



## **Roving Survey of Panama Wilt Disease (*Fusarium oxysporum* f. sp. cubense) of Banana in Bihar**

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### **Authors' contributions**

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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### **ABSTRACT**

A survey of Panama wilt of banana was conducted in different districts of Bihar i.e. Muzaffarpur, Vaishali, Samastipur, Darbhanga, Katihar, Purnea, Bhagalpur, Kishanganj and Saharsa. This disease was present in all the districts with different levels of percent wilt index. In the Vaishali belt (Zone-I), the maximum percent wilt index was recorded in the Vaishali district (30-45%) in cv. Malbhog (AAB) having sucker planting material in the year 2019-20. In the Koshi belt (Zone-II), the percent wilt index (External symptom) was highest in Purnea district (34-42%) in cv. Robusta (AAA) followed by district Saharsa (28-40%) and Kishanganj (25-38%). The lowest percent wilt index was found in districts Bhagalpur (22-38%) and Katihar (24-38%) in the year 2019-20. Panama wilt of banana caused by *Fusarium oxysporum* f. sp. *cubense* TR4 was recorded in the Koshi belt (Zone-II) having cv. Grand naine (AAA) and cv. Robusta (AAA) in Bihar only. While in Vaishali belt (Zone-I) was free from incidence of *Fusarium* wilt of banana incited by *Fusarium oxysporum* f. sp. *cubense* TR4.

**Keywords:** *Fusarium oxysporum f. sp. cubense (FOC)*; panama wilt; race; TR4; Bihar.

## 1. INTRODUCTION

Banana (*Musa paradisiacal* Linn.) is important perennial monocotyledonous fruit crop. It belongs to family Musaceae. It produces seedless parthenocarpic fruit. The cultivated hybrids are generally triploid  $2n=3x=33$ . The banana plant is a tree-like perennial herb. It has 9 to 15 leaves measuring up to 9 ft long and 2 ft wide. It is herb not having woody stem and pseudostem of parent plant dies after every cropping season.

In India, bananas are prevailing and accepted fruits among people. It is available around the year dissimilar to the occasional chance of other fruits. Eighty seven percent of the total bananas cultivated in subtropical and tropical areas are used for household utilization, while only 13% of the product is traded. The Banana is a critical crop at international markets att a cost of 4.7 Billion USD per year [1].

Cultivated banana and plantain are mostly propagated from mutants found in the wild population. The major problem in achieving the high productivity of banana is its susceptibility to various fungal, bacterial, and viral diseases. These diseases reduces yield and degrades the marketability of banana fruits. Important diseases of banana are Panama wilt, bunchy top, bacterial wilt, Sigatoka and fruit rot. Among these, Panama wilt disease is considered to be very serious in banana-growing areas [2].

The most important and economically destructive disease is "Panama wilt", also called as *Fusarium* wilt incited by *Fusarium oxysporum f. sp. cubense*. The Panama wilt disease is most

destructive due to the emergence of new pathogenic races i.e. Tropical race (TR4). Incidence of Panama wilt disease in the Dwarf Cavendish group (Grand naine) of bananas was known to occur in Bihar since 2015.

## 2. MATERIALS AND METHODS

Intensive surveys were conducted in the major banana growing belt of Bihar i.e. Vaishali belt (Zone-I) including Samistipur, Muzaffarpur, Vaishali and Darbhanga districts, and in the Koshi belt (Zone-II) including Katihar, Purnea, Bhagalpur, Kishananj and Saharsa districts. In October, November and December of 2019 each district, banana orchards were surveyed, where wilt disease specimens were collected and calculated the percent wilt index.

### 2.1 Percent Wilt Index (PWI, External symptoms)

Percent wilt index (PWI) per plot was calculated as indicated by the International Musa Testing Programme (IMTP rating scale) under the rating 1-5 scale (Table 1).

### 2.2 Percent Vascular Wilt Index (PVWI, Internal Symptom)

For determination of internal symptom of Panama wilt using the percent vascular wilt index (PVWI) affected plant was cut transversally and longitudinal section determined the percent vascular wilt index (PVWI) as per IMTP rating in 1-6 scale (Table 2).

