were washed with tap water, and then dipped in 0.1% HCl. The samples were then washed with single and double distilled water. These samples were air dried on filter papers and then oven dried at 60±5°C (Chapman, 1964)[5] till constant weight was obtained. The samples were crushed in stainless steel blender and sieved through 0.2 mm mesh.

For estimation of nitrogen, samples were digested in conc. H_2SO_4 in presence of digestion mixture comprising of potassium sulphate, iron sulphate, copper sulphate and salicylic acid in the ratio of 10:1:05:1. The digestion was carried out in the digestion unit by initially keeping the temperature of unit at 100°c for 30 minutes and then raising the temperature to 410°C for 2 hours till the samples became clear. For determination of phosphorus, potassium, calcium, magnesium and sulphur the samples were digested in di acid (nine parts of HNO_3 and four parts of $HClO_4$). The digestion was carried out in 100ml conical flasks on hot plate till the solution became clear.

Distillation of the digested samples for determining Nitrogen was carried out on kjelteck apparatus by collecting ammonia on boric acid forming ammonium borate which was later titrated with N/50 H_2SO_4 following the procedure given by Jackson (1973)[6]. Phosphorus was determined by Vanadomolybdo phosphoric acid yellow colour method as outlined by Jackson (1973)[7] and Potassium was estimated on flame photometer as described by Jackson (1973)[8]. Calcium and magnesium was estimated by Versenate method as described by Jackson (1973)[9]. Sulphur was determined by turbidimetric method given by Chesnin and Yien (1951)[10].

VII. Statistical Analysis

Data was compiled and analysed as per standard statistical procedure (Gomez and Gomez, 1984)[11].

EXPERIMENTAL FINDINGS

Nutrient components of leaf

For convenient interpretation of results, sampling prior to and after pruning have been reflected hereafter as 1st Phase (May 1, May 15 and June 1) and 2nd phase (August 1, August 15, September 1, September 15 and October 1) respectively.

Data pertaining to the macronutrient content of mulberry leaf is presented in Table 1 and illustrated in Fig. 1.

Nitrogen

During 1st phase highest nitrogen content of 3.434 per cent was recorded on May 15 (2nd sampling date) which was at par with the 1st sampling date (May 1) but significantly different from 3rd sampling date i.e. June 1. Whereas during 2nd phase nitrogen content of leaves followed a definite trend and it decreased significantly with maturity. Highest nitrogen content of 4.336 per cent was recorded on 1st sampling date which was significantly different from other sampling dates. Least nitrogen content of 2.953 per cent was recorded on last sampling date i.e. October 1. All sampling dates differed significantly from each other.

Seasonal influences reveal that during 1st phase nitrogen content increased initially and then decreased on the 3rd sampling date while as during 2nd phase there was gradual and significant decrease in nitrogen content with the advancement of season.

Phosphorus

During 1st phase highest phosphorus content (0.261 %) was recorded on the 1st sampling date (May 1) and it decreased significantly with maturity recording minimum content of 0.216 per cent on 3rd sampling date i.e. June 1. Whereas during 2nd phase phosphorus content of leaves decreased gradually with maturity, highest P content of 0.267 per cent was recorded on 1st sampling date which was statistically at par with 2nd sampling date. Lowest P content of 0.150 per cent was recorded on 5th (last) sampling date i.e. October 1 which was statistically at par with P content of 3rd and 4th sampling dates.

Seasonal influence on phosphorus content during 1st phase indicated that P content decreased significantly with maturity while as during 2nd phase there was gradual decrease in P content with the increase in leaf age.

Potassium

Perusal of data reveal that during 1st phase highest potassium content (1.877 %) was recorded on the 1st sampling date i.e. May 1 which was significantly higher than 2nd and 3rd sampling dates which were in turn at par with each other. Potassium content exhibited decline in leaf with maturity. During 2nd phase highest potassium content of 1.545 per cent was recorded on 1st sampling date which was significantly higher than rest of the sampling dates. Potassium content exhibited decline with maturity except for the last sampling date which recorded K content of 1.424 per cent being significantly higher than that of 2nd, 3rd and 4th sampling dates. Lowest K content of 1.306 per cent was recorded on 4th sampling date which was statistically at par with K content of 3rd sampling date.

Seasonal impact on potassium content revealed that during 1st phase potassium content decreased gradually with maturity while as during 2nd phase there was gradual decrease in potassium content up to 4th sampling date with sudden increase on the last sampling date. Higher potassium content was recorded during 2nd phase as compared to 1st phase on corresponding sampling dates.

