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Phytomorphology and Nutrient Dynamics of Mulberry Leaf

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ABSTRACT

Background: The present study on the topic "Phytomorphology and nutrient dynamics of mulberry leaves" revealed high variability among mulberry varieties. Internodes were largest in variety Tr4 (6.06%). Actual leaf area was high in variety S146 (275.57 cm2). Numbers of leaves per meter branch was largest in variety S1531 (20.9). During 5 periodic sampling from sprouting to maturity average fresh and dry leaf weight of 100 leaves was high (197.93g) and (60.24g) respectively during 5th sampling. Average moisture content was high (83.41%) during 1st sampling highest average chlorophyll content (SPAD value) was also observed during 4th sampling (40.01%). Acidity was also high in variety Tr_4 during maturity. Sugar content was high in variety T1 (3.66%) during 1st sampling (15 days). Starch and ash content was high in variety S1708 (43.06%) and (32.50%) during 5th sampling. Nitrogen and protein content was highest in variety S1608 (5.02%) and (31.56%) respectively during 1st sampling.

Methods: In the field-laboratory investigation was conducted at Division of Sericulture and Division of Biochemistry & Plant Physiology, SKUAST-J, Chatha, during spring 2013. Ten mulberry varieties T1, Tr4, V1, S146, S1708, S799, S1608, S1531, S41 and Sujanpur were evaluated for phytomorphological and nutrient dynamic studies. The experiment was laid in Complete Randomized Block Design with three replicates. Each variety was taken as treatment and observations were recorded after 15 days interval upto 75th day after sprouting.

Result: On the basis of current result, parameter observed fluctuations from the date of sprouting till maturity. Varietal response to periodic sampling too varied. Protein decreases age along with sugar, nitrogen. On the contrary starch, biomass, ash, chlorophyll shown a gradual increase. This information can be utilized to harvest a particular type of leaf for a particular age and rearing.

Key words: Acidity, Ash, Chlorophyll, Maturity, Mulberry, Nitrogen, Protein, Starch, Sugars.

INTRODUCTION

Mulberry (*Morus alba*) is a native of Sino-India region, believed to have originated on lower slopes of Himalayas. It is an important genus of an family Moraceae and is having around 68 recognised species available in different parts of the world of which 35 species are found in Asia Gururajan (1962) grouped cultivated forms of mulberry into 3 species namely *Morus alba* (bush mulberry in Karnataka, Tamil Nadu, Andhra Pradesh) *M. bombysis* (Behrampur varieties and West Bengal) *M. latifolia* (include tree mulberry grown in Kashmir and Uttar Pradesh) based on classification by Hotta (1954).

Morus is a perennial deciduous plant, where some species are found in natural habitat up to an elevation of 7000 ft (AMSL) *Morus indica* and *Morus alba* are mostly available in cultivable forms unlike, *M. laevigata* and *M. serrata* (Hooker 1885). It grows in varied types of agro climates, ranging from tropics to temperate regions and is unique in expression showing evergreen habit in tropical areas and deciduous in temperate zones. For optimum sprouting of buds and growth of mulberry the mean atmospheric temperature should not fall below 13°C and it should not exceed above 38°C for best mulberry growth 24-27°C is optimum. Global survey of sericulture industry reveals that mulberry is cultivated in 29 countries. Most of the mulberry growing countries fall in south of equator. *Morus* is a Latin word for mulberry and its leaf protein is the source for silkworm to bio-synthesize silk. Around 70 percent of silk protein produced by a silkworm is directly derived from protein silk of mulberry leaves. Mulberry silkworm being monophogus, the host specificity of these organisms is not mainly due to nutritional superiority *i.e.* in the amount of primary substances in mulberry leaves but also due to the presence of attractants in the leaves. These attractants are compounds which possess characteristic odour and taste.

Hundreds of mulberry varieties have been developed with varying nutritive values with the sole objective of producing protein rich leaf which silkworm ultimately converts into silk protein. The principal mulberry growing states of India are Karnataka, West Bengal, J&K, Tamil Nadu and Andhra Pradesh. Mulberry as manageable trees are raised in temperate climate like Japan and J&K while as it is raised as bush in tropical conditions. Cultivation of mulberry plays a significant role in determining the cocoon production. There is considerable amount of confusion in the taxonomy of genus *Morus* as adopted in different countries perhaps because of its adaptability to cross pollination in nature which

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results in wide variation in plant characters. The leaf quality shows wide variation between different varieties and at times in the same variety also, depending upon the agro climate and age of leaf *etc.* Mulberry leaf matures in about eight to nine weeks, when the nutrient concentration is maximum and full size of leaf lamina is achieved. The quality and quantity of mulberry leaf fed to silkworm determines the end product that is cocoon. The other important characteristics of mulberry leaf include protein content, biomass, carbohydrate, ash and fibre content. These components have direct influence on quality of cocoon production. Depending upon the age of silkworm, leaf requirement differs more or less corresponding to the age of worm. First and second age larvae prefer leaf with maximum protein and moisture content. For post chawki worms, leaf moisture with the range of 65-70 per cent is suited.

