International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Diseases Prevalence in Kinnow (Citrus Nobilis x Citrus Deliciosa) Cultivated in the Sri Ganganagar Geographical Area

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1. Abstract

This study investigates the prevalence of major diseases affecting Kinnow (Citrus nobilis x Citrus deliciosa) orchards in the Sri Ganganagar area of India. Field surveys were conducted across six sampling sites, examining 50 Kinnow plants at each location for four primary diseases: Gummosis, Huanglongbing (HLB), Citrus Canker, and Black Fly infestation. The research employed a stratified random sampling method and utilized standard disease assessment protocols. Results revealed varying disease prevalence across the sampling sites. Citrus Canker emerged as the most prevalent disease, with incidence ranging from 10% to 22%. Gummosis showed a prevalence of 2% to 10%, while Huanglongbing and Black Fly infestations were observed at lower levels (2-6% and 2-4% respectively). The study found that disease prevalence varied significantly among different locations, likely due to differences in environmental conditions and orchard management practices. The paper discusses the potential economic impact of these diseases on Kinnow cultivation and provides recommendations for integrated pest management strategies. These include implementing windbreaks, improving soil drainage, aggressive vector control for HLB, and maintaining strict orchard hygiene. The findings underscore the importance of tailored disease management approaches and the need for ongoing monitoring and research to ensure the sustainable production of Kinnow in the region.

Keywords: Kinnow cultivation, Gummosis, Huanglongbing, Citrus Canker, and Black Fly

1. Introduction

Kinnow, a hybrid variety of citrus fruit, results from the cross-breeding of two citrus cultivars, King (*Citrus nobilis*) and Willow Leaf (*Citrus deliciosa*). This hybrid was developed by H.B. Frost at the University of California Citrus Experiment Station in 1935. Kinnow is primarily grown in the Punjab region of India and Pakistan, and it has gained significant popularity due to its high juice content, appealing flavor, and rich nutritional profile, which includes a high content of vitamin C and antioxidants (Gill *et al.*, 2017).

Kinnow holds substantial economic importance for farmers in the Punjab region and surrounding areas, including Sri Ganganagar. It is a major source of income for small and medium-sized farmers due to its high yield potential and favorable market demand. The cultivation of Kinnow contributes significantly to the local economy by providing employment opportunities and supporting ancillary industries such as packaging, transportation, and agro-processing (Singh & Singh, 2016).

Kinnow cultivation involves specific agronomic practices to achieve optimal yield and fruit quality. These practices include selecting appropriate rootstocks, implementing efficient irrigation systems, and employing integrated pest management (IPM) strategies to control diseases and pests. In the Sri Ganganagar region, farmers utilize both traditional and modern techniques to enhance productivity and ensure sustainable farming practices (Kumar *et al.,* 2018). Thus, studying plant diseases in Kinnow is crucial due to its significant economic impact, nutritional value, and susceptibility to various pathogens. Effective disease management ensures high yield and quality, supporting the livelihoods of farmers and the local economy. Additionally, understanding disease dynamics helps in developing resistant varieties and sustainable agricultural practices, thereby safeguarding Kinnow production against biotic stresses (Singh & Singh, 2016; Gupta *et al.*, 2019).

The current research concerned with the plant diseases in Kinnow (Citrus nobilis x Citrus deliciosa), and it aimed to investigate the disease prevalence and analysis of disease impact in Kinnow (Citrus nobilis x Citrus deliciosa) orchard in the Sri Ganganagar geographical area.

Despite significant advances in understanding Kinnow plant diseases, several gaps remain. There is a need for more comprehensive studies on the integrated pest management (IPM) of Kinnow to prevalent diseases like citrus canker and Huanglongbing. Additionally, the long-term efficacy of current disease management strategies, especially under changing climate conditions, is not well-documented. Furthermore, integrated pest management (IPM) approaches tailored specifically for Kinnow orchards need further exploration to optimize sustainability and reduce reliance on chemical controls (Bové, 2006).

