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Biochemical Analysis of Tomato Plants Grafted onto Wild Brinjal Rootstocks under Fusarium-Nematode Infestation

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***Abstract*— *Tomato (Solanum lycopersicum L.) cultivation is significantly constrained by the concurrent incidence of Fusarium oxysporum and Meloidogyne incognita, resulting in substantial yield losses. Grafting onto resistant rootstocks has emerged as an effective strategy to enhance resistance against these soil-borne pathogens. The present study investigated the biochemical responses of tomato plants grafted onto wild brinjal rootstocks under Fusarium-nematode infested conditions. Among several rootstocks screened in the screenhouse, brinjal roostock RB_5 (Solanum torvum) and RB_3 (a wild brinjal genotype) were identified as the most effective. RB_5 exhibited the highest phenol content (0.420 mg/g FW in roots; 0.349 mg/g FW in stems) and peroxidase activity (2.19 µmol/min/g FW in roots; 1.47 µmol/min/g FW in stems). These biochemical substances are associated with enhanced structural defense and regulation of oxidative stress, contributing to increased resistance. Grafting tomato plants onto resistant wild rootstocks, particularly S. torvum (RB_5), significantly strengthens biochemical defense mechanisms under Fusarium–nematode stress. This approach offers a sustainable, eco-friendly alternative to chemical control, improving plant resilience and supporting higher productivity in Fusarium-nematode infested soils.*

***Keywords*— Biochemical defense, Grafting, Rootstock, Solanum lycopersicum**

I. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most widely cultivated vegetable crops globally, valued for its nutritional and economic significance. However, its productivity is severely constrained by soil-borne pathogens, particularly *Fusarium oxysporum* and root-knot nematodes (*Meloidogyne* spp.), which often occur simultaneously, leading to synergistic detrimental effects on plant health and yield (Meshram and Adhikari, 2024). These biotic stresses induce complex physiological and biochemical responses in plants, affecting their defense mechanisms and oxidative stress regulation. Grafting has emerged as an effective strategy to enhance tolerance against soil-borne pathogens by combining disease-resistant rootstocks with high-yielding scions (Phani *et al*., 2024). Rootstocks such as brinjal (*Solanum melongena*) and resistant tomato cultivars have shown potential in mitigating the adverse effects of Fusarium-nematode complexes. Understanding the biochemical changes induced in grafted plants under such stress is critical for elucidating resistance mechanisms. In this study, the defense responses and stress tolerance of grafted and non-grafted plants were assessed through the analysis of key biochemical parameters: total phenol content (mg/g fresh weight) and peroxidase activity (µmol) in both roots and shoots. These specific substances were chosen due to their pivotal and well-established roles in mediating plant defense mechanisms and serving as reliable indicators of resistance against biotic and abiotic stresses.The findings are expected to contribute to the development of graftingbased strategies for sustainable tomato production in Fusarium-nematode infested soils.

II. MATERIAL AND METHODS

The present study was conducted in the screen-house of the Department of Nematology, CCS Haryana Agricultural University, Hisar. Two resistant rootstock genotypes, RB_3 (wild) and RB_5 (*Solanum torvum)* were utilised for grafting. Three tomato cultivars, namely Pusa Ruby (S_1), Punjab Gaurav (S_2), and a locally grown polyhouse variety (S_3), were selected as scions. These were grafted onto the rootstocks to develop six graft combinations: $RB_3 \times S_1$, $RB_3 \times S_2$, $RB_3 \times S_3$, $RB_5 \times S_1$, $RB_5 \times S_2$, and $RB_5 \times S_3$. All treatments, including grafted and non-grafted plants, were maintained under infested conditions of *Fusarium oxysporum* and *Meloidogyne incognita*. The experimental setup followed a Completely Randomized Design (CRD) with four replications per treatment. For data collection, five tomato plants were randomly selected from each replication. Biochemical analyses, including total phenol content and peroxidase activity in both roots and shoots, were performed using standard protocols. The total phenol content (mg/g fresh weight) of the roots showing resistant reaction was estimated by the method of Swain and Hillis (1959) and Peroxidase activity (U/min/g FW) was assayed as per the method of Machly (1954). Data were statistically analyzed using two-factor ANOVA with the aid of OPSTAT software.

Brinjal Rootstock RB_5

Brinjal Rootstock RB_3

Fig. 1: Resistant rootstocks of brinjal selected from screening against fusarium nematode complex for tomato grafting

III. RESULT AND DISCUSSION

In this study, biochemical mechanisms in roots and stems of grafted and non-grafted plants were established by analysing total phenol content and enzymes, *viz*., peroxidases under fusarium-nematode infested conditions. Phenolic compounds play a major role in the defense mechanism of plants against various infectious agents. The present study indicated that the rootstocks had a significant effect on total phenol content in roots and stems (mg/g FW). Among the evaluated rootstocks, RB_5 consistently demonstrated the highest phenol accumulation, recording 0.420 mg/g FW in roots (Table 1) and 0.349 mg/g FW in scion stems (Table 2). Conversely, the non-grafted scions (R_0) exhibited the lowest phenol content, with values of 0.311 mg/g FW in roots (Table 1) and 0.247 mg/g FW in scion stems (Table 2). However, all the scions and interaction between rootstocks and scions had non-significant effect on phenol content in roots and stems.