Production of mulberry leaves on scientific lines is essential for organizing a sound sericulture industry. India is the world leader in tropical sericulture and stands second in raw silk production in the world. Sericulture in India is practiced in diverse environmental condition, which requires large number of location specific mulberry varieties to meet the specific needs. To achieve this goal it is important to know the status of different nutrients present in the leaf at different developmental stages, besides, phytomorphological characters occurring from sprouting to maturity of the leaf. In this context the present study was envisaged and designed for the observations on some improved mulberry varieties introduced in the local agro climatic conditions of Jammu region of J&K state with below mentioned objectives:

1. To determine the morphometric characters of the improved mulberry varieties.
2. To determine the leaf nutrient status at different developmental stages.

MATERIALS AND METHODS

Present study was undertaken as a part of Post Graduate degree programme under the title "Phytomorphology and nutrient dynamics of mulberry leaf." Ten mulberry varieties T1, Tr4, V1, S146, S1708, S799, S1608, S1531. S41 and Sujanpur were evaluated for phytomorphological and nutrient dynamic studies. The varieties studied are maintained in the germplasm of Division of Sericulture, Udheywala, Jammu as bush plants at a distance of 1×1 m. The experiment was laid in complete randomized block design with three replicates. Each variety was taken as treatment and observations were recorded after 15 days interval up to 75th day after sprouting. The biochemical analysis was conducted at Division of Biochemistry and Plant Physiology, SKUAST-J, Chatha, during spring 2013. The morphological and physical characters of the mulberry varieties were evaluated as under.

Morphological characters

Leaf shape

It was observed visually and classified.

Leaf size

It was determined on the basis of length and breadth with the help of measuring scale. Ten leaves of each variety were taken for the measurements, in replicated form and data was statistically analysed.

Intermodal distance

It was measured with the help of measuring scale. Three plants of each variety were selected. Fifty measurements were taken in each replicate.

Fresh leaf weight

Hundred leaves per replicate of each variety were picked randomly and fresh weight determined. Observation was recorded on samples taken at 15 days interval from the date of sprouting to 75 day of maturity.

Dry weight or biomass

Hundred leaves per replicate of each variety were selected randomly for weighing. Samples were oven dried at 70°C was achieved to determine the dry matter gravimetrically.

Actual leaf area

Fifth or sixth leaf of a branch was selected for calculating actual leaf. Ten leaves of each variety per replicate were plotted graph to determine the area.

Chemical characters

The chemical analysis of leaf was carried out for chlorophyll, moisture, ash content, nitrogen, protein, sugar, starch, acidity and chlorophyll.

Moisture

Moisture was determined gravimetrically by taking a sample of 100 g of leaf and oven dried at 700°C till constant weight was achieved. Moisture was determined as per the following equation:

$$\text{Moisture} = \frac{\text{Fresh weight of leave - Dry weight (leaves)}}{\text{Fresh weight}} \times 100$$

Ash content (%)

5 g of leaf sample was ignited at 600°C to burn off all the organic material. The inorganic material which does not volatize at said temperature is Ash (AOAC, 1965). It was calculated by using following formula:

$$\text{Ash \%} = \frac{\text{Weight of ash}}{\text{Fresh weight}} \times 100$$

Nitrogen content (%)

It was estimated by micro Kjeldahl method (Jackson, 1973). N in sample was calculated by applying the following formula

$$\text{Per cent nitrogen} = \frac{\text{Titer value} \times 0.00014 \times \text{Volume made}}{\text{Liquot take (g} \times \text{Weight of sample (g)}} \times 100$$

Protein content (%)

It was calculated from the value obtained for nitrogen content by applying a factor of 6.25.

Sugar content (%)

Total sugar content was estimated by phenol -Sulphuric Acid method (Dubois *et al*., 1951).

Starch content (%)

It was also estimated by phenol-sulphuric acid method (Dubios *et al*. 1951) Acidity%: Total acidity of mullbery leaf was determined by titration method. Total acidity was calculated in terms of ascorbic acid using formula:

$$\frac{\text{Normality of NaOH} \times \text{E4 weight of Ascorbic Acid} \times \text{Titre value}}{\text{Weight of Sample}} \times 100$$

Chlorophyll content

Total chlorophyll content was determined by using SPAD-502 chlorophyll meter and Spad value was recorded for inferences.