2. Methodology

2.1 Study Area and Sample Selection

The study was conducted in the Sri Ganganagar district, known for its extensive Kinnow cultivation. A stratified random sampling method was used to select 6 Kinnow orchards such as Daulatpura (S-1), 7 F (S-2), Koni (S-3), Mirzawala (S-4), Maderan (S-5), and Fatuhi (S-6). It represents different localities within Sri Ganganagar to ensure diversity in environmental conditions and farming practices (Cochran, 1977).

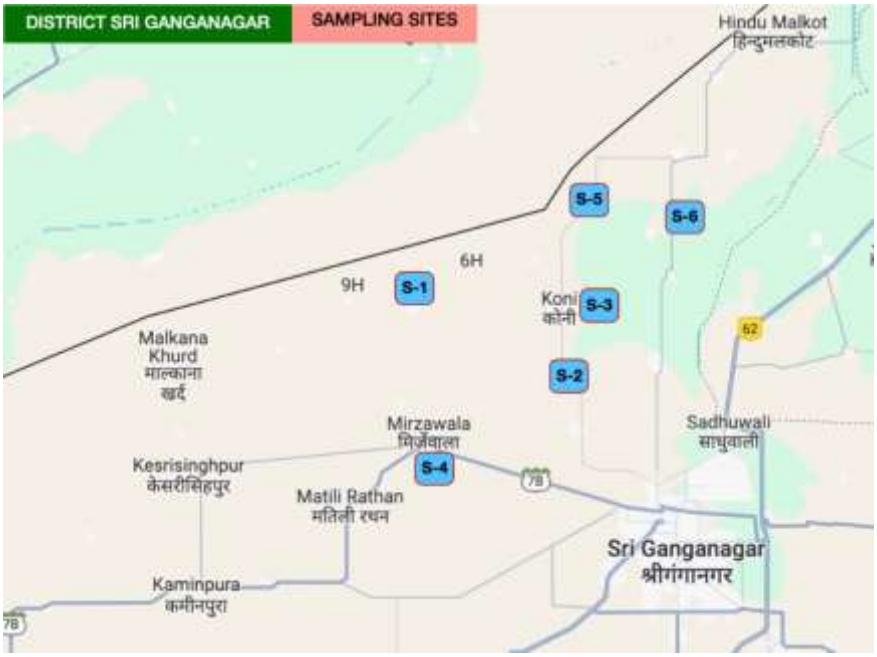

Figure 1: Sampling sites located in District Sri Ganganagar

2.2 Data Collection

Field Surveys: Comprehensive field surveys were conducted to collect data on disease prevalence and severity. The orchard was visited during the October 2023 – November 2023 to collect the data. Standard disease assessment protocols were employed to quantify symptoms on leaves, stems, and fruits (McKinney, 1923).

Environmental Monitoring: Environmental parameters, including temperature, humidity, soil moisture, and pH levels, was monitored using digital sensors and instruments. (Jones *et al.,* 2010).

Farmer Interviews: Structured interviews with orchard owners and workers were conducted to gather information on farming practices, disease management strategies, and economic impact. This helped in understanding the socio-economic aspects of disease prevalence (Bryman, 2016).

2.3 Disease Identification and Diagnosis

Diseases were identified based on visual symptoms and confirmed using laboratory analyses. Samples of infected plant tissues was collected and analyzed using microscopic examination for fungal pathogens (Agrios, 2005).

2.4 Disease Prevalence

To calculate the disease prevalence in a Kinnow orchard through field surveys, a systematic approach was followed (Agrios, 2005). The disease prevalence is calculated as the proportion of diseased plants to the total number of plants surveyed by using the following formula:

$$\text{Disease Prevalence}(\%) = \frac{(\text{Number of Diseased Plants} + \text{Dead Plants})}{\text{Total Number of Plants Surveyed}} \times 100$$

2.5 Data Analysis

The statistical analysis and graphical representation were conducted on the *PaSt* statistical software package 4.17 (Hammer *et al.,* 2001; Hammer *et al.,* 2024).

