Original Research Article

Anatomy and Biochemical study of Collar Rot Resistance in Eggplant

ABSTRACT

Disease reaction of three eggplant varieties (BAUBegun-1, BAUBegun-2 and Dohazari G) to collar rot (*S. rolfsii*) at early flowering stage, anatomy and biochemical aspects of the collar region of the plant were studied. The plants were inoculated following soil inoculation technique using barley culture of the pathogen. All the varieties were infected ranging from 62.50 to 100%. Varieties varied in percent mortality (0.00 - 100). Plants of the eggplant variety BAUBegun-2 although got infected, all regenerated and were graded resistant. The varieties Dohazari G and BAUBegun-1 were graded as susceptible. Anatomy and biochemical constituents namely total phenols, ascorbic acid, total sugar, reducing sugar and Ca-oxalate contents of the collar region were investigated. BAUBegun-2 was characterized with thick cuticle, thick epidermal cells, many trichomes and smaller intercellular spaces in the cortex which restricted the entry of *S. rolfsii* into the cell. A higher level of biochemical activities were observed in eggplant var. BAUBegun-2. There was a clear correlation between anatomical features and biochemical constituents and collar rot incidence. Anatomical features and biochemical constituents as detected to be responsible for the resistance could be used for the development of superior variety with resistance to collar rot.

Key words: eggplant; collar rot; anatomy; biochemical constituents

1. INTRODUCTION

The eggplant or brinjal (*Solanum melongena* L.), a plant of the family Solanaceae and genus *Solanum* is one of the most common, popular and principal vegetable crops grown in Bangladesh and other parts of the world. Due to its low calorific value (24 kcal 100 g^{-1}) and high potassium content (200 mg 100 g^{-1}), it is suitable for diabetes, hypertensive and obese patients [1].

Eggplant is cheap source of carbohydrate and vitamins [2]. For most of the time, except peak period, market price of eggplant compared to other vegetables remains high which encourages the farmer in eggplant cultivation. Moreover, it serves the need in time of vegetable crisis. So there is a need of its enough and better cultivation.

In Bangladesh, eggplant suffers from 12 diseases of which collar rot caused by *S. rolfsii* Sacc. is one of the most important and damaging diseases. The sclerotial bodies of the fungus remain in dormant condition in the soil or plant debris causing pre and post-emergence death of the plants [3]. Crop loss due to collar rot disease is quite evident.

S. rolfsii is chiefly soil-borne and prefers damp, especially water-logged conditions. As the seasons Kharif-l and Kharif-ll of Bangladesh are wet and eventually cause water logging in low lying areas, the incidence of collar rot has been found higher in Kharif-II season than in Rabi season [4]. The pathogen *S. rolfsii* inflicts severe damage right from germination till harvest of the crop in all seasons. It likes soft tissues and causes rots of tissues adjacent to soil. The pathogen attacks the portion of plant adjacent to soil level termed `collar zone´ causing death by disrupting translocation of food from the top to the root zone [5].

Due to collar rot, the whole plant collapses either at seedling stage and or at mature stage. In seedling stage, death of seedling can be supplimented by gap filling but incase of mature plant this can not be possible. So, collar rot becomes a very destructive disease leading to irrepairable loss to the eggplant [5].

The loss caused by this deleterious fungus was reported to be around 60 to 100% and has become a major threat for eggplant cultivation. At present, eggplant cultivation is virtually impossible without pesticide application. Eggplant growers of Bangladesh mostly depend on chemical to keep the crop production steady. Farmers use a wide range of organocarbamate, organophosphorus and synthetic compounds with various spray formulation advocated from time to time against diseases of eggplant [6].

To avoid dependence on chemical control measure, screening eggplant germplasms resistant to the collar rot pathogen is essentially needed. Information on the genetic variation in respect of disease resistance is of great value in enabling the breeder to use the best genetic stock for improvement in a breeding programme. Continued screening of eggplant cultivars collected from different regions of Bangladesh revealed the existence of resistance against *S. rolfsii* in IPM Lab accession no. IPM Lab-

09 (later designated as BAUBegun 2). The basis of resistance to *S. rolfsii* in BAUBegun 2 was required to be determined.