RESULTS AND DISCUSSION

Mulberry leaf is reported to attain maturity in about 8 to 9 weeks depending on the climatic conditions. At maturity leaf attains maximum size and is optimally high in nutrients required by Silkworm for biosynthesis of silk materials and produce cocoons. Although optimal values may be attained on maturity but assimilation starts from sprouting and for different stages of silkworm, leaf is suitable at different stages of development.

In order to analyse the fluctuations the present work was initiated and observations made are detailed as under: Leaf shape:

Leaf shape

Leaf shape was ovate in six varieties are T1, Tr4, S799, 1608, S1531 and S41: wide ovate in S146 and S1708 and narrow ovate in VI. It was deltoid in variety Sujanpur (Table 1).

Leaf size (length and width)

Leaf size fluctuated amongst the varieties on the basis of length and width (Table 1). It was observed that leaf was longest (26.60cm) in Tr4 followed by S146 (2613cm), Sujanpur (22.96cm), T1 (22.96cm), S41 (21.70cm), S1708 (21.66cm), V1 (21.56cm), S1531 (21.03cm). S799 (20.76cm), S1608 (20.00cm). Leaf was widest in variety V1 (40.03cm) followed by S146 (37.33cm), Sujanpur (33.96cm), Tr4 (32.76cm), T1 (32.43 cm), S1708 (32.10cm), S799 (31.70cm), S41 (30.03cm), S1531 (29.86cm) and S1608 (28.46cm).

Actual leaf area

Actual leaf area fluctuated significantly in between the varieties (Table 1). It was maximum (275.57cm^2) in S146 followed by Tr4 (235.83cm^2), S1708 (79.89cm^2) S799 (178.71cm^2), S1531 (167.91 cm^2), V1 (45.19cm^2), Sujanpur (136.37cm^2) T1 (122.71cm^2), S41 (112.07cm^2) and S1608 (101.31 cm^2).

Internodal distance

Internodal distance is one of the most important characters for higher leaf yield. It varied from 6.06 to 4.65cm (Table 1). It was t in Tr4 (6.06cm) followed by V1 (5.78cm), S1708 (5.50cm), S146 in (5.32 cm), S799 (5.13cm), S1608 (5.11 cm), S41 (5.10cm) and S1531 (4.65cm).

Leaves per branch per meter

Number of leaves fluctuated significantly in between the varieties (Table1). It was maximum (20.9) in variety S1531 followed by Sujanpur (19.8), S41 (19.6), S146 (19.6), S1608 (19.3), T1 (19.0) S1708 (18. 2), V1 (18.1) and Tr4 (16.8).

Leaf weight (100 leaves)

The leaf weight on the first sampling (15 days) ranged from 38.16g/100 leaves in variety S1708 to 13.50gm in variety S799. The average leaf weight was 27.43 g. On second sampling (30 days) fresh leaf weight fluctuated from 117.33g/100 leaves in variety Tr4 to 55.33g in variety S146. The average leaf weight was 89.92 g. On third sampling (45 days) fresh leaf weight fluctuated from 161.00g/100 leaves in

Table 1: Morphological characters of mulberry leaf at maturity.

Mulberry variety	At maturity					
	shape	Leaf Length	Size width	Actual leaf Area (cm^2)	Leaves no/ meter/branch	Internodal distance (cm)
T1	Ovate	22.96	32.43	122.71	19.0	5.30
Tr4	Ovate	26.60	32.76	235.83	16.8	6.06
V1	Narrow ovate	21.56	40.03	145.17	18.1	5.78
S146	Wide ovate	26.13	37.33	275.57	19.6	5.32
S1708	wide ovate	21.66	32.10	179.89	18.2	5.50
S799	Ovate	20.76	31.70	178.71	19.6	5.13
S1608	Ovate	20.00	28.46	101.37	19.3	5.11
S1531	Ovate	21.03	29.86	167.91	20.9	4.65
S41	Ovate	21.70	30.03	112.07	19.6	5.10
Sujanpur	deltoid	22.96	33.96	136.37	19.8	5.05
Average		22.53	32.86	165.56	19.09	5.03
CD (5%)		3.00	2.40	20.11	1.33	1.36

variety Tr4 to 96.00 g in variety S146. The average leaf weight was 117.49 g. On fourth sampling date (60 days) fresh leaf fluctuated from 225.33 g/100 leaves in variety Tr4 to 103.33g in variety S146. The average leaf weight was 146.72gm. On last sampling (75 days) fresh leaf weight fluctuated from 269.33g to 109.33gm in variety S799. The average leaf weight was 197.93gm. The differences in between the varieties were significant during all sampling dates (Table 2).