3. Observation

A field survey was conducted across six sampling sites in the Sri Ganganagar area, where 50 Kinnow plants were examined at each sampling site. The survey focused on four major diseases: Gummosis, Huanglongbing (HLB), Citrus Canker, and Black Fly. Accordingly, observations comprising, representative Kinnow plants infected with different plant disease are shown in the figure (Figure-2) and data including the number of infected plants, dead plants, and disease prevalence, are summarized in the table provided (Table-1).

	
Gummosis	**Huanglongbing**

Citrus Canker

Citrus Canker

Black Fry

Dead Plant

Figure 2: Representative Kinnow plants infected with different plant disease

Table 1: Disease prevalence in different sampling sites

S. N.	Sampling Sites	Sample Size	Gummosis			Huanglongbing			Citrus Canker			Black Fry		
			Infected Plants	Dead Plants	Disease Prevalence	Infected Plants	Dead Plants	Disease Prevalence	Infected Plants	Dead Plants	Disease Prevalence	Infected Plants	Dead Plants	Disease Prevalence
1	Daulatpura	50	4	1	10.0	2	1	6.0	10	1	22.0	2	0	4.0
2	7 F	50	3	0	6.0	1	1	4.0	6	2	16.0	1	0	2.0

3	Koni	50	3	1	8.0	2	0	4.0	8	2	20.0	2	0	4.0
4	Mirzawala	50	3	1	8.0	1	0	2.0	6	1	14.0	2	0	4.0
5	Maderan	50	1	0	2.0	2	1	6.0	7	0	14.0	1	0	2.0
6	Fatuhi	50	1	1	4.0	1	0	2.0	4	1	10.0	1	0	2.0