Calcium

During 1st phase highest calcium content of 1.291 per cent was recorded on the 3rd sampling date i.e. June 1 which was significantly higher than 2nd and 1st sampling dates. Calcium content in leaf exhibited significant increase in leaf with maturity whereas during 2nd phase highest calcium content of 1.640 per cent was recorded on 5th sampling date which was significantly higher than rest of the sampling dates. Calcium content exhibited significant increase with maturity. Least Ca content of 1.191 per cent was recorded on 1st sampling date. Calcium content in leaf on all sampling dates was significantly different from each other.

Seasonal influence on calcium content revealed that during both phases Ca content increased significantly with maturity. Calcium content during 1st phase ranged from 0.998 per cent to 1.291 per cent while as during 2nd phase Ca content ranged from 1.191 per cent to 1.640 per cent being higher during 2nd phase than 1st phase

Magnesium

During 1st phase highest Mg content of 0.442 per cent was recorded on the 3rd sampling date i.e. June 1 being significantly different from 2nd and 1st sampling dates which were in turn statistically at par with each other. Magnesium content in leaf exhibited increase with maturity while as during 2nd phase highest Mg content of 0.659 per cent was recorded on 3rd sampling date which was significantly higher than rest of the sampling dates. Magnesium content exhibited increase till 1st September and then decreased gradually till last sampling date. Lowest Mg content of 0.498 per cent was recorded on 1st sampling date.

Seasonal impact on mulberry revealed that during 1st phase Mg content increased gradually with maturity while as during 2nd phase Mg content increased significantly till 3rd sampling date and then decreased till 5th sampling date.

Magnesium content during 1st phase ranged from 0.357 to 0.442 per cent while as during 2nd phase it ranged from 0.498 to 0.659 per cent indicating higher concentration of magnesium during 2nd phase than in 1st phase.

Sulphur

Maximum sulphur content of 0.236 per cent was recorded during 1st phase on the 1st sampling date i.e. May 1 which was significantly higher than 2nd and 3rd sampling dates. Minimum sulphur content of 0.198 per cent was recorded on the 3rd sampling date. Sulphur content in leaf exhibited decline with maturity. Again during 2nd phase maximum S content of 0.409 per cent was recorded on 1st sampling date which was significantly higher than rest of sampling date. Sulphur content exhibited decline with maturity. Lowest S content of 0.101 per cent was recorded on 5th sampling date. Sulphur content of 0.178 per cent recorded on 2nd sampling date was statistically at par with 3rd and 4th sampling dates.

Sulphur content decreased significantly with maturity during 1st phase while as during 2nd phase there was gradual decrease in it with maturity. During 1st phase leaf exhibited higher sulphur content ranging from 0.198 to 0.326 per cent while as during 2nd phase S content was markedly less than that of 1st phase with the exception of 1st sampling date which recorded highest S concentration (0.409 %) among both phases.

VIII. Discussion

The experimental findings recorded during the course of investigation are discussed under the following heads:

Status of primary nutrients with respect to sampling dates

Nitrogen content during 1st phase showed increasing trend (3.053 to 3.434 %) from May 1 to May 15 and decreasing trend (3.434 to 3.426 %) on June 1. Similar trend in nitrogen content has been reported by Bongale *et al.* (1997)[12]. Whereas, during 2nd phase it decreased significantly (4.336 to 2.953 %) with maturity. Present findings receive support from the findings of Nakajima (1975)[13]; Rangaswami *et al.* (1976)[14]; Jawale *et al.* (1981)[15]; Sreedhara *et al.* (1988)[16]; Sinha *et al.* (1993)[17]; Chaluvachari and Bongale (1994)[18]; Shivaprakash *et al.* (2000) [19] and Singhal *et al.* (2006)[20].

Phosphorus content during both the phases decreased significantly (0.261 to 0.216 in 1st and 0.267 to 0.150 % in 2nd phase) with maturity which is in conformity with the findings of Satpal *et al.* (2004)[21], Malik and Ahmad (2008) [22]and Haseeb (2010)[23] who have reported similar trend while working on mulberry, pear and plum respectively. The present observations are also supported by earlier reports of Batjer and Westwood (1958)[24] in peach; Rehalia and Nijjar (1986)[25] in sub tropical peaches; Chandel and Rana (2004)[26] in kiwi fruit and Rehalia and Sandhu (2005)[27] in persimmon.

Potassium content decreased significantly (1.877 to 1.711 %) with maturity from May 1 till June 1. Similar trend been reported by Malik (2008)[28] in pear leaf, whereas during 2nd phase potassium decreased gradually (1.545 to 1.306 %) till September 15 and then increased slightly (1.424 %) on last sampling date i.e., October 1. Similar observations have been reported by Himelrick and Pollard (1977)[29] in apple and Saini *et al.* (1998)[30] in plum.