Identification of resistance is possible through anatomical structures like parenchyma cells, epidermic layers etc. that regulate the entry of fungi into plant tissue and movement of the fungi inside the host [7]. Anatomical features are in-built structures either pre-existing or self-generated by plants in response to invading pathogen. Biochemical activities regulated by constituents like phenols, ascorbic acid, reducing sugar and Ca-oxalate offer resistance to invading pathogen [5]. Eggplant with such characters will be of immense importance to the programme for developing resistance in the host. Very little work has been done in this area both home and abroad [5, 8]. Therefore, the present research work was designed to investigate the anatomical features and biochemical constituents conferring resistance to collar rot pathogen *S. rolfsii.*

2. MATERIALS AND METHODS

The study was carried out at the Plant Disease Diagnostic Clinic, Field laboratory of the Department of Plant Pathology and laboratory of the Department of Crop Botany, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh.

The eggplant cultivars used in the experiment were BAUBegun-1 (IPMLab 31), BAUBegun-2 (IPMLab 09) and Dohazari G (IPMLab 12). Seeds of these cultivars were collected from the IPM and Plant Disease Diagnostic Laboratory, the Department of Plant Pathology, Bangladesh Agricultural University (BAU), Mymensingh.

Tray soil prepared by mixing soil, sand and well decomposed cow dung (2:1:1) was sterilized with formalin solution (4%) @ 200 ml/cft soil following the procedure of Dhasgupta [9]. One hundred seeds were sown in each tray (37 cm X 29 cm).

The experimental plot prepared properly was cleaned off of the weeds and stubbles. Well decomposed cow dung was applied and thoroughly mixed up with soil. Before final land preparation, inorganic fertilizers and manures were applied on the basis of fertilizer recommendation guide of Anonymous [10]. Fifteen healthy seedlings of 28 days old of each variety were planted in the field maintaining plant to plant distance 75 cm and line to line 100 cm. Irrigation and weeding were done as and when necessary.

The pathogen was isolated from naturally infected eggplant. The infected collar region with pathogenic structures were collected and repeatedly washed in fresh water and surface sterilized with 10% Clorox for 1 minute followed by three times washing in distilled water. Inocula were placed on APDA and incubated at 22 ± 2°C for 7 days. The fungus was identified following the keys outlined by Aycock [11] and Barnett [12]. The pathogen was purified and multiplied subsequently through (hypal tip) culture on PDA for preparation of inocula. Inocula of the pathogen, *S. rolfsii* were prepared in barley culture following the procedure of Babar [5].

Six plants were individually inoculated in each plot in each replication by mixing 10 g of infested barley grain with soil near plant base and covered with moist cotton [5]. Equal numbers of plants were kept uninoculated as control. Inoculation was done in the afternoon; cotton was kept moist by adding water as required.

After inoculation, observations were made regularly. Records were maintained on:

I. Number of plants infected of each variety in each replication,
II. Lesion size (in cm),
III. Variety wise plants reactions as a part of response to infection e.g., reduction of base diameter,
IV. Number of plants killed (Mortality).

After inoculation, mortality was recorded upto 20 days and expressed in percentage and the data were analyzed following the Completely Randomized Design.

The tested varieties were placed in various categories of resistance and susceptibility on the basis of mortality percentage using the standard rating scale (1-9) developed by ICRISAT [13].

Scale	Mortality (%)	Reaction
1	0	Resistant (R)
2-3	10 or less	Moderately resistant (MR)
4-5	11-20	Tolerant (T)
6-7	21-50	Moderately susceptible (MS)
8-9	51-above	Susceptible (S)

2.1 Histopathology

Histopathology of the diseased plants of variety BAUBegun-1, BAUBegun-2 and Dohazari G were studied by sectioning (T.S.). Sectioning was done following the procedure of Babar [5]. Microphotographs of diseased plant tissues were taken.

2.2 Biochemical study

Total phenol, ascorbic acid, total sugar, reducing sugar, Ca-oxalate, moisture and dry matter content of both susceptible and resistant cultivars were done.