The higher total phenol content observed in grafted plants may help control root-knot nematode and fusarium wilt under infested conditions. Bajaj *et al*. (1983) stated that total phenol content in roots and stems indicated the level of resistance against root-knot nematodes in tomato. Total phenol content in roots also showed a negative association with root-knot index, as well as number of galls and number of egg masses per root system. Mahajan *et al*. (1985) also reported the nematicidal activity of phenolic compounds. The post-infection increases in phenols, accumulating at infection sites, likely contribute to the plant's defense mechanism by disrupting pathogen metabolic activities, leading to increased root length (Gopinatha *et al*., 2002). Naik *et al*. (2024) similarly reported an accumulation of higher phenolics in plants subjected to stress conditions, reinforcing the role of these compounds in plant defense.

Table 1: Effect of rootstocks, scions and their interactions on total phenol content in roots (mg/g fresh weight) under fusarium-nematode infested conditions

Scion (B) / Rootstock (A)	Pusa Ruby (S_1)	Punjab Gaurav (S_2)	Polyhouse LC (S_3)	Mean A
RB_5	0.413	0.426	0.420	0.420
RB_3	0.396	0.405	0.401	0.401
$^*R_0$	0.301	0.323	0.308	0.311
Mean B	0.370	0.385	0.376	
CD at 5% level of significance				
Factor A (treatment)= 0.02				
Factor B (rootstock)= NS				
Factor A×B= NS				

*Non-grafted scions

Table 2: Effect of rootstocks, scions and their interactions on total phenol content in scion Stems (mg/g fresh weight) under fusarium-nematode infested conditions

Scion (B) / Rootstock (A)	Pusa Ruby (S_1)	Punjab Gaurav (S_2)	Polyhouse LC (S_3)	Mean A
RB_5	0.345	0.353	0.349	0.349
RB_3	0.310	0.324	0.322	0.319
$^*R_0$	0.243	0.251	0.246	0.247
Mean B	0.299	0.309	0.306	
CD at 5% level of significance				
Factor A (treatment)= 0.032				
Factor B (rootstock)= NS				
Factor A×B= NS				

*Non-grafted scions

The enzyme peroxidase is intrinsically linked to plant defense mechanism by catalyzing the condensation of phenolic compounds into lignin. The current model suggests that peroxidase aids in defense by converting phenolic monomers from the phenylpropanoid pathway into insoluble polymers (Robb *et al*, 1991). It has been demonstrated that peroxidase plays an important, early and specific role in hypersensitive containment of the pathogen (Peng and Kuc, 1992). Estimation of peroxidase activity in the present study indicates that all the resistant rootstocks possessed higher peroxidase activity than the susceptible ones. Specifically, rootstock RB_5 showed the highest peroxidase activity in roots, *i.e.,* 2.19 µmol (Table 3) and stems, *i.e*., 1.47 µmol (Table 4), whereas non-grafted scions (R_0) exhibited the minimum activity of 1.01 µmol in roots (Table 3) and at 0.71 µmol in stems (Table 4). Consistent with phenol content, peroxidase activity varied non-significantly among scions and their interactions with rootstocks. Peroxidase activity was found to be higher in all resistant rootstocks compared to the susceptible ones, with RB_5 showing the maximum levels. These observations align with earlier studies reporting the role of peroxidase in induced systemic resistance across plant species (Hammerschmidt *et al*., 1982; Dalisay and Kuc, 1995; Ramamoorthy and Samiyappan, 2001). Similar findings were also reported by Rani *et al*. (2008) and Sundhariaya (2008) in tomato, and Sherly (2010) in *Solanum* species.

Table 3: Effect of rootstocks, scions and their interactions on peroxidases (U/min/g FW) in roots under fusarium-nematode infested conditions

Scion (B) / Rootstock (A)	Pusa Ruby (S_1)	Punjab Gaurav (S_2)	Polyhouse LC (S_3)	Mean A
RB_5	2.13	2.26	2.19	2.19
RB_3	1.91	1.97	1.95	1.94
*R_0	0.98	1.05	1.01	1.01
Mean B	1.67	1.76	1.71	
CD at 5% level of significance				
Factor A (rootstock)= 0.11				
Factor B (scion)= NS				
Factor A×B= NS				

*Non-grafted scions

Table 4: Effect of rootstocks, scions and their interactions on peroxidases (U/min/g FW) in scion Stems under fusarium-nematode infested conditions

Scion (B) / Rootstock (A)	Pusa Ruby (S_1)	Punjab Gaurav (S_2)	Polyhouse LC (S_3)	Mean A
RB_5	1.44	1.52	1.46	1.47
RB_3	1.10	1.26	1.14	1.16
*R_0	0.67	0.75	0.71	0.71
Mean B	1.07	1.17	1.10	
CD at 5% level of significance				
Factor A (rootstock)= 0.09				
Factor B (scion)= NS				
Factor A×B= NS				

*Non-grafted scions

IV. CONCLUSION

This biochemical analysis revealed that grafting tomato plants onto resistant wild rootstocks particularly with brinjal rootstocks RB_5, induced elevated levels of total phenol content and increased activity of crucial defense enzymes such as peroxidases. These observed biochemical alterations underscore the enhanced intrinsic defense mechanisms and improved physiological performance of grafted plants, leading to robust resistance against the devastating Fusarium-nematode complex under infested conditions. Consequently, this sustainable grafting strategy offers a viable and eco-friendly approach to mitigate soil-borne pathogen pressures, reduce dependency on chemical controls, and ultimately bolster crop resilience, yield, and overall plant health in tomato cultivation.

V. AUTHORS' CONTRIBUTION

Conceptualization of research (IA and KY); Designing of the experiments (IA and KY); Contribution of experimental materials (IA and KY); Execution of field/lab experiments and data collection (KY and AK); Analysis of data and interpretation (KY, K, VK and PP); Preparation of the manuscript (KY, SK and PP)

VI. DECLARATION

The authors declare that there is no conflict of interest.

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