**Table 1. International Musa Testing Programme (IMTP rating scale) under the rating in 1-5 scale**

Category	Reaction
1	Healthy
2	Little chlorosis and wilting with no petiole bending
3	Moderate chlorosis and splitting of leaf base and wilting with some petiole bending
4	Severe chlorosis and wilting, petiole bending and stunting of newly emerged leaf
5	Dead

$$\text{Percent Wilt index} = \frac{\text{Total sum of numerical rating} \times 100}{\text{Total number of plants observed} \times \text{maximum category in the score chart}}$$

**Table 2. IMTP rating in 1-6 scale**

Rating	Symptom
1	Corm completely clean
2	Discoloration of isolated point
3	1/3 parts of vascular tissue discoloration
4	Between 1/3 to 2/3 parts of vascular tissue discoloration
5	Greater than 2/3 parts of vascular tissue discoloration
6	Complete discoloration of vascular tissue

$$\text{Percent vascular wilt index} = \frac{\text{Total sum of numerical rating}}{\text{Total number of plants observed} \times \text{maximum category in the score chart}} \times 100$$

### 2.3 Collection of Disease Sample

During the survey sampling of the banana plants showing typical external symptom of Panama wilt were collected from the farmer's fields. Each sample was placed in a paper towel and identified with the location and variety. The sample was brought at the Department of Plant Pathology, RPCAU, Pusa-laboratory, washed thoroughly in running tap water to remove soil particles and kept in the refrigerator at 4°C for further studies.

### 3. RESULTS AND DISCUSSION

Panama wilt of banana incited by *Fusarium oxysporum* f. sp. *cubense* is a devastating disease in Bihar, due to the presence of new pathogenic race Tropical Race 4 (TR4). An intensive survey was conducted in October, November, and December of 2019 in all the major banana growing districts of Bihar. All banana districts are categorized into two belts i.e. Vaishali belt (Zone-I) and Koshi belt (Zone-II). Vaishali belt (Zone-I), includes four districts i.e. Samastipur, Muzaffarpur, Vaishali and Darbhanga. While the Koshi-belt (Zone-II)

includes five districts i.e. Bhagalpur, Katihar, Purnea, Saharsa and Kishanganj. In the Vaishali belt, Panama wilt index percent was found highest in the Vaishali district in cv Malbhog(AAB) having sucker planting material (30-45 %) followed by Muzaffarpur (25-42 %), Samastipur (30-40 %) and Darbhanga (28-38 %) during 2019-20. Among the banana cultivars, highest percent Panama wilt index was observed in cv Malbhog (AAB) (30-45 %) while lowest in cv Alpan (AAB) (12-18 %). In the Dwarf Cavendish group of banana cultivars like Robusta (AAA) and Grand naine (AAA) were free from Panama wilt disease during the survey.