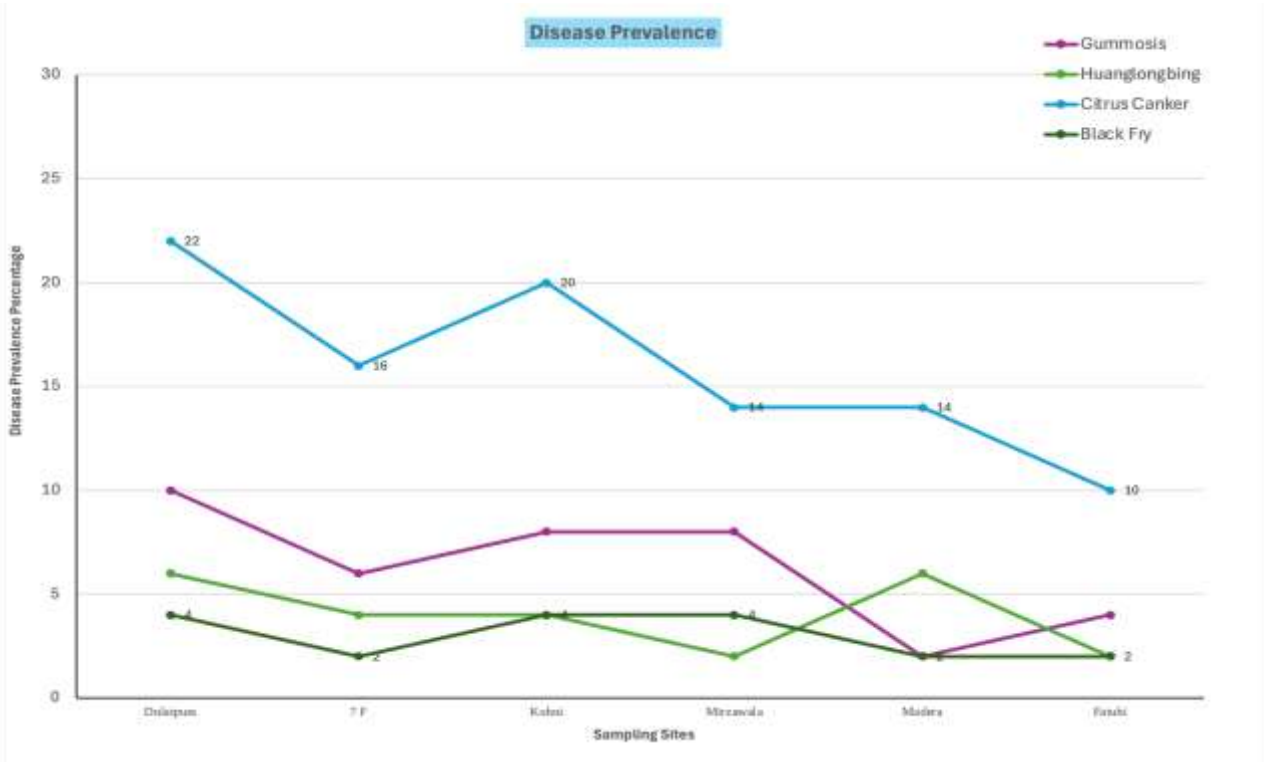

Figure 2: Disease prevalence in different sampling sites

Result and Discussion

The survey indicates a varying prevalence of different diseases across the six sampling sites. In concern to Gummosis, the highest prevalence was observed at Daulatpura (10.0%) sampling site, with four infected plants and one dead plant. Maderan sampling site showed the lowest prevalence (2.0%), with one infected plant and no dead plants. Similarly, in the case of Huanglongbing (HLB), the highest prevalence was observed at Daulatpura and Maderan (6.0% each) sampling sites and lowest prevalence was observed at Mirzawala and Fatuhi (2.0% each) sampling sites. Citrus Canker is most prevalent plat disease found in the Kinnow orchards. The highest prevalence was observed at Daulatpura (22.0%) sampling site, with ten infected plants and one dead plant. The lowest prevalence was at Fatuhi (10.0%) sampling site, with four infected plants and one dead plant. Finaly, Black Fly, the highest prevalence was observed at Daulatpura and Koni (4.0% each) sampling sites and lowest prevalence was observed at Maderan and Fatuhi (2.0% each) sampling sites.

3.1 Gummosis

The Kinnow (Citrus nobilis x Citrus deliciosa) orchards in the Sri Ganganagar area revealed gummosis prevalence ranging from 2% to 10% across the sampling sites. Gummosis, characterized by the exudation of gum from the bark of affected trees, is a complex disease that can be caused by various pathogens, with *Phytophthora spp.* being the most common in citrus. According to Savita and Nagpal (2012), *P. nicotianae* and *P. citrophthora* are the predominant species causing gummosis in citrus in India. The disease typically affects the trunk and main branches, leading to bark cracking, wood decay, and gum exudation. In severe cases, it can result in tree decline and death. In the field survey, the presence of dead plants due to gummosis (1 in Daulatpura, 1 in Koni, and 1 in Fatuhi) underscores the potential severity of this disease.

The variation in gummosis prevalence across the sampling sites (2-10%) likely reflects differences in environmental conditions and orchard management practices. Graham and Menge (2000) highlighted that factors promoting gummosis include, Excessive soil moisture and poor drainage, Soil compaction, Planting trees too deeply, Mechanical injury to the trunk, and Prolonged contact of irrigation water with the trunk. Thus, discrepancy in such orchard management practices lead to the variation in gummosis prevalence across the sampling sites.

Further, the higher prevalence in Daulatpura (10%) might indicate more favorable conditions for Phytophthora, possibly due to heavier soils, poorer drainage, or irrigation practices that keep the trunk base wet for extended periods.

Gummosis can significantly impact tree health and productivity. Adaskaveg *et al.* (2015) reported that severe gummosis infections can reduce yields by up to 40% and shorten the productive lifespan of citrus trees. The disease interferes with water and nutrient transport, leading to reduced vigor, smaller fruit size, and increased susceptibility to other stresses. Thus, it is expected that a significant yield reduction will be noticeable in the sampling sites according to the prevalence of the gummosis.