In the present study the highest level of N, P and K during earlier stages could be attributed to absorption and mobilisation from the previous year's reserves as resumption of vegetative growth coincides with mobilisation of reserves from branches. Thomas (1927)[31], Sharma and Chandel (2005)[32] have also reported similar pattern of nutrient composition while carrying work on *Pyrus malus* L. and kiwifruit respectively.

The decreasing trend of N, P and K observed during the 2nd phase might be due to growth dilution effect as also reported by Smith (1962)[33], Leece and Gilmour (1974)[34], Chuntanaparb and Cummings (1980)[35] and because of high mobile nature of the nutrients within the plant system. Cameron *et al.* (1952)[36] have also attributed this condition to utilisation of these nutrients by various sinks at different stages of development while working on influence of age of leaf, season of growth and fruit production on the size and inorganic composition of Valencia orange leaves.

Status of secondary nutrients with respect to sampling dates

Calcium content increased significantly (0.998 to 1.291 during 1st and 1.191 to 1.640 % during 2nd phase) with leaf maturity during both the phases. The present results are in line with those of Jawale *et al.* (1981)[37]; Satpal *et al.* (2004)[38]. Similar findings have also been reported by Sanchez-Alonso and Lachica (1987)[39] in cherry, Verma and Bhandari (1990)[40] in peach.

Magnesium content increased significantly (0.357 to 0.442 %) with maturity from May 1 till June 1 which was true during 2nd phase as well up to 1st September (0.498 to 0.659 %). This however, showed a decrease from 0.659 to 0.561 % towards October 1.

The increasing trend of calcium and magnesium with the age of leaf could be attributed to limited mobility of these elements in phloem (Smith, 1962; Leece and Gilmour, 1974)[41-42]. The increase in calcium may also be attributed to deposition of calcium as calcium pectate in middle lamella and replacement of starch deposits by calcium oxalate crystals which help in sequestering calcium in the leaves (Shear and Faust, 1980)[43]. Calcium incorporated into cell wall becomes immobilised and cannot move to other parts thus resulting in higher contents in medium and coarse leaves. Whereas, increase in magnesium content may also be attributed to decrease in potassium content of leaves as these ions are strong antagonists, thus the cation magnesium is accumulated at the expense of potassium decrease (Loue, 1964)[44]. However, decrease in magnesium content on October 1 may also be due to lower soil temperature which alters root activity and in turn affects cation absorption as has also been reported by Melich and Reed (1948)[45].

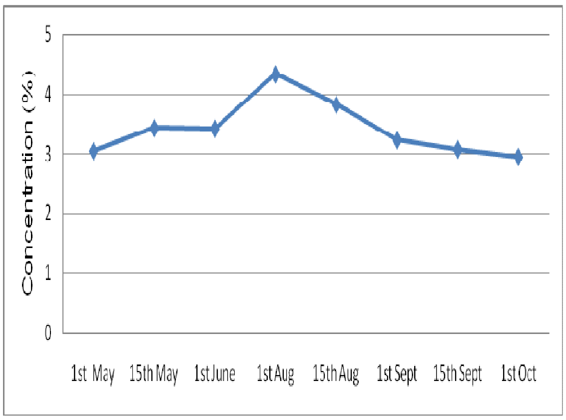
Reverse was the case with sulphur content which exhibited significant decrease (0.326 to 0.198 during 1st and 0.409 to 0.101 % during 2nd phase) with maturity during both the phases. The decline in sulphur content could be due to dilution effect of growth and also due to utilisation of sulphur by growing points (Smith and Reuther, 1950)[46]. Similar pattern has been reported by Saini *et al.* (1998)[47] in plum and Rehalia and Sandhu (2005)[48] in persimmon.

IX. Conclusion

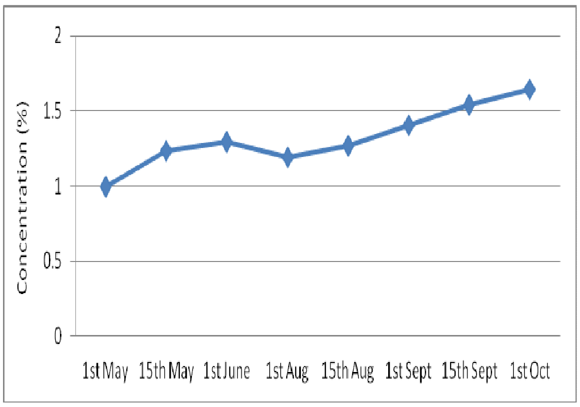
Almost all the nutrients exhibited highest concentration in leaf on 1st of August and the period between 1st and 15th of August has been found to be stable period for most of the nutrients during 2nd phase, thereby, envisaging August 1 as the suitable time for taking up of 2nd commercial silkworm rearing on June pruned plots.