Dry matter (g/100 leaves)

The dry weight on first sampling (15 days) fluctuated from 8 33g /100 leaves in variety S1708 to 3.00gm in variety S799. The average dry weight was 5.84g. On second sampling 30 days) it fluctuated from 25.00g/100 leaves in variety V1 to 11.66 gm in variety S799. The average dry weight was 17.06 g. On third sampling (45 days) dry weight fluctuated from 39.33/100 leaves in variety S1531 to 14.66 g in variety T1. The average dry weight was 25.82 g on fourth sampling (60 days) dry weight fluctuated from 78.60 g100 leaves in variety Tr4 to 22 in variety T1. The average dry weight was 40.52 g. On last sampling (75 days) dry weight fluctuated from 96.66g/100 leaves in variety Tr4 to 25.33 g in variety S799. The average dry weight was 60.24 g. The differences in between the varieties were significant (Table 3).

Moisture content

The moisture content on first sampling fluctuated (15 days) from 87.98 per cent in a variety S41 to 78.77 per cent in variety S1531. The average moisture content was 83.41 per cent. On second sampling (30 days) it fluctuated from 83.51 per cent in variety S799 to 76.22 per cent in variety S1608. The average moisture content was 79.87 per cent. On 3rd sampling on (45 days) it fluctuated from 81.43 per cent in variety Tr4 to 72.17 per cent in variety S1531. The average moisture content was 76.37 per cent. On 4th sampling (60 days) moisture content fluctuated from 76.79 per cent in variety S146 to 65.30 per cent in variety Tr4. The average moisture content was 71.10 per cent. On last sampling (75 days) moisture content fluctuated from 76.56 per cent in variety S146 to 56.28 per cent in variety S1708. The average moisture content was 68.41 per cent. The differences in between the varieties were significant during first 4 samplings and non-significant during 5 sampling (Table 4).

Table 2: Fluctuations in fresh (100 leaves) weight content (g) during developmental stages.

Mulberry variety	Fresh leaf weight content (g) days after sprouting				
	15	30	45	60	75
T1	32.33	74.50	96.66	105.33	175.33
Tr4	36.88	117.33	161.00	225.33	269.33
V1	27.03	132.66	154.33	162.66	255.33
S146	26.33	55.33	96.00	103.33	182.00
S1708	38.16	109.50	110.33	138.66	142.66
S799	13.50	68.06	99.83	105.33	109.33
S1608	20.50	88.66	101.66	172.66	214.66
S1531	30.66	71.33	104.00	142.00	255.33
S41	27.66	88.22	121.11	167.33	208.00
Sujanpur	21.33	93.66	130.00	144.66	167.33
Average	27.43	89.92	117.49	146.72	197.93
CD (5%)	4.32	24.77	35.25	19.64	63.60

Table 3: Fluctuations in dry (100 leaves) weight content (g) during different developmental changes.

Mulberry variety	dry leaf weight content (g) days after sprouting				
	15	30	45	60	75
T1	5.66	13.00	14.66	22.66	48.00
Tr4	6.83	19.50	25.33	78.00	96.66
V1	6.00	25.00	36.00	48.00	76.00
S146	5.83	12.66	16.33	24.00	42.60
S1708	8.33	19.16	24.33	44.00	50.00
S799	3.00	11.66	16.33	26.60	25.33
S1608	4.83	15.00	28.66	45.33	68.60
S1531	7.00	15.00	39.33	41.66	79.30
S41	6.33	20.66	28.66	41.00	54.00
Sujanpur	4.66	19.00	28.66	34.00	62.00
Average	5.84	17.06	25.82	40.52	60.24
CD (5%)	1.23	3.26	8.20	26.92	28.01

Nitrogen content

The nitrogen content on first sampling (15 days) fluctuates from 5.02 per cent in variety S1608 to 4.06 per cent in variety Tr4. The average nitrogen content was 4.61 per cent. On second sampling (30 days) it fluctuated from 4.74 per cent in variety S1531 to 3.77 per cent in variety Tr4.The average nitrogen content was 4.38 per cent. On 3rd sampling (45 days) nitrogen content fluctuated from 4.58 per cent in variety S1608 to 3.69 per cent in variety Tr4. The average nitrogen content was 4.26 per cent. On 4th sampling (60 days) nitrogen content fluctuated from 4.53 per cent in variety S1531 to 3.42 per cent in variety VI. The average nitrogen content was 4.09 per cent. On last sampling (75 days) nitrogen content fluctuated to 3.35 per cent variety Tr4. The average nitrogen content was 3.95 per cent. The differences in between the varieties were significant (Table 5).

