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Changes in Biochemical Constituents and Photosynthetic Pigments in Spiralling Whitefly (*Aleurodicus dispersus*) Infested Mulberry Foliage

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Abstract

Variation in the photosynthetic pigments and biochemical constituents in mulberry foliage (6 varieties viz., M_5, MR_2, Mysore local, S_{36}, S_{54} and V_1) were studied due to spiralling whitefly (Aleurodicus dispersus Russell) infestation. The biochemical constituents (amino acids, soluble proteins, reducing sugars, soluble sugars, starch and phenols) were altered in the spiralling whitefly infested mulberry leaves. Changes were also observed in the photosynthetic pigments (total chlorophyll, chlorophyll – a, chlorophyll – b, chlorophyll – a/b ratio and carotenoids). The pest infestational changes in these components lead to inferior nutritive values in mulberry foliage. The growth and development of the silkworms (Bombyx mori L) will be affect adversely and leads to the inferior quality and quantity of the silk.

Keywords: Biochemical constituents, Mulberry, Photosynthetic pigments, Spiralling whitefly.

Introduction

The productivity of mulberry (*Morus alba* L.), the sole food plant of silkworm *Bombyx mori* L. is influenced by various factors such as agronomical practices, adverse weather, and biotic factors – pest and diseases. *Aleurodicus dispersus* Russell (Homoptera: Aleurodidae), is a one important insect pest attacking mulberry leaves[1]. Its native is Caribbean region and highly polyphagous pest. Because of its unique nature of eggs laying in a typical spiral pattern, it has been commonly called as 'spiralling whitefly'. Adults and nymphs of the pest remain in colonies under the surface of leaves and sucking the sap of the leaves which leads to chlorosis, defoliation and stunted growth. The profuse white waxy material secreted by this pest is readily spread by wind, causing annoyance[2].

The honey dew excreted by these insects will fall on the upper surface of the lower leaves which becomes a medium for developing "sooty mould" fungus, *Capmodium* sp. It, in turn, reduces the photosynthetic area by blocking the leaf and thus reduces the productivity. This leads to further deterioration in the nutritional quality of leaf. Mulberry leaf yield was reduced by 28.09% when the infestation of spiralling whitefly (*Aleurodicus dispersus* Russell) exceeded 50% leaf area. Feeding of infested leaves caused drastic reduction in economic parameters of silkworm recording up to 48.09% cocoon yield loss and 71.31% monetary loss compared to the worms fed with healthy leaves[3].

The present study was taken up to find out the impact of spiralling whitefly infestation on the photosynthetic pigments and biochemical constituents in the leaves of some popular indigenous mulberry varieties.

Materials and Methods

In the present investigation, the healthy and spiralling whitefly (*Aleurodicus dispersus* Russell) infested mulberry foliage of 6 widely cultivating varieties (M_5, MR_2, Mysore local S_{36}, S_{54} and V_1) were chosen. The fresh leaves were used to determine the photosynthetic pigments by following standard procedure[4].

The mulberry leaves were oven-dried and processed to analyse the biochemical components *viz*., amino acids[5], total soluble proteins[6], total reducing sugars[7], total soluble sugars and starch[8], total phenols[9]. The results were subjected to statistical Student's t-test and per cent change over healthy ones.

Results and Discussion

It is a known fact nutritive constituents of mulberry leaves play a major role in quality and quantity silk production. All biochemical components (free amino acids, total soluble proteins, total reducing sugars, total soluble sugars, starch and total phenols) and photosynthetic pigments (total chlorophyll, chlorophyll – a, chlorophyll – b, chlorophyll – a/b ratio and carotenoids) and showed a variation in *A. dispersus* infested mulberry compared to healthy leaves.

Biochemical Constituents (Table– 1): Free Amino Acids: The spiralling whitefly infested leaves shows a varied free amino acids contents in all the varieties compared to healthy ones. The reduction was in the range of 18.56 % and 9.78 % in S_{36} and MR_2 varieties respectively. The increased free amino acid content was maximum (61.11 %) and minimum (7.49 %) in the leaves of V_1 and S_{54} varieties respectively.

Table–1
Biochemical changes (dry weight) in the spiralling whitefly - infested mulberry leaves