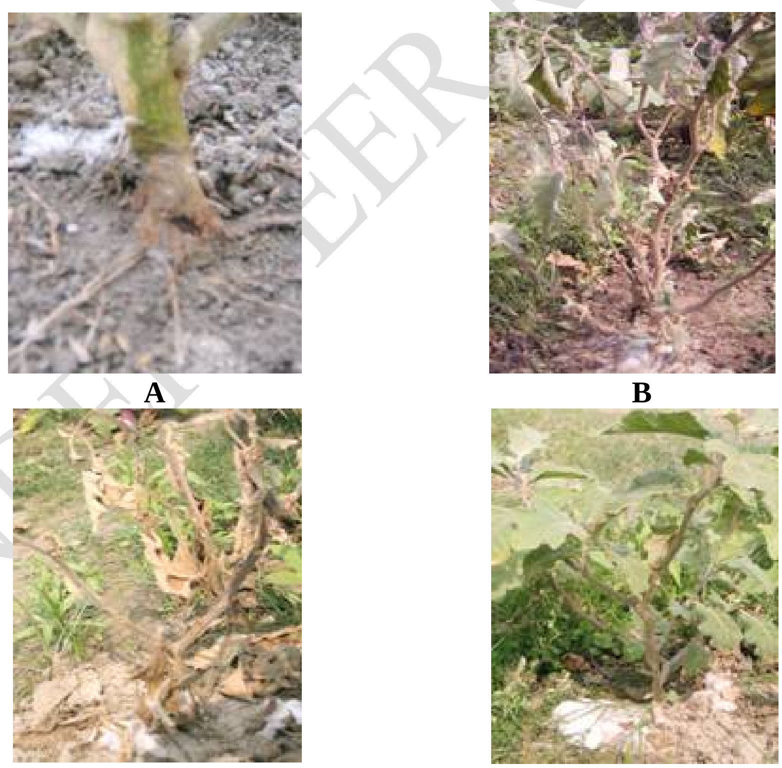
Estimation of total phenol with Folin-Denis reagent is based on the reaction between phenol and an oxidizing agent phosphomolybdate, which results in the formation of a blue complex [14]. The intensity of the coloured complex was measured in a colorimeter. Ascorbic Acid was determined by following visual titration method based on reduction of 2, 6-dichlorophenol indophenol dye. Ascorbic acid was extracted as 6% Metaphosphoric acid from infected and estimated by titrimatric method [15]. Total sugar content was determined by the anthrone method [16]. Reducing sugar content was determined according to the method of Miller [17] where dinitrosalicylic acid used for the development of colour. The method of Srivastava and Krishanan [18] was adopted for the determination of oxalate content. Moisture and dry matter on leaf and stem of three cultivars of eggplant were determined by the methods described in the Manual of Analysis of Fruit and Vegetable Products by Ranganna [19].

Data collected from both the field and laboratory experiments were subject to F test following computer statistical package MSTAT-C (Version 1998) and Statistical Package for Social Sciences and treatment means were compared through DMRT.

3. RESULTS

3.1 Development of Collar Rot Symptoms on Inoculated Eggplant

One day after inoculation of the plants with the barley culture of the pathogen, white mycelial growth was observed on soil surface near the plant base. On the second day, white mycelial mat was formed which advanced rapidly towards plant base. Immature white rounded sclerotia were also observed on soil surface near plant base, which gradually turned brown to black and started to germinate producing white mycelia. Symptoms as expressed by the plants due to collar rot were exhibited through development of lesions resulting characteristics collar rot of the plants, thus enhancing wilting, yellowing and leaf fall, ultimately killing the plants in susceptible varieties, BAUBegun-1 and Dohazari G (Photo. 1. A - C). In variety BAUBegun-2, plant base showed infection, growth of *S. rolfsii* and slight shredding of the tissues (Photo. 1. D). However, the variety BAUBegun-2 remained green and carried flowers and fruits as normal.



Photograph 1. (A-D). Development of collar rots in eggplant

A. Typical collar rot symptom with sclerotia at the base of the eggplant
B. Infected eggplant showing wilting symptom (BAUBegun 1)
C. Dohazari
D. Collar rot infected eggplant variety BAUBegun-2 plant remained green after Infection

3.2 Effect of Collar Rot Infection in Eggplant

All the tested varieties were infected within 3-4 days of inoculation of the plants with the pathogen. Percent plant infections among the varieties were not significantly different. Variety BAUBegun-2 had 62.50 percent plant infection, the lowest (Table 1). Uninoculated plants did not develop any infection.

The collar rot symptoms were manifested by lesion developed at collar zone of eggplant. The lesion size was significantly different among the varieties. The variety Dohazari-G produced the largest lesion 2.35 cm and BAUBegun-1 produced 1.92 cm lesion that indicated their susceptibility to collar rot disease. Whereas the variety BAUBegun-2 produced the smallest lesion which was 1.19 cm that indicated its resistance to collar rot disease (Table 1).