Protein content

The protein content on first sampling (15 days) fluctuated from 30.53 per cent in variety S1531 to 25.46 per cent in variety Tr4. The average protein content was 28.83 per cent on second sampling. On second sampling (30 days) it fluctuated from 30.43 per cent in variety S1531 to 23.56 percent in variety Tr4. The average protein content was 27.30 per cent. On 3rd sampling (45 days) protein content fluctuated from 29.46 per cent in variety S153l to 22.66 per cent in variety Tr4. The average protein content was 26.30 per cent. On 4th sampling (60 days) protein content fluctuated from 28.46 percent in variety S1531 to 20.26 per cent in variety Tr4.The average protein content was 25.04 per cent. On last sampling date (75 days) protein content fluctuated from 28.00 per cent in variety S1531 to 19.40 per cent variety VI. The average protein content was 24.12 per cent. The differences in between the varieties were significant (Table 6).

Ash content

The ash content on first sampling (5 days) fluctuated from 22.50 per cent in variety S146 to 7.50 per cent in variety Sujanpur. The average ash content was 12.04 per cent. On second sampling (30 days) it fluctuated from 17.66 per cent in variety S41 to 8.73 per cent in varitey Sujanpur. The average ash content was 14.00 per cent. On 3rd sampling (45 days) ash content fluctuated from 27.50 per cent in variety S41 to 11.16 per cent in variety V1. The average ash content was 16.15 per cent. On 4 sampling (60 days) ash content fluctuated from 27.50 per cent in variety S41 to 11.16 per cent in variety V1. The average ash content was 17.32 per cent. On last sampling date (75 days) ash content fluctuated

Table 4: Fluctuations in the leaf moisture content (%) during different developmental stages.

Mulberry variety	moisture contents (%) days after sprouting				
	15	30	45	60	75
T1	86.05	82.46	76.35	74.31	74.30
Tr4	84.15	83.37	81.43	65.30	64.73
V1	83.68	79.60	73.52	70.46	70.10
S146	82.33	77.79	77.75	76.79	76.56
S1708	82.78	82.60	78.29	67.62	56.28
S799	84.96	83.51	77.75	76.06	72.88
S1608	84.56	76.22	73.52	69.14	68.09
S1531	78.77	77.20	72.17	69.00	59.84
S41	87.98	77.14	76.31	75.71	54.00
Sujanpur	78.87	78.87	78.12	66.66	74.80
Average	83.41	79.87	76.37	71.10	68.41
CD (5%)	1.41	6.36	4.36	6.30	N.S

Table 5: Fluctuations in leaf nitrogen content (% dry wt.) during developmental stages.

Mulberry variety	Nitrogen content (% dry wt.) days after sprouting				
	15	30	45	60	75
T1	4.63	4.46	4.35	4.16	3.73
Tr4	4.06	3.77	3.69	3.54	3.35
V1	4.77	4.37	3.83	3.42	3.40
S146	4.50	4.25	4.12	3.66	3.58
S1708	4.61	4.39	4.21	4.45	4.21
S799	4.72	4.54	4.45	4.39	4.22
S1608	5.02	4.63	4.58	4.50	4.47
S1531	4.89	4.74	4.55	4.53	4.53
S41	4.32	4.15	4.04	3.91	3.62
Sujanpur	4.63	4.51	4.41	4.40	4.39
Average	4.61	4.38	4.26	4.09	3.95
CD (5%)	0.15	0.22	0.22	0.22	0.49

from 32. 50 per cent in variety S1708 to 10.53 per cent variety V1. The average ash content was 19.28 per cent. The differences in between the varieties were significant (Table 7).

Starch content

The starch content on first sampling (15 days) fluctuated from 26.26 per cent in variety S1708 to 3.33 per cent in variety V1. The average starch content was 9.95 per cent. On second sampling (30 days) it fluctuated from 32.76 percent in variety S1708 to 4.50 percent in variety S799. The average starch content was 12.83 percent. On 3rd sampling (45 days) starch content fluctuated from 36.50 percent in variety S1708 to 7.60 percent in variety S799. The average starch content was 15.97 percent. On 4th sampling (60 days) starch content fluctuated from 40.50 percent in variety S1708 to 9.40 percent in variety V1. The average starch content was 18.90 percent. On last sampling date (75 days) starch content fluctuated from 43.06 percent in variety S1708 to 13.06 percent in variety S799. The average starch content was 22.61 percent (Table 8). The differences in between the varieties were significant (Table 1).

Chlorophyll content (SPAD value)

The chlorophyll content based on SPAD reading on first sampling (5 days) fluctuated from 31.70 percent in variety S41 to 17.90 per cent in variety S799 (Table 9). The average chlorophyll content was 24.9 per cent. On second sampling (30 days) it fluctuated from 44.03 per cent in variety S1708 to 31.66 per cent in variety S799. The average chlorophyll content was 37.76 percent. On 3rd sampling (45 days) chlorophyll content fluctuated from 45.40 percent in variety S1708 to 33.80 per cent in variety V1. The average chlorophyll content was 39.80 per cent. On 4th sampling (60 days) chlorophyll content fluctuated from 45.40 per cent in variety S1708 to 35.20 per cent in variety S1608. The average chlorophyll content was 40.10 per cent. On last sampling (5 days) chlorophyll content fluctuated from 44.70 percent in variety S1708 to 33.90 percent in variety S1608. The average chlorophyll content was 38.42 per cent. The differences in between the varieties were significant.

