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Understanding Pest And Disease Management Strategies Among Banana(*Musa ParadisiacaL.*, Musaceae) Farmers In Bihar

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ABSTRACT

Bananas (Musa paradisiaca L., Musaceae)hold a significant cultural, social, and economic position in India, especially in tropical and subtropical regions. Despite its historical roots and extensive global cultivation, banana production faces numerous challenges, including pest and disease infestations, declining soil fertility, and climate variability. This research investigates the perceptions and management practices of banana farmers regarding pests and diseases in Bihar, India, a major contributor to global banana cultivation. Employing an ex-post facto research design, the study surveyed 200 farmers from two districts, Bhagalpur and Khagaria, utilizing semi-structured interviews and data analysis through IBM SPSS Statistics. Demographic and agricultural practice differences between the districts were observed, highlighting variations in age, education, experience, and training. Both districts identified the Banana Scarring Beetle and Panama wilt as significant pests and diseases, with Bhagalpur farmers perceiving higher severity levels. Targeted training programs focusing on plant protection practices, especially in Bhagalpur, and effective disease management strategies, particularly for Panama wilt, was recommended. Promotion of fungicides like carbendazim, integrated pest management, continuous monitoring, and stakeholder collaboration were suggested for enhancing disease control efforts. Further research to understand perception differences would inform tailored interventions, contributing to the resilience and sustainability of banana farming in Bihar and beyond. The study encountered few challenges, such as the necessity for meticulous cross-verification of information, arranging convenient interview times with respondents, and gaining access to farmers' fields to precisely evaluate disease and insect infestations affecting banana crops. The insights gleaned from this research will significantly aid in the effective management of banana pests and diseases, particularly Fusarium wilt, leading to enhanced income generation for farmers.

Keywords: *Banana Farmer, Pesticide efficacy, Bihar, Fusarium Wilt,Banana scarring beetle, Insect Monitoring*

INTRODUCTION

Banana(*Musa paradisiaca* L., Musaceae) holds a significant position as a staple fruit crop in various tropical and subtropical regions of India, contributing to the cultural, social, and economic fabric of the nation. Its symbolic presence in festivals and rituals embellish occasions with auspiciousness, reflecting its deep-rooted cultural significance. With historical roots tracing back to Alexander the Great's invasion of India in 327 BC, bananas had evolved from indigenous species to modern edible varieties, primarily *Musa acuminata* and *Musa balbisiana*, thriving in the lush rainforests of Southeast Asia.Globally, bananas were cultivated across more than 130 countries, covering 5.00 million hectares and yielding approximately 103.63 million tonnes annually, making it one of the most extensively grown fruit crops. In this context, India emerged as a key player, being the largest producer of bananas worldwide.

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Within India, Bihar stood out as a significant contributor to banana cultivation, with approximately 31069.6 hectares dedicated to its growth, accounting for 3.5% of the nation's banana cultivation. Despite its prominence,banana production faces multifaceted challenges, including pest and disease infestations, declining soil fertility, and climate variability. The management of pests and diseases, in particular, posed a critical concern for banana farmers, impacting productivity and livelihoods. Understanding farmers' perceptions and management practices in tackling these challenges was paramount for sustainable banana cultivation. This research aimed to investigate the perceptions and management practices of banana farmers regarding pests and diseases in Bihar. It synthesizes existing literature and empirical evidence to provide insights into various factors influencing farmers' decisions, including knowledge levels, adoption of agricultural practices, socio-economic factors, and technological interventions. By elucidating the complex interplay of these factors, the study seeks to offer actionable recommendations for enhancing pest and disease management strategies in banana farming, thereby contributing to the resilience and sustainability of this vital agricultural sector.

Banana farming faced numerous constraints, spanning socio-demographic factors and agricultural practices.

Raising awareness, in collaboration with relevant authorities, about the benefits of disease-free tissue-cultured bananas and adopting low-cost tissue-culture technology can significantly enhance banana production[1]. Furthermore, farmers' perceptions regarding banana pest control significantly influence the adoption of control practices [2]. Factors such as banana genotypes, management practices, and suitable land acreage also impact pest and disease management in banana cultivation [3]. The level of knowledge and attitude towards banana cultivation technology, social influence, and farmer innovativeness were additional determinants affecting technology adoption [4][5-6].Challenges persisted due to low awareness of eco-friendly pest management practices among banana growers, economic status, education, and feasibility considerations[7][8].Moreover, farm size, household demographics, consumer preferences, and risk orientation significantly influenced technology preferences among farmers [9][10].Early-stage adoption of hybrid banana varieties was mainly driven by traits such as resistance to nematodes and tolerance to weevils [11].Climate change and escalating input costs further compound challenges in banana cultivation[12].Major constraints included insufficient knowledge, labor intensiveness, limited market access, viral and pest infestation, declining soil fertility, and *Fusarium* wilt [13][14-17].Panama disease TR4 and Banana Xanthomonas Wilt (BXW) pose significant threats to banana production[18][19].Timely agricultural data collection focusing on disease spread and control effectiveness remains a critical challenge [20].The dominance of agricultural research institutions in banana technology development, coupled with the limited integration of social aspects including gender, presents further hurdles [21]. While top-down approaches were common, bottom-up approaches are advocated to foster co-innovation in banana pest and disease management[22]. Efforts to create awareness among banana growers about eco-friendly pest control methods and the integration of tissue-cultured bananas with improved crop management practices are essential for sustainable banana production [23][24]. Additionally, addressing regulatory hurdles and public perceptions is crucial for the adoption of genetically engineered bananas [25].Various pest control methods, including pesticide application and the use of disease-resistant varieties, are integral to sustainable banana farming [26][27].