Table-1: Seasonal trends in the leaf macronutrient content (%) of mulberry.

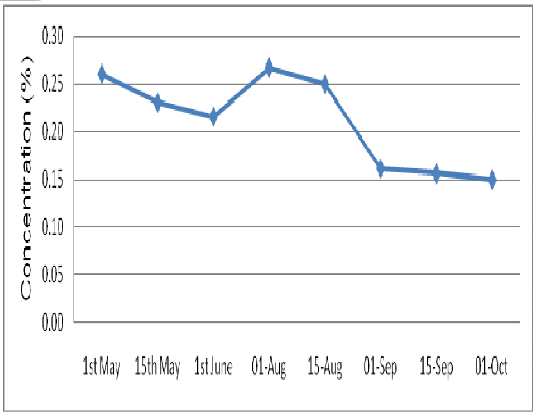
Nutrients	1st Phase (prior to pruning)				2nd Phase (after pruning)					
	May 1	May 15	June 1	CD (0.05)	Aug. 1	Aug. 15	Sept. 1	Sept. 15	Oct. 1	CD (0.05)
Nitrogen	3.053	3.434	3.426	0.1100	4.336	3.826	3.236	3.080	2.953	0.1023
Phosphorus	0.261	0.230	0.216	0.0079	0.267	0.250	0.161	0.156	0.150	0.0177
Potassium	1.877	1.734	1.711	0.0344	1.545	1.362	1.307	1.306	1.424	0.0303
Calcium	0.998	1.233	1.291	0.0569	1.191	1.264	1.409	1.539	1.640	0.0514
Magnesium	0.357	0.387	0.442	0.0305	0.498	0.624	0.659	0.607	0.561	0.0283
Sulphur	0.326	0.259	0.198	0.2732	0.409	0.178	0.173	0.158	0.101	0.0205



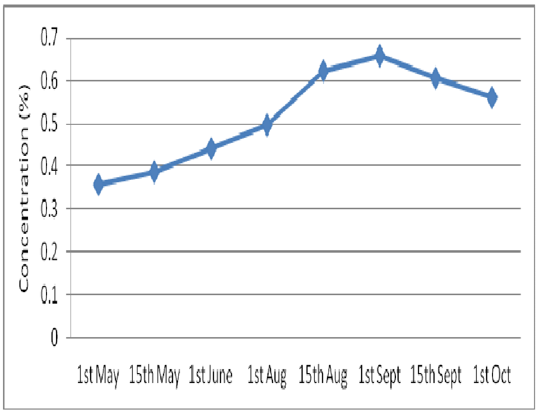
Seasonal variation in N content (%)



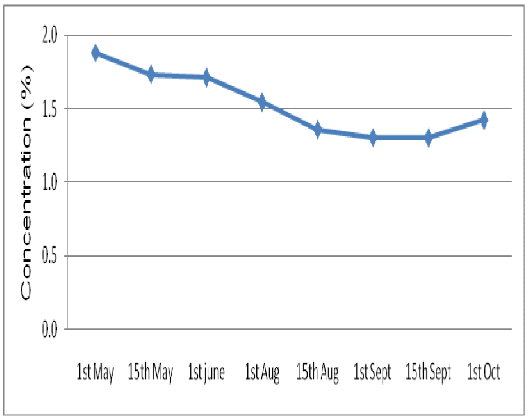
Seasonal variation in Ca content (%)



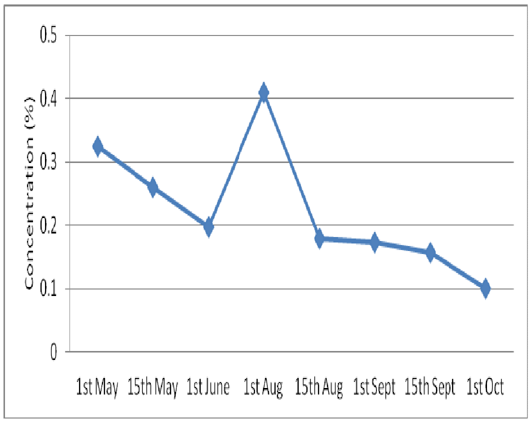
Seasonal variation in P content (%)



Seasonal variation in Mg content (%)



Seasonal variation in K content (%)



Seasonal variation in S content (%)

Fig.1. Seasonal variation in macronutrient contents

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