Sugar content

The sugar content on first sampling (5 days) fluctuates from 3.40 per cent in variety T1 to 1.53 percent in variety S799 (Table 10). The average sugar content was 2.21 per cent. On second sampling (30 days) it fluctuates from 3.40 per cent in variety T1 to 1.40 percent in variety S1531. The average sugar content was 2.15 per cent. On 3rd sampling (45 days) sugar content fluctuated from 3.43 per cent in variety Sujanpur to 1.20 per cent in variety S799. The average sugar content

Table 6: Fluctuations in leaf protein content (% dry wt.) during different developmental stages.

Mulberry variety	Protein contents (% dry wt.) days after sprouting				
	15	30	45	60	75
T1	29.40	26.60	25.06	25.43	23.23
Tr4	25.46	23.56	22.66	20.66	20.36
V1	30.33	26.80	24.63	20.26	19.40
S146	28.50	26.33	25.20	23.43	21.30
S1708	28.20	26.60	27.70	27.70	26.33
S799	29.30	11.66	27.50	26.50	25.53
S1608	31.56	30.20	28.46	27.46	26.73
S1531	30.53	30.43	29.46	28.46	28.00
S41	26.50	25.30	25.13	24.53	24.40
Sujanpur	28.56	28.46	27.26	27.26	26.00
Average	28.83	27.30	26.30	25.04	24.12
CD(5%)	0.30	0.33	0.65	0.59	0.42

Table 7: Fluctuations in leaf ash content (% dry wt.) during different developmental stages.

Mulberry variety	dry leaf weight content (g) days after sprouting				
	15	30	45	60	75
T1	10.00	11.43	14.63	14.16	12.16
Tr4	11.00	11.20	25.33	15.33	15.16
V1	12.50	15.20	36.00	11.16	10.53
S146	22.50	15.16	16.33	13.36	12.43
S1708	11.00	17.50	24.33	24.33	32.50
S799	8.66	13.33	16.33	15.46	19.33
S1608	12.30	13.33	28.66	15.46	17.33
S1531	11.50	16.50	39.33	20.16	21.70
S41	13.33	17.66	28.66	27.50	31.73
Sujanpur	7.50	8.73	28.66	16.33	20.00
Average	12.04	14.00	25.82	17.32	19.28
CD (5%)	0.62	0.44	8.20	0.49	0.46

was 2.04 per cent. On 4th day sampling (60 days) sugar content fluctuated from 3.40 per cent in variety T1 to 1.20 per cent in variety S799. The average sugar content was 2.01 per cent. On last sampling date (5 days) sugar content fluctuated from 2.70 per cent in variety T1 to 1.10 per cent variety S799. The average sugar content was 1.64 per cent. The differences in between the varieties were significant (Table 9).

Acidity

Acidity of mature mulberry leaf varied significantly in between the varieties. Highest acidity was seen in variety Tr4 (8.94%) followed by S799 (6.45%), S1531 (6.30%), S146 (6.01%) and least (4.69%) in V1.

The present observation for dissertation on the topic "Phytomorphology and nutrient dynamics of mulberry leaf presented a varied picture of different characters and their variations during different developmental stages. Amongst the ten varieties under study morphological characters as biochemical well characters exhibited interesting patterns. The observations made are being inferred character wise. Leaf shape in majority of varieties was ovate. Only one variety Sujanpur differs with deltoid type of leaf. This may be due to the fact that most of the varieties are developed as selection from similar stock by artificial or natural means. In general mulberry leaf tends to be ovate in shape. Similar observations were made by Gupta (2006) and Mazal (2009). Intermodal distance indicates the superiority of the variety in yield parameters as lower internodal distance means high number of leaves per unit length of branch. In the present study, average value stood at 5.30 cm. Individual varieties although differed significantly but remained very close to the average fluctuating from 6.06 to 4.65 cm. Shortest intenodal distance indicated the superiority of variety S1531 amongst the present varieties under study. Anonymous (1997) reported that variety Chak majra had much lower intenodal distance (4.3 cm). Gupta (2006) reported that variety Sujanpur showed intermodal distance of 4.01cm.

Actual leaf area showed wide variation over the average of 165.56 cm^2. The diploid varieties showed smaller leaves as compare to triploid. Tetraploid variety also posses smaller leaves. Largest leaf was observed in variety S146 a diploid variety. Although ploidy level is known to exhibit in the form of large appendages but in the present case diploid variety exhibited superiority. Gupta (2006) observed that leaf area range from 171.70 cm^2 (C-763) to 267.30 cm^2 (BC-259).