Base diameters of tested varieties were reduced due to collar rot as compared with uninoculated check. Percent reduction in base diameter differed significantly among the varieties. The highest reduction in base diameter was recorded in the variety BAUBegun-1 and lowest in the variety BAUBegun-2 which was 8.43% (Table 1).

None of BAUBegun-2 plants were killed while all plants of the varieties Dohazari G and BAUBegun-1 were killed. Thus the variety BAUBegun-2 was graded resistant and the other two varieties were graded susceptible (Table 1).

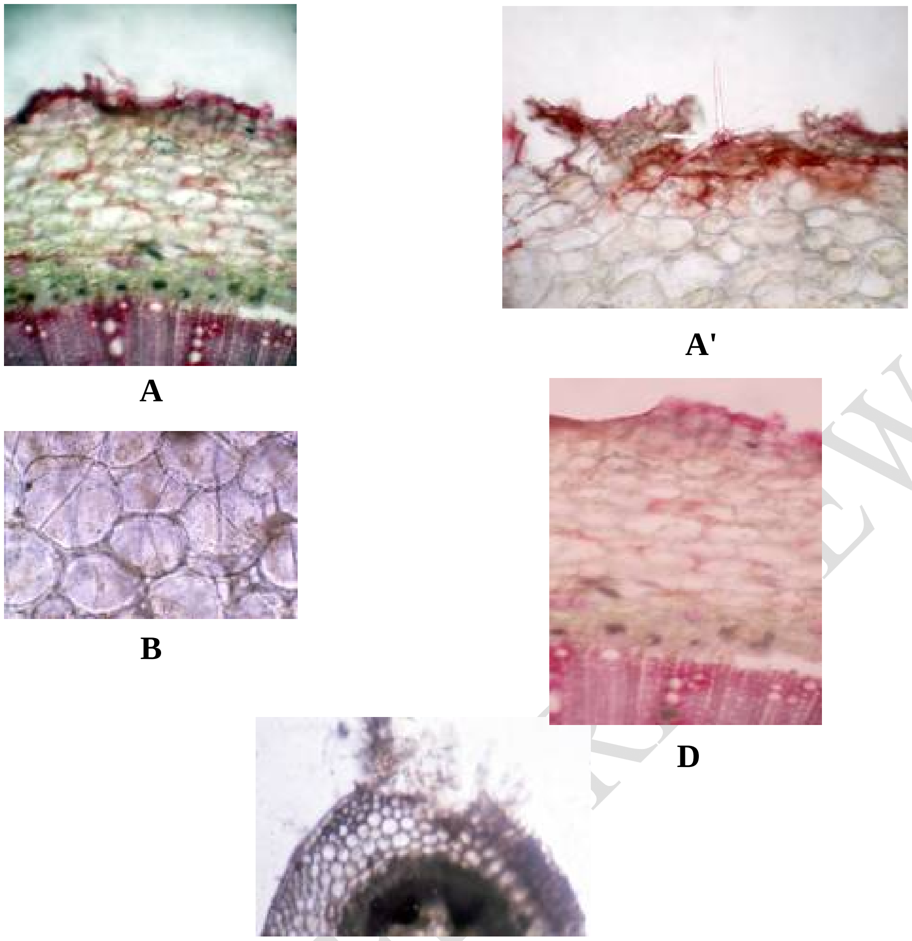
Table 1. Disease Reaction of three Eggplant Varieties against *S. rolfsii* Causing collar Rot

Sl. No.	Accession No.	Eggplant varieties	% plant infection	Lesion size (cm)	% Reduction in base diameter	Percent plant mortality	Varietal reaction
1	IPM lab-31	BAUBegun-1	100.00	1.92	12.43	100.00	S
2	IPM lab-09	BAUBegun-2	62.50	1.19	8.43	00.00	R
3	IPM lab-12	Dohazari G	100.00	2.35	11.18	100.00	S
	LSD (P=0.01)		ND	0.32	1.81	ND	

Number of plants counted is 24 in each variety. ND= Not done, S = Susceptible, R =Resistant

3.3 Histopathology of Collar Rot of Eggplant

Microscopic observation of cross section of affected collar zone of eggplant revealed that the mycelia of the pathogen on reaching the collar zone of the plants aggregated and settled on cuticular surface, adjacent to soil surface from where penetration of cuticles occurred followed by infection (Photo. 2. A, A'). Cuticles were discolored, and then rotting started with longitudinal progress towards the upper region along the stem as well as circular progress around the base. From observation it obviously appeared that the pathogen first multiplied and increased inoculum density through formation and sub-sequent germination of sclerotia in order to increase inoculum potential for successful infection of the host.