3.2 Huanglongbing (HLB)

The prevalence of Huanglongbing (HLB) ranged from 2% to 6% across the sampling sites. Huanglongbing, also known as citrus greening disease, is caused by the phloem-limited bacterium *Candidatus Liberibacter* asiaticus in Asian countries including India (Bové, 2006). The disease is considered one of the most devastating citrus diseases worldwide due to its rapid spread, difficulty in management, and severe impact on tree health and fruit production. HLB affects all citrus cultivars and causes a wide range of symptoms. Gottwald (2010) described the primary symptoms as, Blotchy mottling of leaves, yellow shoots, Twig dieback, Root decay, and Fruit drop and malformation. The field observation of dead plants due to HLB (1 in Daulatpura, 1 in 7 F, and 1 in Maderan) underscores the lethal potential of this disease. Further, infected trees typically become unproductive within 5-8 years of infection, and fruit from infected trees are often small, misshapen, and have a bitter taste (Wang and Trivedi, 2013), thus it is expected a reduction in the overall yield of Kinnow.

As, HLB is primarily transmitted by the Asian citrus psyllid (*Diaphorina citri*). Grafting with infected plant material can also spread the disease. Halbert and Manjunath (2004) noted that *D. citri* can acquire the bacterium in as little as 15 minutes of feeding on an infected plant and can transmit it to healthy plants within an hour. Therefore, the relatively low prevalence in study area (2-6%) could suggest that vector populations are currently low or that control measures have been somewhat effective. However, even low levels of HLB are concerning due to its potential for rapid spread.

3.3 Citrus Canker

Citrus canker, caused by the bacterium *Xanthomonas citri* subsp. *citri*, emerged as the most prevalent

disease in the current study of Kinnow (Citrus nobilis x Citrus deliciosa) orchards in the Sri Ganganagar area. The prevalence ranged from 10% to 22% across the sampling sites, with Daulatpura showing the highest incidence (22%) and Fatuhi the lowest (10%).

Citrus canker is characterized by distinctive raised, corky lesions on leaves, stems, and fruits. These lesions can lead to premature leaf and fruit drop, reducing tree vigor and fruit yield (Sharma and Sharma, 2009; Ali *et al.*, 2023). According to Gottwald *et al.* (2002), severe infections can result in up to 69% yield loss, highlighting the economic significance of this disease. Thus, the high prevalence observed in the study aligns with the aggressive nature of the pathogen and its ability to spread rapidly under favorable conditions. Das (2003) noted that the disease can affect all above-ground parts of citrus trees and all cultivated citrus varieties, although some show varying degrees of susceptibility.

Further, the variation in prevalence across the sampling sites (10-22%) likely reflects differences in microclimatic conditions. Citrus canker thrives in warm, humid environments, which are typical of the Sri Ganganagar region. Pruvost *et al.* (2002) demonstrated that temperatures between 20-30°C and high relative humidity (>80%) are optimal for infection and lesion development. The higher prevalence in Daulatpura (22%) might indicate more favorable conditions for the pathogen, possibly due to factors such as higher humidity, more frequent rainfall, or less effective windbreaks. Conversely, the lower prevalence in Fatuhi (10%) could suggest less conducive environmental conditions or more effective disease management practices.

Alongside, wind-driven rain is a primary mode of bacterial dispersal for citrus canker. Bock *et al.* (2005) found that wind speeds as low as 8 m/s can create wind-blown inoculum, facilitating disease spread. This underscores the importance of windbreaks in disease management, as suggested by Gottwald *et al.* (2002). Human activities, such as movement of infected plant material and contaminated equipment, also play a crucial role in long-distance spread. Accordingly, findings highlight the need for strict phytosanitary measures and farmer education to limit disease transmission between orchards.