Table 8: Fluctuations in leaf starch content (%dry wt.) during different developmental stages.

Mulberry variety	Starch contents (% dry wt.) days after sprouting				
	15	30	45	60	75
T1	14.40	18.40	20.30	22.56	26.13
Tr4	15.63	15.33	16.10	22.30	24.43
V1	3.33	5.56	8.63	9.40	10.56
S146	3.51	8.59	12.53	14.60	20.50
S1708	26.26	32.76	36.50	40.50	43.06
S799	3.35	4.50	7.60	9.70	13.60
S1608	5.36	9.53	12.53	15.26	22.43
S1531	6.63	8.63	15.46	18.63	22.28
S41	3.67	5.66	9.43	15.66	20.26
Sujanpur	17.41	19.43	20.66	20.43	22.93
Average	9.95	12.83	15.97	18.90	22.61
CD (5%)	0.41	0.40	0.51	0.52	0.36

Table 9: Fluctuations in leaf chlorophyll (SPAD value) during developmental stages.

Mulberry variety	Chlorophyll conent (SPAD value) days after sprouting				
	15	30	45	60	75
T1	22.10	43.30	42.20	42.70	42.80
Tr4	23.90	44.00	44.30	44.40	44.10
V1	25.20	33.75	33.80	36.90	35.30
S146	21.20	33.70	37.70	39.20	35.80
S1708	31.60	44.03	45.90	45.40	44.70
S799	17.90	31.66	35.70	40.50	34.80
S1608	27.90	33.60	36.49	35.20	33.90
S1531	31.70	39.88	41.80	37.00	37.00
S41	25.10	37.38	42.20	41.50	40.80
Sujanpur	22.40	36.31	38.00	38.40	35.00
Average	24.90	37.76	39.80	40.10	38.42
CD(5%)	1.34	2.21	1.87	1,39	1.90

Table 10: Fluctuations in leaf sugars (%dry wt.) during different developmental stages.

Mulberry variety	Sugar content (% dry wt.) days after sprouting				
	15	30	45	60	75
T1	3.66	3.40	3.40	3.40	2.70
Tr4	2.56	2.63	2.46	2.46	1.80
V1	2.63	2.46	2.40	2.40	1.73
S146	1.50	1.46	1.36	1.36	1.30
S1708	1.70	1.50	1.30	1.30	1.30
S799	1.53	1.70	1.20	1.20	1.10
S1608	1.80	1.93	1.70	1.70	1.37
S1531	1.60	1.40	1.46	1.46	1.53
S41	1.76	1.73	1.73	1.73	1.11
Sujanpur	3.40	3.30	3.43	3.43	2.48
Average	2.21	2.15	2.04	2.04	1.64
CD(5%)	0.49	0.49	0.53	0.46	0.41

Mazal (2009) also reported that variety Sujanpur had the maximum leaf area of (177.83 cm^2).

Number of leaves per meter branch is inversely related to internodal distance. It did fluctuate significantly and showed highest value in variety of S1531 where internodal distances were small. The number fell drastically to 16.8 in Tr4 where the internodal distance was the largest. This again is an indicator of high leaf productivity of a particular variety. Leaf size, length and width was more or less corresponding to the actual leaf area in S1608 where these two characters fell much below the average. Predictably this variety has the smallest leaf. The longest leaf (S146) corresponded well with the largest leaf but in width V1 had the broadest leaf apparently leaf length contribute to actual size increase as in case S146 which was 26.13 cm long leaf being the longest of all having an edge over average by about 20 per cent. Although V1 showed 30 per cent advantage over the average width but in this case length fell about 15 percent below the average leading to one of the smallest leaf area. Mazal (2009) reported that variety L-10 has the longest leaf whereas variety Sujanpur has the widest leaf.

Fresh leaf weight as observed during five development intervals each at the gap of 15 days did not show any particular pattern in single variety. The highest weight on day 15 was observed in S1708. This variety did not show any fluctuations about average in subsequent observations. At the mid developmental stage fresh weight excelled in Tr4 and retained this advantage till maturity after 60 days. This pattern indicates that a particular group of variety has weight advantage during early developmental stages. Diploid varieties gained significant fresh weight at the time of maturity as was evident in variety S1531, V1 *etc*. Gargi *et al* (1997) reported fresh weight variation from 511.7 to 394.5 gm. Gupta (2006) reported a high fresh weight of 563. 22g/100 leaves in mulberry variety BC-529. Mazal (2009) reported a high fresh weight of 435.0gm in variety L-10.