Photograph 2. (A-D). Transverse section of infected basal stem of eggplant cvs. BAUBegun-1 and Dohazari G

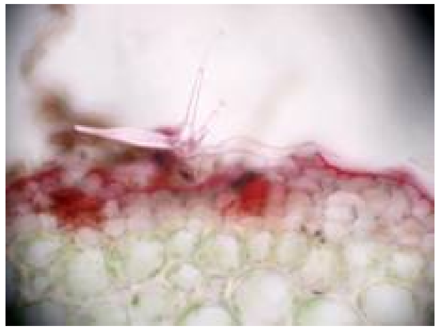
A. Mycelial aggregation on cuticular surface of the host, Dohazari G

A'. Mycelial aggregation on cuticular surface of the host, BAUBegun-1

B. Spreading of mycelia in between and within the cells

C. Disintegration of Cell wall, degradation of cell substances and disorganization of cortical cell layers

D. An irregular rotting of cells occurred in vascular zone and the pathogen did not enter into the xylem vessels



Photograph 3. Transverse section of infected basal stem of eggplant cv. BAUBegun-2

After penetration, pathogen spreads both in between (inter-cellular) and within (intra-cellular) the cells, thus covering entire cell mass of the cortex with an interwoven mycelial network (Photo. 2. B). As a consequence of penetration, cell wall disintegrated, cell substances degraded, cortical cell layers disorganized (Photo. 2. A, A'-C) and rotten. Rotting of cortical cell layers with large parenchymatous cell was rapid. The progressive invasion slowed down when the pathogen reached the vascular tissues. The xylem vessels were clear. Around the vessels woody parenchyma was distorted. Thus there was an irregular rotting of cells occurred in vascular zone.

Cross sections from diseased stem under microscope showed that the pathogen did not enter into the xylem vessels; the microphotography also reflected the clear xylem of the infected tissues (Photo. 2. D). This indicates that the pathogenic invasion is not systemic.

These changes in the anatomical structures were observed in the infected collar zone of the susceptible varieties BAUBegun-1 and Dohazari G. In BAUBegun-2, the pathogen did not enter into the cortical region. Disintegration of cell, degradation of cell substances and finally rotting occurred only in the epidermal region (Photo. 3).

From the study it appears that all the eggplant varieties got infection by the pathogen *S. rolfsii* and there is no significant difference in percent plant infection among the varieties. Siddique [20] had also the similar findings while working with 10 eggplant varieties.

The lesion size of collar rot significantly differed in different varieties. This could be explained by the variation in susceptibility of the eggplant varieties. The variation in lesion size after infection indicates differences in plant's capacity to cope with the pathogenic invasion that might be inherent character of the plants.

Variations in reaction to collar rot among the eggplant varieties were observed at early flowering stage. Only the variety BAUBegun-2 was graded resistant (R) which showed no mortality. Siddique [20] categorized eggplant variety Mirsarai-1 as resistant to collar rot at early flowering stage and Begum *et al.* [3] categorized eggplant vars. D. R. Chowdhury and Longla as resistant to collar rot at early stage.

The effect of collar rot on base diameter was quite apparent. The differences in reduction of base diameter may be due to the differences in the susceptibility to collar rot of the varieties. The variety BAUBegun-2 showed the lowest reduction in base diameter.

S. rolfsii entered into the lower part of the stem and destroyed almost all thin-walled living tissues, cortex and phloem in particular. The destruction of cortex and phloem disrupted the conduction of food materials resulting in the death of the plant. The present findings are in agreement with the report of Siddique [20] who studied pathogenic effect of *S. rolfsii* on some selected varieties of brinjal and Babar [5] who studied the pathogenic effect of *S. rolfsii* on sunflower and had the similar views.

In BAUBegun-1 and Dohazari G the pathogen, *S. rolfsii* entered into the plant body through a few sites located over the entire epidermal circumference. In case of massive attack a number of epidermal cells were bulged out and decreased in wall thickness and protoplasmic consistency. Ultimately, all these epidermal cells were disorganized. In such a situation also the hyphae of the pathogen had been found to take bi-directional path, adaxial and lateral. Due to the lateral pathogenic action, the intact epidermis on other sides of the penetrating point had been found to be separated from the adjoining adaxial cortex.