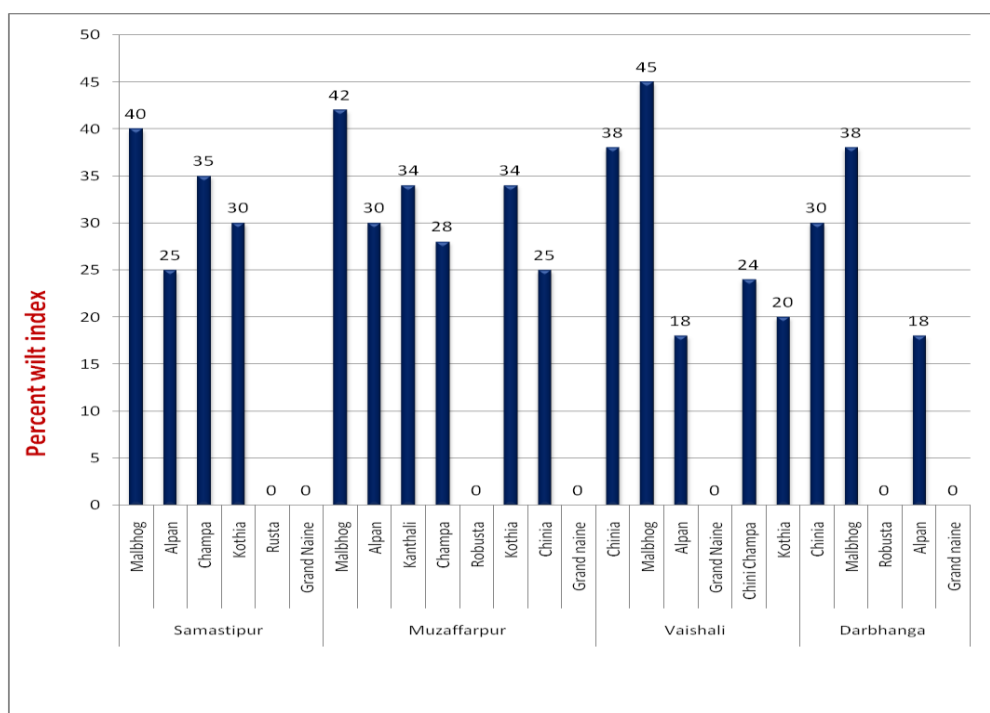
In the Koshi belt, the highest percent wilt index (External symptom) was found in cv. Robusta (AAA) in Purnea district (34-42 %) followed by Saharsa(28-40 %), Kishanganj(25-38 %), Bhagalpur (22-38 %) and Katihar(24-38 %). Panama wilt of banana incited by *Fusarium oxysporum* f. sp. *cubense* TR4 was only recorded in the Koshi belt (Zone-II) of Bihar. While Zone-I was found free from *Fusarium* wilt of banana incited by *Fusarium oxysporum* f. sp. *cubense* TR4. Data are presented in Tables 3 and 4.



**Plate1. Panama wilt infected banana orchards at Dhamdaha village, Purnia district of Bihar**

**Table 3. Panama wilt of banana in Vaishali belt (Zone I) of Bihar during 2019-20**

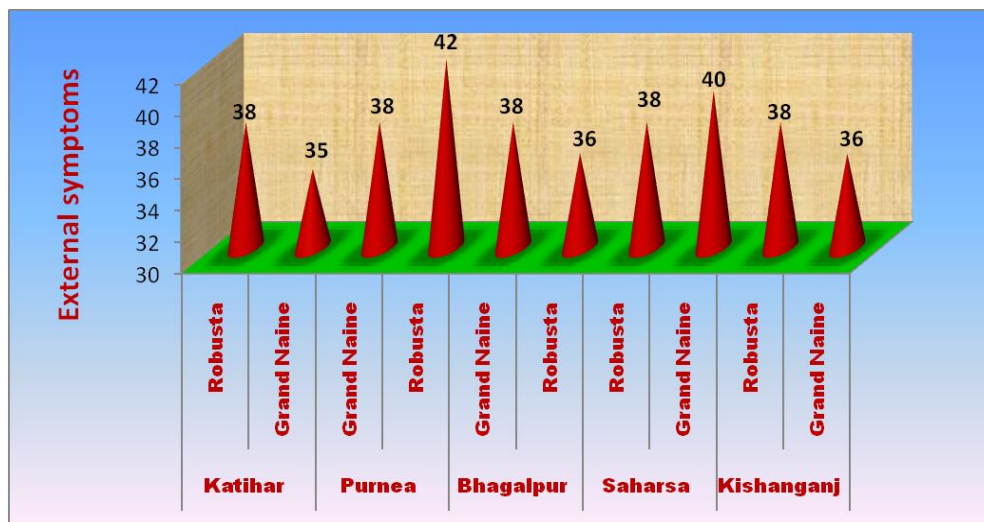
Districts	Variety	Genomic group	No. of orchards surveyed	Planting material	External symptoms (PWI 1-5 IMTP rating scale)
Samastipur	Malbhog	(AAB)	26	Sucker	30-40
	Alpan	(AAB)		Sucker	18-25
	Champa	(AAB)		Sucker	20-35
	Kothia	(ABB)		Sucker	25-30
	Robusta	(AAA)		Sucker	0
	Grand naine	(AAA)		Tissue Culture	0
Muzaffarpur	Malbhog	(AAB)	28	Sucker	25-42
	Alpan	(AAB)		Sucker	26-30
	Kanthali	(AAB)		Sucker	25-34
	Champa	(AAB)		Sucker	20-28
	Robusta	(AAA)		Sucker	0
	Kothia	(ABB)		Sucker	22-34
	Chinia	(AAB)		Sucker	22-25
	Grand naine	(AAA)		Tissue Culture	0
Vaishali	Chinia	(AAB)	24	Sucker	25-38
	Malbhog	(AAB)		Sucker	30-45
	Alpan	(AAB)		Sucker	14-18
	Grand naine	(AAA)		Tissue Culture	0
	Chini Champa	(AAB)		Sucker	20-24
	Kothia	(ABB)		Sucker	14-20
Darbhanga	Chinia	(AAB)	22	Sucker	22-30
	Malbhog	(AAB)		Sucker	28-38
	Robusta	(AAA)		Sucker	0
	Alpan	(AAB)		Sucker	12-18
	Grand naine	(AAA)		Tissue Culture	0



