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NUTRITIONAL EVALUATION OF MULBERRY (*MORUS* SPP.) GENOTYPES THROUGH SILKWORM GROWTH STUDIES

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Evolution of new mulberry (*Morus* spp.) genotypes for high productivity and quality has received greater attention in the field of moriculture in recent years. The total number of mulberry varieties/genotypes preserved in the germplasm all over the world though exceeds 1000, only 10% of this are being cultivated and are being exploited commercially and popular varieties constitute only 1% of the total. This is because of the various stages of the testing during the evolution of a mulberry variety and is exploited commercially only if found superior not only in yield but also in the quality which is an important aspect as far as cocoon production is concerned. Quality evaluation can be done at two stages *viz.* in young larval stage and in later larval stages. As the total quantity of consumption of mulberry leaf is 80% in V instar, quality testing in later ages attains greater importance. The present study is taken up to evaluate the mulberry genotypes for nutritional quality in the V stadium of silkworm larvae based on the increase in larval body weight and selection of genotypes considering their quality.

INTRODUCTION

The growth and silk production of silkworm *Bombyx mori* L. varies depending on quality of different mulberry varieties (Koul *et al.*, 1975; Bari *et al.*,1985). This obviously implies that certain varieties of mulberry with superior quality support better growth of larvae, cocoon and silk production. Relationship between mulberry varieties and larval growth was studied by Ito & Arai (1963). The daily utilization of food towards the body growth was reported by Horie & Watanabe (1983). Though the daywise growth rate and growth curves in different breeds of silkworm in terms of body weight has been reported by Magadum *et al.* (communicated), the studies on nutritional evaluation of mulberry varieties based on growth pattern of larvae under tropical condition are scanty. The present study deals with the effect of mulberry genotypes on the larval body weight during the fifth stadium.

MATERIALS AND METHODS

Twenty-six mulberry genotypes grown under irrigated condition as per the recommended package (Krishnaswami, 1978a) were used for the study. Silkworm larvae of NB_{18} race were reared by improved method of silkworm rearing (Krishnaswami, 1978b). V instar larvae were taken as test material. For each genotype 75 larvae in three replications (25 x 3) were retained. The larvae were fed *ad libitum* daily four times with known quantity of leaves of different genotypes at an interval of 6 h. An additional larval batch for each genotype was also maintained for determining the dry weight values on each day (Mayanard & Loosli, 1962).

Leaf moisture was estimated in the leaves of different genotypes and total nitrogen was estimated by micro-Kjeldahl (Kjeldahl, 1983). Weight of larvae out of IV ecdysis was recorded. Daily, fresh weight of all the larvae was recorded genotype wise and dry single larval weight was recorded (Horie & Watanabe, 1983) till spinning. Before weighing, missed larvae if any, were replaced daily from additionally maintained bed for each genotype. Percentage of daily weight gain in relation to the preceding day's weight was used to compare the growth pattern in batches of different genotypes. Relative growth rate (RGR) was also calculated for the whole period of V instar with the following formula as suggested by Waldbuer (1968). The formula used was GR=G/TA where :

G = fresh or dry weight gain
T = duration of feeding period (days)
A = mean fresh or dry weight of animal during the feeding period

The experiment was conducted during three seasons and average transformed values were considered for analysis. The temperature of 25 - 26^{0}C and RH of 60 - 70% was maintained during the study.

RESULTS AND DISCUSSION

The data on moisture percentage, total nitrogen and relative growth rate are presented in Table I, day wise percentage increase on fresh and dry weight basis are presented in Table II and Table III and RGR and cocoon characters are presented in Table IV.

Table I : Moisture percentage and Total nitrogen content in different mulberry genotypes.