The present finding differs with the report of Siddique [20] who studied pathogenic effect of *S. rolfssi* on some selected varieties of eggplant. According to him the pathogenic mycelia attack the collar region of the plant and progress longitudinally. Adaxial and lateral paths of the pathogenic hyphae have not been detected there. From that report one gets an impression that the epidermis is affected in the form of a ring which progresses only in the upward direction.

From the present investigation, it cannot be said whether the hyphae of *S. rolfsii* enter into the plant body through some holes, cracks or ruptures as exist on the cuticle and abaxial wall of epidermis, or the hyphae secrete some enzymes which soften or perforate the cuticle and cell wall [21]. Many fungi enter into the plant body through crack, ruptures or holes as formed on the epidermal wall due to the stress of secondary growth [22]. Further investigation is required to ascertain the same and establish the truth.

In phloem, the sieve elements (sieve tube member and companion cell) and phloem parenchyma (axial and ray) of both primary and secondary in origin had been found to be thin walled, and were easily accessible to the pathogen. Next to middle cortex, tissues of phloem were vulnerable to the fungal attack. Similar observations were made by a number of workers [20-21]. Young phloem parenchyma (axial and ray) and companion cells had been found to be easily destroyed in eggplant stem by the pathogen, *S. rolfssi.* Along with companion cells, the sieve tube members were disorganized resulting serious disruption of food transport mechanism causing death of the plant at length. Similar report was made by Siddique [20].

Due to collar rot, disintegration and rotting of basal cuticle tissues disturbed translocation of food materials led to nutritional deficiency in plants which hampered normal physiology in sensitive varieties. Base diameter was reduced due to destruction of basal cuticles and exposing the wood (lying under callus tissues) which the plants could not recover.

The pathogen failed to enter into cortex of BAUBegun-2. The thick cuticle, compact epidermal cells and small abaxial cells of the cortex with smaller intercellular spaces restricted the penetration by the invading pathogen.

3.4 Biochemical study

Biochemical analysis indicated a differential status of compounds like total phenol, ascorbic acid, total sugar, reducing sugar and Calcium oxalate content in three cultivars of eggplant.

Phenol content was highest in the leaf and stem of the cultivar BAUBegun-1 and second highest was in the leaf of the cultivar Dohazari G. The lowest amount of phenol was present in the leaf of the cultivar BAUBegun-2 (Table 2). There were no significant differences among the cultivars in ascorbic acid content of the leaves. However, stem of cultivar BAUBegun-2 had the highest content of ascorbic acid followed by that in the stem of cultivar BAUBegun-1. The amount of total sugars was highest in both the leaves and stem of cultivar BAUBegun-2. The second highest amount of total sugar was detected in the leaves of cultivar BAUBegun-1. Cultivar Dohazari G has the lower contents of total sugar all through (Table 2). Leaves and stem of BAUBegun-2 had the highest content of reducing sugar. The second highest amount of reducing sugar was detected in cultivar Dohazari G. BAUBegun-2 had the higher content of Ca-oxalate in both leaves and stem. The cultivars BAUBegun-1 had the lowest Ca-oxalate content (Table 2). Dry matter contents were highest in both leaves and stem of cultivar BAUBegun-2. Second highest amount of dry matter was found in Dohazari G. The highest moisture (%) was recorded in the leaf of the cultivar BAUBegun-1 and stem of Dohazari G. The cultivars BAUBegun-2 carried the lowest moisture percentage (Table 2). The cultivars BAUBegun-1, BAUBegun-2 and Dohazari G were statistically identical in terms of containing moisture (%) in stem (Table 2).

3.5 Relationship between anatomy and biochemical constituents and collar rot resistance in eggplants

BAUBegun-1 is characterized with thin cuticle, few trichomes, loosely attached epidermal cells and large intercellular spaces. Phenol contents in the stem is higher; ascorbic acid, reducing sugar, Ca-oxalate and dry matter content are lower. Moisture is higher. The variety was graded susceptible to *S. rolfsii* (Table 3).

The variety BAUBegun-2 is having thick cuticle, thick epidermis, many trichomes and smaller intercellular spaces restricted the entry of the pathogen. Ascorbic acid, reducing sugar and Ca-oxalate contents were higher in the stem of this variety though phenol contents was lower. Dry matter (%) was higher and moisture was lower than other two varieties. Thus the variety was graded resistant (Table 3).