**Fig. 1. Panama wilt of banana in Vaishali belt (Zone I) of Bihar during 2019-2020**

**Table 4. Panama wilt of banana in Koshi belt (Zone- II) of Bihar during 2019-2020**

Districts	Variety	Genomic group	No. of orchards surveyed	Planting material	External symptoms (PWI 1-5 IMTP rating scale)
Katihar	Robusta	(AAA)	25	Sucker	24-38
	Grand naine	(AAA)		Tissue culture	26-35
Purnea	Grand naine	(AAA)	30	Tissue culture	24-38
	Robusta	(AAA)		Sucker	34-42
Bhagalpur	Grand naine	(AAA)	28	Tissue culture	22-38
	Robusta	(AAA)		Sucker	26-36
Saharsa	Robusta	(AAA)	26	Sucker	26-38
	Grand naine	(AAA)		Tissue culture	28-40
Kishanganj	Robusta	(AAA)	15	Sucker	25-38
	Grand naine	(AAA)		Tissue culture	28-36



**Fig. 2. Panama wilt of banana in Koshi belt (Zone II) of Bihar during 2019-20**

Initial reports of the presence of *Fusarium* wilt of banana are from Panama, Costa Rica, and Honduras [3].

The fungus *Fusarium oxysporum* f. sp. *cubense* was initially isolated in India from diseased banana plant tissue in Bengal. Panama wilt resistance cultivars were Amritsagar, Kabuli, Agnishwar and Chinchamapa [4].

Banana cultivars Chinnamondan plantains at Sholavandan and Arapalayam, Madras, were affected with Panama wilt nearly 30 % of the total plants were damaged. Later, Wollenweber found that the causal agent was as *Fusarium oxysporum* f. sp. *cubense* var *Inodoratum* [5].

Poona was, the major source of spreading *Fusarium* wilt attacking the locally grown Son variety [6]. Panama wilt was extensively

investigated in the agro-ecological conditions of Bihar [7].

*Fusarium* wilt of banana spread with in the country by infected planting material in the South African population. The availability of single planting material and narrow diversity of the pathogen showed to be reduced through disease management practices, including genetic host resistance [8].

Recent presence of destructive virulent race of the fungus *Fusarium oxysporum* f. sp. *cubense* in Asia, was identified as the tropical race 4 (TR4). In the 1990s, it affected the Cavendish banana in Malaysia and Indonesia 1990s and in the Northern Territory of Australia it became epidemic in the years 1997 to 1999. In 2004, serious infection in the banana crop by this race was reported in Guangdong province, South China [9].

*Fusarium oxysporum* f. sp. *cubense* TR4, which affects banana crops in Asia, is a major threat to the banana industry. In Latin America, where almost 100 % is planted to Cavendish subgroup of banana which is highly susceptible to TR4 [10].

In 2013, race TR4 was found in Jordan, the first official report of the presence of TR4 in the Southeast Asia-Pacific region. In 2014 survey conducted found another infected area in the North of the original outbreak [11,12] reporting that TR4 is a serious problem for the Cavendish group of banana developing zones in Pakistan noting that cv. Basrai to be affected by TR4 in specific areas in the Sindh territory creating devastation for the banana industry and seriously affecting the Pakistani economy.