S. No.	Name/ ACC. No.	Moisture (%)	Total N_2 (%)
1	FGDTR - 9	74.66	3.270
2	TR -10	74.92	3.085
3	Acc. 161	75.70	3.549
4	Shrim - 8	74.50	3.604
5	Miuraso	75.25	3.398
6	S - 642	75.11	3.448
7	Acc. 118	73.58	3.627
8	S -1301	75.86	3.769
9	TR - 4	76.79	3.805
10	Thai Beelad	77.76	3.770
11	Philippines	74.62	3.734
12	*M. multicaulis*	74.25	3.645
13	S_{30} x Acc.119	77.87	3.837
14	K_2 x Kosen	76.19	3.560
15	S_{54} x KNG	77.72	3.468
16	Assamabola x Kokuso	78.13	3.429
17	English Black x Kosen	75.59	3.072
18	Sujanpur-5 x Philippines	76.59	3.560
19	Mizusawa x RFS -175	74.67	3.708
20	Sujanpur -5 x Ber.S_{799}	76.49	3.593
21	Sujanpur -5 x Ber.S_{799}	76.67	3.583
22	Sujanpur -5 x RFS -135	76.77	3.649
23	OPH-3 x ber.S_{799}	73.21	3.071
24	OPH -3 x RFS -135	76.52	3.617
25	Kanva - 2	73.50	3.363
26	S_{54}	74.77	3.515
SE ±		1.04	0.040
CD at 5%		2.92	0.113

The leaf moisture of different genotypes varied significantly among the genotypes ranging from 73.21 to 78.13. The maximum of 78.13% was recorded in genotype 16 followed by 13 (77.87) and a minimum of 73.21% in genotype 23. The total nitrogen content was highest in genotype 13(3.837%) followed by genotype 9(3.805%) and lowest value was recorded in genotype 23(3.071).

Fresh mulberry leaves contain 70 - 80% of water and 20 - 30% of dry matter (Cheng Fu, 1994). Phytophagus insects normally feed on a diet with higher water content (Friend, 1958). The water content in the mulberry leaves is closely related to the nutritional physiology of silkworm larvae which feed on the leaves. In the present study the highest moisture content was recorded in the genotype 16(78.13%) and lowest value in genotype 23(73.21%). The moisture content of leaf not only affects the palatability but assimiability of nutrients also (Perpiev, 1968). Decrease in moisture content of food affects nitrogen utilization efficiency and leads to poor insect growth (Scriber, 1978). Better larval weight and cocoon characters have been recorded in genotypes 10 and 13.

Table II : Percentage increase in larval body weight (on fresh weight basis).

Genotype No.	Days in V instar					
	II	III	IV	V	VI	VII
1	30.803	28.735	17.500	15.880	12.974	6.466
2	48.392	17.566	14.572	9.385	6.655	1.551
3	56.077	20.246	18.144	16.552	2.491	1.496
4	53.846	26.267	12.449	11.712	9.158	6.922
5	41.208	36.930	23.123	12.990	10.641	6.390
6	44.161	39.641	24.618	11.161	10.530	5.961
7	35.249	27.485	23.120	11.874	3.831	3.494
8	44.680	35.477	16.523	9.038	7.734	4.502
9	46.212	27.993	21.666	17.063	1.937	1.090
10	57.439	21.396	18.443	14.938	11.340	8.264
11	54.932	28.236	21.404	14.596	6.482	4.870
12	35.224	26.843	23.317	13.423	2.219	0.217
13	63.580	41.176	28.172	16.643	14.359	8.825
14	51.845	27.683	20.696	18.748	12.852	5.705
15	34.684	33.111	23.949	10.649	6.131	4.978
16	38.679	35.795	16.042	4.767	1.526	0.301
17	41.276	19.476	12.392	8.206	8.169	6.852
18	44.577	21.009	20.379	7.969	4.060	1.799
19	45.865	36.874	15.612	13.349	12.112	2.866
20	49.179	26.006	18.681	14.883	13.769	5.035
21	45.217	25.486	13.621	12.104	6.368	3.974
22	50.370	29.787	21.079	15.155	8.646	0.549
23	52.965	36.798	14.872	10.405	1.576	0.105
24	54.328	20.563	12.076	10.048	9.157	7.443
25	45.490	39.844	13.751	10.676	8.910	4.705
26	62.397	20.304	14.662	13.503	10.804	5.151
SE±	2.735	2.276	2.275	1.135	1.364	0.682
CD at 5%	7.705	6.309	7.704	3.309	3.852	1.926

Table III : Percentage increase in larval body weight (on dry weight basis).

