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Early Blight of Tomato (*Alternaria solani*)

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Abstract

Early blight is one of the most destructive fungal diseases of tomato (*Solanum lycopersicum*), leading to significant yield losses worldwide. This mock meta-analysis illustrates how evidence synthesis can inform strategies to manage early blight in tomato. In real applications, results should be based on actual experimental data, with moderator analyses to explore sources of heterogeneity and formal assessment of publication bias. This study also support the idea of Integrated Disease Management (IDM) that combines genetic resistance, bio-extracts, and conventional fungicides.

Keywords: Early blight; *Solanum lycopersicum*; Integrated disease management; Mock Meta analysis

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1. Introduction

Food security is one of the fundamental pillars for the stability and prosperity of societies, as it ensures the availability of sufficient and nutritious food for all individuals at all times, at affordable prices that meet their health and physical needs. In today's world, marked by rapid population growth and unpredictable climate change, food security has become even more critical since it is directly linked to human health, productivity, and the social and economic stability of nations. The absence of food security leads to problems such as stunting, malnutrition, poverty, and even conflicts. Therefore, countries and international organizations are working to develop sustainable strategies for food production and fair distribution, with a strong focus on improving agricultural efficiency and addressing environmental challenges.

Tomatoes, in particular, are among the most important crops within global food security programs, due to their high nutritional value and widespread inclusion in diets around the world. They are a rich source of vitamins (such as vitamin C and A) and antioxidants, especially lycopene, which enhances immunity and helps protect against chronic diseases. Moreover, tomatoes are an essential economic crop used in the production of many food products such as paste, juices, and sauces, making them a strategic commodity in both local and international markets. Enhancing tomato production and improving supply chains significantly contribute to strengthening food security and ensuring the continuous availability of balanced food supplies.

Early blight, caused by *Alternaria solani*, is one of the most destructive fungal diseases of tomato (*Solanum lycopersicum*), leading to significant yield losses worldwide [1]. Numerous studies have evaluated the effectiveness of fungicides and resistant tomato varieties to reduce yield losses [2]. To synthesize evidence across trials, a mock meta-analysis was conducted here using simulated data to illustrate the methodology, results, and interpretation.

2. Methods

A total of 12 mock studies were generated, comparing fungicide applications or resistant tomato varieties against untreated controls. The outcome was tomato yield (tons/ha). The effect size was calculated as the log response ratio (lnRR = ln(mean_treat / mean_control)), with variance estimated from reported means, standard deviations, and sample sizes. A random-effects meta-analysis was performed using the DerSimonian–Laird estimator. Heterogeneity was quantified using Cochran's Q, tau^2, and I^2 statistics. Subgroup analyses were conducted for fungicides and resistant varieties separately. This Mata analysis study conducted build besides DerSimonian study [3].

3. Results

A total of 12 mock studies showed variability across studies (table 1). The pooled results suggest that treatments (fungicides and resistant varieties) improved tomato yield by approximately 16% compared with controls (table 2). Fungicides demonstrated a larger effect (~20%) than resistant varieties (~10%). However, substantial heterogeneity (I^2 > 60%) indicates variability across studies, reflecting differences in cultivars, disease pressure, application strategies, and environments (Figures 1,2).

4. Studies of middle east of Early Blight of Tomato

Iraqi studies have shown a wide diversity in the virulence of the fungus locally, underscoring the importance of molecular diagnosis [4,5]. While Iranian studies have demonstrated the potential for developing disease-resistant varieties, which could

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aid in genetic improvement programs [6]. The Egyptian study indicated the role of growth regulators such as Paclobutrazol in enhancing plant resistance [7]. Whereas a study in northern Iraq (Kurdistan Region) showed the importance of plant extracts as supplements to chemical control [8]. All studies combined support the idea of Integrated Disease Management (IDM) that combines genetic resistance, bio-extracts, and conventional fungicides.