Leaf dry weight picked up at 45 days stage reaching on average value of 25.82 per cent. In the early stages the dry weight remained very low. On an average 50 per cent weight was gained in first 30 days with a Jump from is to 30 days weight gained was subsequently. Variety Tr4 excelled in dry weigh post 60 days indicating its suitability for feeding of worms. Gupta (2006) reported high biomass (140.9 g/100) leaves in variety BC259. The least biomass reported 70.02 g was in case of variety Tr-10 comparatively in the present case, low leaf biomass can be attributed to overall thin leaves.

Moisture content on an average gradually decline from early to late developmental stages as is indicated by the average value fall from 33.41 per cent on day 15 to 68.41 percent on day 75 Tetraploid variety and S41 exhibited higher moisture content during early and mid-developmental stages. At maturity variety S146 surpassed all varieties in the leaf moisture content indicating no permanent pattern in all varieties. This can be utilized for selective feeding Hesketh *et al.* (1985) reported co-relation between leaf thickness and moisture conservation, Susheelamma and Jolly(1986) observed that the size and frequency of stomata play a major role in moisture retention, transpiration and gas exchange. Gargi *et al.* (1997) reported moisture range 73.0 to 75.5 per cent during spring season. Sujathamma and Dandin (2000) concluded that lower number of stomata increased the water retention capacity. Bari and Quadar (2002) reported highest water content 77.0 per cent in mulberry variety BSRM-4.

Mallikarunappa *et al.* (2002) reported highest moisture in variety Viswa and S-36. Ninge Gawda and Sudhakar (2002) concluded that stomatal size and frequency of mesophyll, cuticle thickness and leaf thickness influence the moisture percentage of leaf. Gupta (2006) reported maximum moisture (76.8%) in variety Chak Majra in local agro climatic conditions. Maza (2009) reported maximum moisture content (78.23 per cent) in variety L-10.

Chlorophyll content on the basis of SPAD value reached a platue in first four week with average slightly going down in the late developmental stage. Although varieties showed difference in SPAD value indicating that chlorophyll content gets stabilized in 1st four weeks of development. During further development does not show any increase. It may be

due to the fact that chlorophyll being basic ingredient of solute assimilation reached a peak in early development.

Ash content as an indicator of inorganic salt accumulation in leaf did show a linear change corresponding with stage of development. Variety Sujanpur showed least value of ash in first two developmental stages. This is utility for feeding early age worm which do not require an indicator of its low ash content in mulberry varieties with non- significant differences among the varieties. Mazal (2009) showed ash content range from 9.59 to 13.00 per cent. Sugar percent in general decreased with the age but at different developmental stages the difference in between varieties varied significantly. Tetraploid variety exhibited higher sugar content all through five developmental stages of observatation. It indicates that high sugar varieties can be utilized in the advanced stages where energy required for physiological process is high as leaf intake gets increased in quantity.

Acidity of leaf on maturity was above four percent in all varieties. Triploid variety showed highest acidity. This is an indicator of subsequent break down to sugar levels which was very low in variety Tr4. However no significant correlation could be driven between sugars and acidity.

Starch content on an average increase gradually from day 15 to day 75. However at maturity level starch percentage stood at 22.61 per cent.

Nitrogen content of leaf showed a declining trend with developmental stage in the early age. Average value stood at 4.65 per cent falling gradually at the final stages. This is an indicator of protein accumulation on percentage basis which goes down where as some other parameters including ash etc increase. This information is of utility for selecting protein rich leaf for chawki where worm eat less but need high quality food for their growth and development. Nitrogen content may not have significant health impact on accumulation of silk content.

Corresponding to leaf nitrogen protein also showed declining trend with development of leaf and went down from 28.83 percent on day 15 to 24.12 per cent on day 75. Silkworm leaf ingestion is very low in early stages. Varieties with high protein content *e.g.* S1531 would be suitable for feeding. In later stages where food intake is high, varieties with partially reduce protein content can also give optimal results as at this stage worms go for quantity feeding irrespective of quality. Horie *et al*. (1978) concluded that for optimal growth of silkworm larvae the dietary protein level requirement is 20-25 per cent. Sujathamma and Dandin (2000) reported gross protein in mulberry varieties varied from 19.5 to 23-5 per cent. Gupta (2006) reported gross protein range 16.7 to 23.7 per cent. Mazal (2009) reported crude protein range 22.14 to 26.79 per cent. In brief, present study has confirmed that biochemical parameters fluctuate from sprouting to maturity. This fluctuation varies from variety to variety. On the basis of these studies, particular variety can be selected for feeding of specific age worms so as to meet the optimal feeding requirement of silkworm.

Reduction in protein contents in the later stages can also be attributed to the fact that at early stage due low dry weight percentage, protein content show higher value. In later stage due to increase in dry weight percentage protein content percentage come down.

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