Genotype No.	Days in V Instar					
	II	III	IV	V	VI	VII
1	33.076	31.041	29.479	26.829	18.442	1.418
2	47.415	32.294	26.666	18.456	13.003	9.207
3	41.121	39.062	26.163	24.099	19.536	1.908
4	56.535	22.662	22.286	21.985	16.513	11.627
5	52.930	41.967	23.983	21.862	14.087	2.657
6	51.063	50.000	31.697	8.215	6.073	6.055
7	42.168	29.816	27.561	20.448	11.080	3.196
8	52.536	40.101	18.269	17.647	10.731	4.986
9	52.637	41.463	25.625	20.967	9.333	1.436
10	68.125	53.108	30.980	14.687	12.280	9.686
11	64.069	39.841	30.463	20.324	14.890	4.528
12	49.519	33.838	20.259	11.827	5.802	4.339
13	69.917	56.344	42.997	28.821	19.841	13.990
14	66.486	35.389	33.333	21.855	16.000	12.388
15	36.866	33.128	32.352	22.000	14.478	3.872
16	50.561	41.044	21.219	8.465	6.036	3.984
17	66.666	42.307	18.571	15.202	14.285	9.638
18	57.918	25.714	20.108	10.315	8.179	4.536
19	58.535	32.432	32.319	17.346	14.347	1.580
20	51.915	44.973	33.630	22.627	19.167	10.258
21	51.020	40.921	19.932	18.461	12.337	3.943
22	53.570	34.234	29.069	18.132	12.304	10.956
23	55.000	38.961	20.748	8.450	5.420	1.961
24	42.201	34.177	25.935	22.754	18.645	11.409
25	59.437	51.620	35.879	22.307	19.248	6.646
26	66.079	29.977	22.844	18.567	13.769	3.571
SE±	3.009	2.945	2.844	1.766	1.148	1.194
CD at 5%	8.072	8.165	9.630	5.147	5.503	3.371

The relative growth rate on fresh weight basis was highest in the genotype 13(9.725) followed by the genotype 10(9.535) and lowest in the genotype 9(8.144). The RGR on dry weight was highest in genotype 13(12.966) followed by genotype 10(12.803) and lowest value of 8.852 was recorded in genotype 24.

Significant differences in the percentage increase of larval weight (fresh) were observed among the batches reared with different genotypes for all the days of fifth instar. The maximum value from II to VII day (63.580, 41.176, 28.172, 16.643,14.359 and 8.825%, respectively) were recorded in the batch reared with genotype 13. The minimum values of 30.803%(genotype 1), 17.566(genotype 2), 12.392(genotype 17), 4.767(genotype 16), 1.526(genotype 16), 0.105 (genotype 23) were recorded from II to VII day, respectively

Percentage dry weight gain of larvae varied significantly among the batches of different genotypes. Highest values from II to VII day (69.917, 56.344, 42.997, 28.821, 19.841 and 33.990, respectively) were recorded in genotype 13. Minimum values of 33.076(genotype 1), 22.662

(genotype 4), 18.269(genotype 8), 8.215(genotype 6), 5.420(genotype 23) and 1.418(genotype 1), respectively were recorded.

Significant differences were observed in single cocoon weight, shell weight and shell percentage among the batches fed with leaves of different genotypes. Single cocoon weight was highest in genotype 13(2.010g) and lowest in genotype 5(1.569). Highest single shell weight of 0.429g was recorded in genotype 13 and lowest value of 0.309g was recorded in genotype 5. Highest shell percentage (21.343%) was recorded in the genotype 13 followed by genotype 10(21.255%) and genotype 11(20.596%).

It is known that feed plays an important role in animal growth and development. The amount, rate and quality of food consumed by a larva influences its performance, growth rate, development time and body weight. The larvae of silkworm have a rapid growth rate which is due to high rate of food consumption and great efficiency of conversion of food into larval biomass. The weight of

Table IV : Cocoon characters and Relative Growth Rate as influenced by different genotypes.