In 2018, tropical race 4 (TR4) as identified in Myanmar. The samples were analyzed from the isolates collected in Laos, Vietnam and Myanmar, providing proof of that the TR4 strain in these countries could have been introduced from China [13].

Detailed studies –determined that TR4 strain was identified in lower Carmel coastal plain (1200 ha), Jordan valley (800 ha) of Israel and western Galilee (500 ha) [14].

Surveys in various districts of Sri Lanka (Rajanganaya, Kandy, Kegalle, Rambukkana, Warakapola, Matale, Dambulla, Attanagalla, Ratnapura, Hamabanthota and Udawalawe) have determined banana developing regions infected by *Fusarium oxysporum* f. sp. *cubense* [15].

Presence of *Fusarium oxysporum* f. sp. *cubense* TR4 has been identified in Barari village in Katihar district of Bihar. The incidence of Panama wilt disease ranged from 2 to 26.6 % in Cavendish banana cvs. Robusta and Grand naine. There was a variation in percent wilt index between banana cultivars. At present, based on the surveys the presence of new pathogenic race TR4 is a serious threat to the banana industry in Bihar [16]. The first incidence of Panama wilt of banana was reported at Bihar (Hazipur) [17].

Singh (2002) described the prevalence of *Fusarium oxysporum* f. sp. *cubense* (FOC) race 1 and 2 in banana-growing areas of Vaishali and Samastipur districts of Bihar, India. Race 1 of FOC had been previously reported, but the existence of race 2 was probably for the first time.

Singh (2005) reported that Malbhog (AAB, silk) banana was becoming extinct in the Vaishali area of Bihar due to wilt. The traditional growers have discarded Malbhog in favour of other cultivars like Chinia and Alpan.

Singh (2003) first reported a breakage of resistance in Alpan (AAB, Mysore group) to FOC race 1 which was earlier considered resistant to wilt. Its incidence varied from 0-16 %.

*Fusarium oxysporum* f. sp. *cubense* (FOC) was present in Uttar Pradesh in September 2017 [18].

Surveyed Panama wilt affected areas in Bihar during 2016-17 to 2018-19 showed that the highest percent wilt index was recorded in cv. Malbhog (AAB) from 36-40 % to 30- 34 % during 2016-17 to 2018-19 while, in Samastipur districts, lowest percent wilt index was found in cv. Alpan (AAB) from 21-23 % to 16-17 % during 2016- 17 to 2018-19 in the Darbhanga district of Vaishali belt (Zone-I). In the Koshi belt (Zone-II), the highest percent wilt index was recorded in cv. Grand naine (AAA) from 23-25 % to 28-34 % during 2016-17 to 2018-19 of Bhagalpur district and lowest percent wilt index was found in cv. Basrai (AAA) from 9-11 % to 14-18 % during 2016-17 to 2018-19 of Kishanganj district [19].

#### 4. CONCLUSION

Intensive surveys were conducted during 2019-20 in all the major banana growing districts of Bihar in Zone-I and Zone-II. In Vaishali belt (Zone-I) includes four districts Samastipur, Muzaffarpur, Vaishali and Darbhanga. While in Koshi-belt (Zone-II) include five districts Bhagalpur, Katihar, Purnea, Saharsa and Kishanganj. Panama wilt of banana incited by *Fusarium oxysporum* f. sp. *cubense* TR4 was recorded in the Koshi belt of Bihar only. While Zone-I was free from the incidence of Panama wilt of banana incited by *Fusarium oxysporum* f. sp. *cubense* TR4. In Vaishali belt (Zone-I) Panama wilt index percent was found highest (30-45 %) in district Vaishali followed by Muzaffarpur (25-42 %), Samastipur (30-40 %) and Darbhanga (28-38 %). In Koshi-belt (Zone-II) maximum (34-42 %) incidence of *Fusarium* wilt of banana was found in Purnea followed by district Saharsa (28-40 %), Kishanganj (25-38 %), Katihar (24-38 %) and minimum wilt incidence in Bhagalpur (22-38 %).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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