On the other hand, the variety Dohazari G was graded susceptible to *S. rolfsii* though it contained higher amount of phenols. The variety Dohazari G has the highest amount of moisture and lower amount of dry matter (Table 3).

Table 2. Biochemical compounds, dry matter and moisture content in three cultivars of eggplant

Cultivar	Phenol (mg/100gm sample)		Ascorbic acid (mg/100gm sample)		Total sugar (mg/100gm sample)		Reducing sugar (mg/100gm sample)		Ca-oxalate (mg/100gm sample)		Dry matter (g/100 gm sample) (%)		Moisture (g/100 gm sample) (%)	
	Leaf	**Stem**	**Leaf**	**Stem**	**Leaf**	**Stem**	**Leaf**	**Stem**	**Leaf**	**Stem**	**Leaf**	**Stem**	**Leaf**	**Stem**
BAUBegun 1	136.50	97.50	5.92	2.69	1608.15	1308.45	810.00	540.50	261.28	222.85	16.24	20.80	83.67	79.43
BAUBegun 2	79.55	72.25	5.75	4.55	1807.85	1308.45	944.50	928.00	268.96	299.70	18.06	22.83	81.69	76.78
Dohazari G	118.00	88.25	5.39	2.87	1278.20	1008.85	877.50	802.00	268.93	245.91	17.77	21.16	81.76	80.48

Table 3. Relationship between varietal disease reactions to anatomical structures and biochemical constituents in eggplant

Eggplant variety	Anatomical structures of stem	Biochemical composition of stem							Reaction to Collar rot *S. rolfsii*
		Phenol (mg/ 100g)	**Ascorbic acid (mg/ 100g)**	**Total sugar (mg/ 100g)**	**Reducing sugar (mg/ 100g)**	**Ca-oxalate (mg/ 100g)**	**Dry matter (g/100g) %**	**Moisture (g/100g) %**	
BAUBegun 1	Cuticle thin, Trichomes few, Epidermal cells loosely attached, Abaxial cells of the cortex are large with more intercellular spaces.	97.50	2.69	1308.45	540.50	222.85	20.80	79.43	Susceptible
BAUBegun 2	Cuticle thick, Trichomes many, Epidermal cells compact, Abaxial cells of the cortex are smaller with smaller intercellular spaces.	72.25	4.55	1308.45	928.00	299.70	22.83	76.78	Resistant
Dohazari G	Cuticle thin, Trichomes few, Epidermal cells not compact, Abaxial cells of the cortex are large with more intercellular spaces.	88.25	2.87	1008.85	802.00	245.91	21.16	80.48	Susceptible

Higher phenol content in the diseased cultivars BAUBegun-1 and Dohazari G as observed may be due to the production of phenolic acids by the pathogen *in vitro* and those in the infected plants and agreed with Aggarwal and Mehrotra [23], who reported alterations in phenolic compounds in Colocasia due to *Phytophthora colocasiae* infection.

The present results also corresponded with Alozie *et al.*[24] who found *Colletotrichum gloeosporioides (Glomerella cingulata)* infected yam (*Dioscorea alata*), phenol content was higher than in healthy material, and Gupta and Kaushik [25] reported total phenol content was higher in alternaria blight diseased leaves and siliquae walls of mustard compared to healthy leaves of mustard. The increase in total phenol content in susceptible cultivars BAUBegun-1 and Dohazari G after infection reflected the response of the host to check the attack of pathogen and is confirmed by reports of Barua and Das [26] in fruit rot resistant chilli and Kumar and Balasubramanian [27] in *Puccinia arachidis* inoculated groundnut.

Jindal [28] and Kumar *et al.* [29] found (other than eggplant) resistant cultivars contained higher levels of total phenol which are contradictory to the results of the present study. But it may be possible that resistant cultivars contained higher level of total phenol and phenol content increased in susceptible cultivars after infection.

BAUBegun-2 had the highest amount of ascorbic acid in stem and correspondingly the lowest disease incidence. There are evidences that plants having higher amount of ascorbic acid are less susceptible to pathogenic attack. The present findings are supported by Zhang *et al.* [30] who found high contents of ascorbic acid in sweet potato which was characterized by high resistance to *Fusarium oxysporum*, Wang *et al.* [31] the resistant cultivar of watermelon to *Fusarium oxysporum* f. sp. *niveum*, maintained a higher content of ascorbic acid than the susceptible cultivar, Gong *et al.* [32] developed total disease resistant cucumber variety containing higher amount of ascorbic acid than that of the control and Kalarani *et al.* [33] found resistant genotype of chilli against fruit rot caused by *Colletotrichum capsici* contained higher ascorbic acid than susceptible ones.