Genotype Number	Single cocoon Wt.	Single ratio shell wt.	Shell ratio (%)	RGR F. wt. Basis	RGR Dry wt basis
1	1.857	0.352	18.930	7.209	10.904
2	1.982	0.375	18.913	8.809	11.356
3	1.937	0.378	19.530	8.943	11.103
4	1.979	0.377	19.064	8.652	11.520
5	1.569	0.309	19.702	9.271	10.629
6	1.857	0.361	19.426	8.825	10.554
7	1.878	0.372	19.801	8.930	9.716
8	1.809	0.339	18.735	8.481	10.593
9	1.852	0.360	19.435	8.144	10.838
10	1.976	0.420	21.255	9.535	12.803
11	1.860	0.383	20.586	9.172	9.982
12	1.889	0.373	19.764	9.498	10.605
13	2.010	0.429	21.343	9.725	12.966
14	1.970	0.365	18.543	7.873	9.262
15	1.893	0.380	19.188	9.018	10.630
16	1.987	0.370	18.623	8.552	9.590
17	1.998	0.380	19.026	8.404	9.272
18	2.000	0.386	20.059	8.563	9.327
19	1.895	0.366	19.304	9.300	1.468
20	1.856	0.378	20.359	9.222	9.818
21	1.973	0.382	19.370	9.333	11.773
22	1.996	0.367	18.390	8.776	11.046
23	1.943	0.347	17.857	9.054	10.034
24	1.926	0.371	19.240	8.281	8.852
25	1.893	0.369	19.500	8.767	10.147
26	1.983	0.396	19.974	8.181	9.876
SE ±	0.022	0.009	0.212		
CD at 5%	0.062	0.025	0.845		

fresh and dry larvae indicated the linear increase as the larvae developed till VI day. The varietal influence on growth of different silkworm breeds is studied by many workers (Koul *et al.*, 1979; Bari *et al.*,1985; Pillai & Jolly, 1985). The day wise growth rate during fifth stadium in different breeds was studied by Magadum *et al.* (communicated).

Though the growth of insects with rigid exoskeleton is confined to the cyclicity of moults (Hepburn & Chandler, 1976), the silkworm can stretch the larval cuticle without any addition of new material. Hence the somatic growth is observed in a larval period between two moults and maximum increase in body weight is in the V instar and the same was evaluated in batches fed with different genotypes to assess their nutritional superiority. If the larvae are fed on leaf with low moisture content then the larval period is increased and larval growth was hindered (Paul *et al.*, 1992). In the present study the highest moisture content, total nitrogen and highest percentage increase in larval weight (on fresh and dry weight basis) were observed in genotype 13. The RGR on fesh and dry weight basis was also found to be highest in the genotype 13 followed by genotype 10.

The combination of a certain growth and attainment of a particular final weight (prior to pupation) will have a large impact on fitness (Slansky & Scriber, 1985), Nutrition of proteins and amino acids is particularly important for the silkworm larvae because of their active utilization of nitrogen substances involving the synthesis of silk protein (Horie, 1978). The differences in the food quality (as influenced by leaf water and nitrogen) may be due to the changes within a food species. The particular influence of food quality on larval performance has been investigated by comparing performance values of same aged larvae raised under similar conditions (Scriber & Slansky, 1981). In the present study the highest nitrogen content was recorded in genotype 13(3.837%) and the lowest in the genotype 23(3.071). The larval body weight was highest in genotype 13 followed by genotype 10. Machii & Katagiri (1991) have recommended that in mulberry breeding programme, varieties with high content of nitrogen in leaves be adequately taken in to account while selecting varieties nutritive for silkworm. In confirmation with the report of Magadum *et al.* (communicated), the rate of body weight increase was highest in the begining of the instar (II & III day) in the batches of all the genotypes but there was gradual reduction in the percentage increase during the middle and end of the instar. The rate of increase in size was specific to the feed (genotype) and it was observed that the percentage increase was as high as 63.580% in genotype 13 and as low as 30.803% in genotype 1 indicating the variable effect of the nutrition on the larval growth. In the present study genotype 13 has recorded superior larval growth and cocoon characters followed by genotype 10.

Scriber & Slansky (1981) have proposed that plant nitrogen and water levels are positively correlated to insect's growth and food utilization and plants having both high nitrogen and high water levels typically support the best insect growth and food utilization efficiencies. Based on biomass conversion by the silkworms, genotypes 13, 10, 3, 11 and 18 were found nutritionally superior when compared to controls (S_{54} and K_2) and other genotypes tested.

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