3.4 Black Fly

The current study of Kinnow (Citrus nobilis x Citrus deliciosa) orchards in the Sri Ganganagar area revealed Black Fly infestation prevalence ranging from 2% to 4% across the sampling sites. The term "Black Fly" in citrus typically refers to the citrus blackfly (*Aleurocanthus woglumi* Ashby), which belongs to the family Aleyrodidae. Gill (2010) described the citrus blackfly adult as a small (1.3-1.6 mm long) dark bluish-black insect with reddish-brown eyes and white-banded legs and antennae. The wings are covered with a grey powdery wax, giving them a slate blue appearance when viewed with the naked eye. In India, it has been reported from various citrus-growing regions, including Punjab and Rajasthan (Sharma and Batra, 2001). The relatively low prevalence in the study (2-4%) suggests that current management practices may be keeping the pest population under control. However, even at low levels, black flies can impact fruit quality and yield.

Further, the data indicates a relatively uniform distribution of black fly across the surveyed area, with a slightly higher prevalence in Daulatpura, Koni, and Mirzawala. The consistency of infestation across all sites suggests that the environmental conditions throughout the study area are suitable for black fly survival and reproduction, although at low levels.

Alongside, the climate or microclimate of the Sri Ganganagar area might not be optimal for explosive growth of black fly populations. As noted by Steinberg and Dowell (1980), black fly development is optimal at temperatures between 25-28°C, with populations declining at higher or lower temperatures. Apart from it, the low prevalence could also indicate a healthy population of natural predators or

parasitoids keeping the black fly population in check. As, Summy *et al.* (1983) highlighted the importance of natural enemies in controlling black fly populations in citrus orchards.

4. Recommendation and Disease Management Practices

Based on the field survey of Kinnow orchards in the Sri Ganganagar area, several plant diseases were observed, each requiring specific management strategies. Citrus canker emerged as the most prevalent disease, with an incidence ranging from 10% to 22% across sampling sites. To manage this bacterial disease, a multi-faceted approach is recommended. Implementing windbreaks can reduce the spread of bacteria through wind-blown rain (Gottwald *et al.*, 2002), while pruning and destroying infected branches during dry weather can help minimize inoculum. Copper-based bactericides should be applied preventively, especially before and after rainy periods (Behlau *et al.*, 2010).

Gummosis, caused by *Phytophthora spp*., showed a prevalence of 2% to 10%. Management should focus on improving soil drainage, avoiding trunk injuries, and ensuring proper planting depth (Graham and Menge, 2000). Phosphorous acid treatments, either as trunk injections or foliar sprays, have shown effectiveness in managing this disease (Graham *et al.*, 2011). For new plantings, using resistant rootstocks like trifoliate orange or its hybrids can provide long-term protection (Ferguson *et al.*, 1990).

Huanglongbing (HLB) and black fly infestations were observed at lower levels (2-6% and 2-4% respectively), but their potential for rapid spread necessitates vigilant management. For HLB, aggressive psyllid control using rotations of different insecticide classes is crucial, along with prompt removal of infected trees (Bassanezi *et al.*, 2013). Black fly management should incorporate regular monitoring using yellow sticky traps (Aubert, 1990), conservation of natural enemies, and judicious use of selective insecticides when necessary (Uygun *et al.*, 2010).

An integrated pest management (IPM) approach, combining cultural, biological, and chemical control methods, is recommended for overall orchard health. This should include maintaining strict orchard hygiene, regular monitoring for early detection (Stansly and Rogers, 2006), optimizing nutrition and irrigation practices (Obreza and Morgan, 2008), and keeping detailed records of disease incidence and treatments. Collaboration with local agricultural research institutions can provide access to the latest management techniques and potentially allow participation in field trials of new control methods.

5. Conclusions

This study on disease prevalence in Kinnow orchards in Sri Ganganagar has revealed significant insights into the distribution and impact of major citrus diseases. Citrus canker emerged as the most prevalent issue, with incidence rates of 10-22%, followed by gummosis (2-10%), Huanglongbing (2-6%), and black fly infestations (2-4%). The variability in disease prevalence across sampling sites underscores the influence of local environmental conditions and management practices on disease development. These findings highlight the need for tailored, site-specific disease management strategies.

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