Mulberry varieties	Free amino acids (mg/g)		Total soluble proteins (mg/mg)		Total reducing sugars (mg/g)		Total soluble sugars (mg/g)		Total starch (mg/g)		Total phenols (mg/g)	
	Healthy	Infested	Healthy	Infested	Healthy	Infested	Healthy	Infested	Healthy	Infested	Healthy	Infested
M_5	9.94	11.88	76.7	70.20**	42	44.40**	2.8	1.9	0.99	0.91	3.96	4.14
	(+20.73)		(-8.47)		(+5.71)		(-32.20)		(-8.11)		(+4.55)	
MR_2	11.04	9.96	58.5	54.6	58.8	61.20**	2.57	2.47	1.31	1.24	4.74	4.18
	(-9.78)		(-6.67)		(+4.08)		(-3.70)		(-5.44)		(-11.81)	
Mysore local	8.2	9.48*	160.8	155.60**	92.53	96.54*	2.66	2.42	1.05	0.96	7.32	2.84
	(+15.61)		(-3.23)		(+4.33)		(-8.93)		(-7.69)		(-61.20)	
S_{36}	11.64	9.48	136.5	124.80**	58.8	63.60**	2.38	2.28	1.13	1.15	6.34	6.54
	(-18.56)		(-8.57)		(+8.16)		(-4.00)		(+28.57)		(+3.15)	
S_{54}	13.88	14.92*	136.5	145.00*	73.2	78.40**	2.57	2.19	1.31	1.42	2.76	3.82
	(+7.49)		(-6.19)		(+7.10)		(-14.81)		(+8.16)		(+38.41)	
V_1	2.16	3.48*	118.95	109.90**	124.8	112.80**	2.61	2.69	0.96	0.83	4.92	5.4
	(+61.11)		(-7.65)		(-9.62)		(+3.03)		(-13.89)		(+9.76)	

** Significant at 1% level; *Significant at 5% level; Values in the parenthesis indicate % difference over healthy (+ = more than; - = less than).

The amino acids are organic compounds which contain as acid and an amino group. There are hundreds of amino acids, but only twenty two are found in appreciable quantities in proteins. The biosynthesis of silk fibre by silkworm, *B. mori* requires 10 essential amino acids, which precursors have to be present in its diet i.e., mulberry leaves[10]. The mulberry leaves are quite rich in amino acid content and satisfy the requirements of silkworm. In mulberry leaves, the number of amino acids available is twenty. The amino acid components of proteins in mulberry leaves are glycine, alanine, valine, leucine, aspartic acid, glutamine, phenylalanine, praline, hydroxyproline, cysteine, etc.[11].

Total Soluble Proteins: The *A. dispersus* infested mulberry leaves of all the six varieties showed a reduction in their total soluble proteins contents. It was minimum (3.23%) in Mysore local and maximum (8.57%) in the leaves of S_{36} varieties. Protein is the main constituent of mulberry leaves and it is reported that nearly 70 percent of the silk proteins produced by a silkworm is directly derived from the proteins of mulberry leaves. The main parts of proteins of mulberry leaves are globulin, glutein, prolamine, albumin, protease etc.[11]. The crude proteins were significantly decreased in spiralling whitefly infested mulberry (variety: M_5) leaves in comparison with the healthy ones[11]. The protein content in the *A. dispersus* infested mulberry (M_5 var.) leaf was 9.65 % and in the healthy it was 20.72 %[12]. Leaf sap sucking nature of spiralling whitefly may leads to alter in the metabolic function of plant by either fail in mobilisation of proteins for repair of damaged tissues in order to resist or either decline in protein, which may be cause of decline in protein content[13].

It may be also due to utilization of nutritive sap for fast multiplication of insect. Hydrolysis of proteins by proteolytic enzymes secreted by the pest itself may be the other cause for lowering of proteins[14]. Synthesis pattern of protein to overcome the injury and develop resistance may results in increased protein content[15].

Total Reducing Sugars: There were changes in reducing sugars in the infested leaves compared to healthy one. The reduction in total reducing sugars was 9.62% in the leaves of V_1 variety. It was increased in the range of 4.08% in MR_2 to 8.16 % in S_{36} varieties due to pest infestation. The reducing sugars requirement is very essential along with amino acid for the biosynthesis of sericin and fibroin by the silkworm[16]. The deformation of leaf lamina due to pest attack is the precursor for the alteration in the reducing sugars[13].

Total Soluble Sugars: The total soluble sugars differed in the *A. dispersus* infested foliage of all six mulberry varieties studied compared to healthy ones. The reduction was minimum (3.70 %) and maximum (32.20 %) in the leaves of in the leaves of MR_2 and M_5 varieties respectively. The soluble sugars were increased by 3.03 % in spiraling whitefly infested leaves of V_1 variety. Drastic reduction in the sugars, nitrogen, phosphorus, calcium and magnesium in *A. dispersus* infested mulberry (variety: M_5) leaves[17].

Starch: The *A. dispersus* infested leaves of all varieties showed variation in their starch content. The reduction was in the range of 5.44 % to 13.89 % in the leaves of MR_2 and V_1 respectively. The increase was maximum (28.57 %) and minimum (8.16 %) in the leaves of S_{36} and S_{54} varieties respectively due to pest infestation.

Total Phenols: There were changes in the total phenols in the *A. dispersus* affected leaves all mulberry varieties considered. The decrease was maximum (61.21 %) and minimum (11.81 %) in the leaves of Mysore local and MR_2 varieties respectively. The phenolic contents were increased in the range of 3.15 % in the leaves of S_{36} to 38.41 % in the leaves of S_{54} variety. The accumulation of phenolics in the host may inactivate the enzyme which inhibits the further advance of the pathogenic organism by limiting its source of nutrients[18]. Similar kind of alteration in the biochemical constituents were observed in other cases when mulberry leaves were affected by various pests - such - as jassids[19], leaf roller[20,21], mealy bugs[22], thrips[15] and giant African snails[23]. The disturbed normal host metabolism due to pest attack may be the precursor for the variation[24]. This variation may impacts adversely on nutritional components of mulberry foliage, in turns affect the silkworms' growth and development.