The information obtained through biochemical analysis corroborate with the field records where BAUBegun-1 and Dohazari G were found more susceptible. Schaaf [34] revealed the ascorbic acid as an additional potent promoter-stimulating agents related to pathogen defense in transgenic tobacco plants.

The lowest amount of total sugar and maximum disease was found from the cultivar Dohazari G followed by cultivar BAUBegun-1 but cultivar BAUBegun-2 had minimum disease and higher amount of total sugar both in stem and leaf. These results consented to the proposal of Chattopadhyay [35], who found total sugar content fell more rapidly in susceptible mustard plant to *Alternaria brassicae* and depletion of sugars were greater in lesions than in lesion free areas of infected leaves, Khirbat and Jalali [36], who observed total sugar content in susceptible genotype of chickpea to *Ascochyta* *rabiei* were low, Kumar *et al.* [29], who showed *Albugo candida* infection to susceptible Indian mustard caused a greater decrease in total sugar of susceptible compared to resistant varieties.

The ability of resistant variety BAUBegun-2 to prevent greater loss of total sugar upon infection appeared important for resistance. Resistant plants also possessed higher levels of constitutive and is supported by Chakrabarty *et al.* [37], who found similar results in cotton resistance to grey-mildew.

Cultivar BAUBegun-2 (resistant) had minimum disease and higher amount of reducing sugar but BAUBegun-1 (susceptible) had the lowest amount of reducing sugar and maximum disease followed by cultivar Dohazari G. Similar results were found by Deeb *et al.* [38] in barley infected by *Helminthosporium sativum* where reducing sugar concentration were higher in non-inoculated susceptible varieties, seedlings and adults and infection reduced reducing sugar concentration in susceptible plants compared with controls. Sindhan *et al.* [39] found in mungbean cercospora leaf spot where reducing sugar content were higher in healthy leaves of susceptible genotypes than of resistant ones and their amount decreased in diseased leaves of resistant and susceptible genotypes. Shete and Munjal [40] also showed that the reducing sugar levels in the leaves of susceptible and resistant mung bean cultivars decreased under the pathogenesis of powdery mildew. Such a decline in the content of sugars was more pronounced in the susceptible cultivars than in the resistant ones.

The higher amount of Ca-oxalate in healthy tissues of eggplant stem as found in the present investigation have support from Tarabeih and Menoufi [41] who found that plants grown in CaCO3 rich soil were more resistant to collar rot by *S. rolfssi.* This may be explained as the oxalic acid carried by the fungus is being tied-up as calcium oxalate and the fungus becoming inactive. Secondly, high level of CaCO3 causes increase in soil pH which becoming less suitable for growth and development of *S. rolfsii* as it thrives well in soil pH 5.0. Similar views have been expressed by Babar [5] who found higher amount of Ca-oxalate in collar rot resistant cultivars of sunflower.

The lower percentage dry matter content was found in the leaf of highly susceptible cultivar BAUBegun-1. Percent dry matter content was highest in the leaf of resistant cultivar BAUBegun-2.

Percentage moisture was higher in the leaves and stem of highly susceptible cultivars BAUBegun-1 and Dohazari G. While it was lower in resistant cultivar BAUBegun-2. Dry matter content confers stoutness of the plant body whereas moisture makes succulent. Therefore, varieties with higher dry matter content and lower moisture show resistance to invading pathogen. The findings of the present study are in line with these views but do not agree with Gong *et al.* [32] who found water content 0.5% higher in Xiangpuanggua 5, a new cucumber (*Cucumis sativus*) F1 hybrid compared with those of control variety Xianghuanggua 2 having disease resistance also higher than that of the control.

4. CONCLUSIONS

Anatomical features and biochemical constituents as analyzed in the present study are indicative of resistance of eggplant var. BAUBegun 2 to collar rot pathogen *S. rolfsii.* BAUBegun 2 is already released as a collar rot resistant variety. The characteristic resistant features of BAUBegun 2 could be transferred to cultivated eggplant varieties through conventional breeding and also through molecular technique.

5. REFERENCES

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