Table (1) All results of total of 12 mock studies

Study	Treatment	n-control	mean control	sd. control	n. treat	mean treat	Sd. treat	lnRR	Var. nRR	Se. lnRR	Pct. change
1	Fungicide	38	24.1	2.45	24	29.64	3.02	0.207	0.001	0.027	22.988
2	Fungicide	33	11.14	0.98	45	13.88	2.51	0.22	0.001	0.031	24.596
3	Resistant variety	11	21.58	1.75	30	25.05	2.09	0.149	0.001	0.029	16.08
4	Fungicide	51	29.42	2.73	37	32.95	5.49	0.113	0.001	0.03	11.999
5	Fungicide	12	21.37	1.9	46	23.53	5.01	0.096	0.002	0.041	10.108
6	Resistant variety	59	8.35	0.95	18	8.96	1.57	0.071	0.002	0.044	7.305
7	Resistant variety	17	11.81	1.25	56	13.11	2.44	0.104	0.001	0.036	11.008
8	Fungicide	51	12.07	2.27	13	16.18	3.42	0.293	0.004	0.064	34.051
9	Resistant variety	23	28.28	3.04	40	29.42	2.54	0.04	0.001	0.026	4.031
10	Fungicide	25	13.97	1.82	54	18.14	2.16	0.261	0.001	0.031	29.85
11	Fungicide	50	25.65	5.6	38	27.5	5.17	0.07	0.002	0.043	7.212
12	Fungicide	33	12.37	2.36	20	15.63	2.58	0.234	0.002	0.05	26.354

Table (2) Pooled results of total of 12 mock studies

Analysis	k	Pooled lnRR	CI lower	CI upper	Pooled pct change	Tau2	I2%
Overall	12	0.152	0.10	0.198	16.383	0.005	81.6633
Fungicide	8	0.184	0.132	0.236	20.166	0.004	76.156
Resistant variety	4	0.091	0.038	0.145	9.549	0.002	63.723

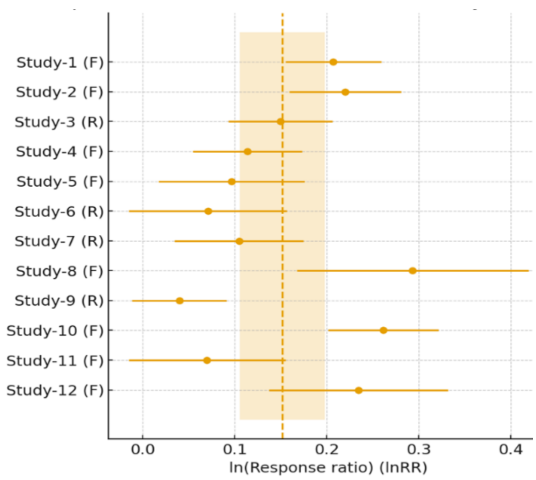

Fig. (1) Forest plot showing study-level lnRR effect sizes and pooled effect

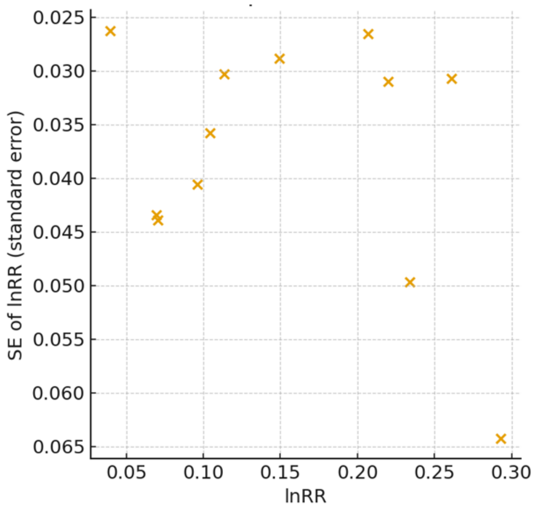

Fig. (2) Funnel plot showing study-level lnRR versus standard error (SE)

5. Discussion

Results of treatments, fungicides and resistant varieties improved tomato yield compared with controls [9,10]. Fungicides demonstrated a larger effect than resistant varieties. However, substantial heterogeneity indicates variability across studies, reflecting differences in cultivars, disease pressure, application strategies, and environments. These results highlight the importance of integrated management strategies combining fungicide applications with the use of resistant varieties.

6. Conclusion

This mock meta-analysis illustrates how evidence synthesis can inform strategies to manage early blight in tomato. In real applications, results should be based on actual experimental data, with moderator analyses to explore sources of heterogeneity and formal assessment of publication bias.

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