Photosynthetic pigments (Table–2): The photosynthetic pigments varied in the *A. dispersus* infested mulberry varieties considered in this study. The decrease in the total chlorophyll content was maximum (31.35%) and minimum (1.95%) in the leaves of MR_2 and M_5 varieties respectively. The total chlorophyll content in the spiralling whitefly infested leaf was 1.02 mg/g whereas healthy leaf had 3.40 mg/g[12]. The spiraling whitefly infested leaves shown an increase in total chlorophyll content in S_{36} (4.54%) and Mysore local (23.38%) varieties. The chlorophyll-a content was decreased in spiraling whitefly infested leaves of M_5 and V1 varieties respectively by 2.76% and 32.88% compared to healthy ones. It was increased by 2.32% in S_{36} and 25.89% in Mysore local varieties. The chlorophyll – b content was increased in the range of 1.12 % to 36.32% in the leaves of M_5 and V_1 mulberry varieties respectively. The chlorophyll-b content was decreased in spiraling whitefly infested MR_2 (28.57%) and no changes in Mysore local variety. A significant reduction in chlorophyll-a and chlorophyll–b contents in the spiralling whitefly infested mulberry (variety – M_5) leaves[17]. They also noticed a variation chlorophyll-a/b ratio depending upon the variation in chlorophyll-a and chlorophyll–b. In the present study, chlorophyll-a/b was decreased in the range of 3.82 % to 50.75 % in the leaves of M_5 and V_1 varieties respectively. The increase in the chlorophyll–a/b ratio was 22.27 % in Mysore local and 24.12 % in the leaves of S_{54} variety. The carotenoids were decreased in the range of 2.20 % in M_5 and 35.89 % in the leaves of V_1. The increase in the carotenoids content was 2.57 % in S_{36} and 11.43 % in Mysore local variety compared to healthy ones.

Table–2
Changes in the photosynthetic pigments (mg/g. fresh weight) of spiralling whiteflies - infested mulberry leaves

Mulberry varieties	Total chlorophyll		Chlorophyll – a		Chlorophyll – b		Chlorophyll – a/b		Carotenoids	
	Healthy	Infested	Healthy	Infested	Healthy	Infested	Healthy	Infested	Healthy	Infested
M_5	2.3	2.25**	1.81	1.76**	0.48	0.49	3.74	3.60*	1.14	1.11**
	(-1.95)		(-2.76)		(+1.12)		(-3.82)		(-2.20)	
MR_2	2.71	1.86**	2.08	1.41**	0.63	0.45	3.32	3.12**	1.16	0.91**
	(-31.35)		(-32.31)		(-28.57)		(-5.68)		(-21.45)	
Mysore local	2.84	3.50**	2.53	3.18**	0.32	0.32	8.02	9.81**	1.21	1.35**
	(+23.38)		(+25.89)		(----)		(+22.27)		(+11.43)	
S_{36}	2.8	2.93**	2.33	2.38**	0.5	0.54**	4.66	4.41**	1.21	1.24**
	(+4.54)		(+2.32)		(+15.99)		(-5.36)		(+2.57)	
S_{54}	2.72	2.25**	2.23	1.91**	0.49	0.40**	4.54	5.64**	1.28	1.07**
	(-17.02)		(-14.05)		(+30.71)		(+24.12)		(-16.22)	
V_1	1.89	1.48**	1.58	1.06**	0.31	0.42**	5.09	2.51**	0.89	0.57**
	(-21.49)		(-32.88)		(+36.32)		(-50.75)		(-35.89)	

**Significant at 1% level; * Significant at 5% level; Values in parenthesis indicate % difference over healthy (+ = more than; - = less than; ---- = not altered)

Similar reduction in the photosynthetic pigments was observed during similar kind of pests attacking mulberry leaves namely mealy bugs, leaf roller, thrips and giant African snails. The variation in chlorophyll content adversely affects the efficiency of photosynthesis[25], which ultimately lead to reduced protein synthesis[26]. Obviously the foliage suffers from nutritional inferiority, may impact adversely on growth and development of silkworm, which ultimately leads to the cocoon crop failures[12, 27-29].

Conclusion

The nutritive status of the mulberry leaves influences the growth and development of silkworms in turns leads to the quality and quantity silk production. The pest attacked leaves are one of the major constraints to quality silk production. In the present study it has been proved that the spiraling whitefly attack results in imbalances in the biochemical and photosynthetic pigments in the mulberry leaves. It causes deficiency or physiological disorders in leaves and they become malformed, deformed, chlorotic and nutritionally inferior. Feeding such mulberry leaves to the silkworm is detrimental and causes economic losses to the farmers. Hence, farmers must protect mulberry foliage from the "Spiralling whitefly" attack by following suitable eco-friendly Integrated Pest Management (IPM) practices.

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