MATERIALS AND METHOD

The study employed an ex-post facto research design to observe effects that had already occurred their likely causes. Two districts in Bihar namely Bhagalpur and Khagaria (Figure 1)were purposefully selected based on their significant banana cultivation areas. Within each district, one block was further selected based on banana cultivation prevalence. Subsequently, four villages were randomly chosen from each block, and from each village, 25 banana cultivators or farmers were randomly selected, resulting in a sample size of 200. A semi-structured interview schedule was developed for data collection. Before administration, the schedule underwent a pretest among 20 banana farmers who were not included in the final data collection sample. IBM SPSS Statistics was utilized for data analysis.

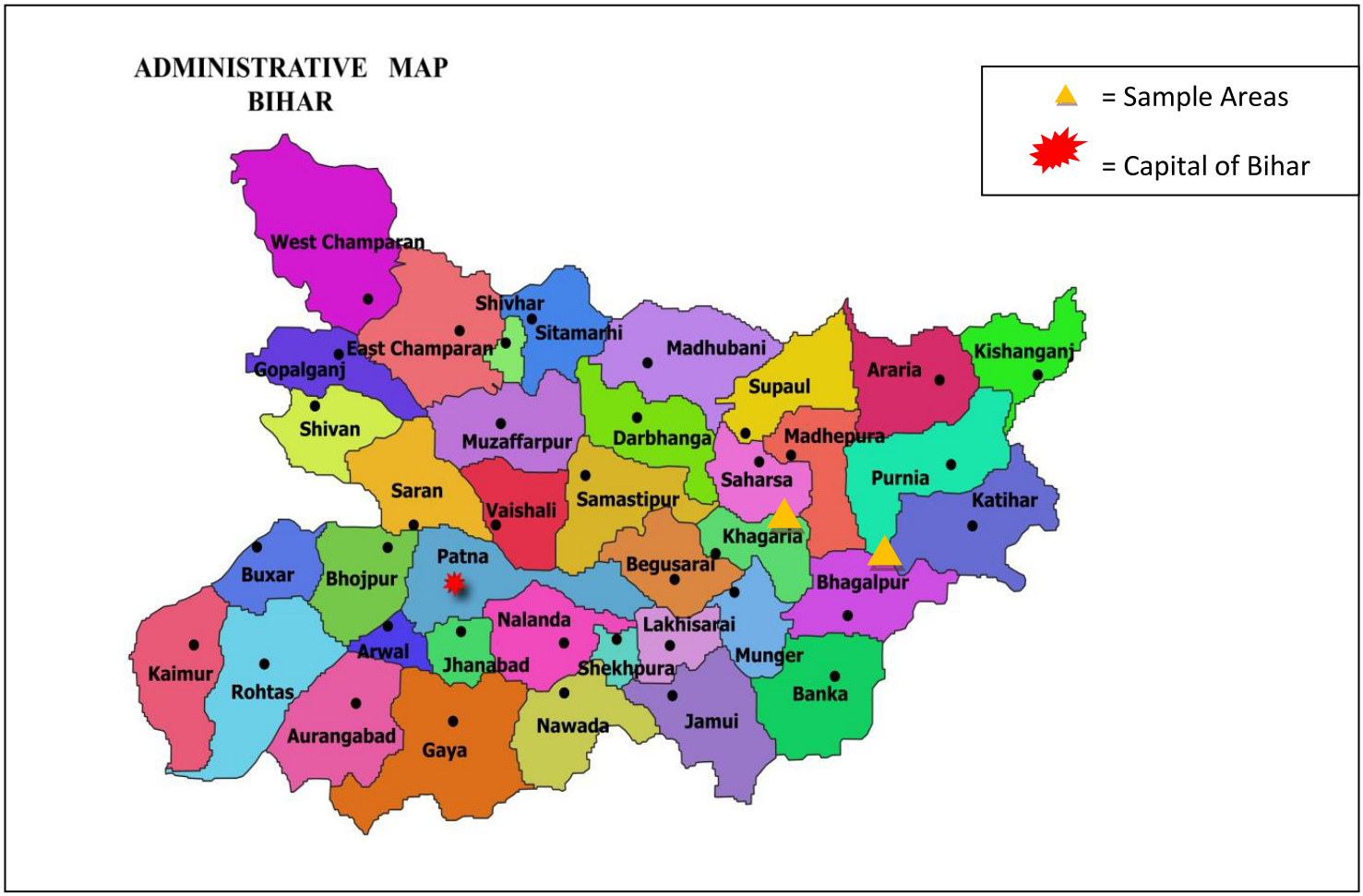

Figure 1: Map Showing districts from where data was collected for the research work source:https://upload.wikimedia.org/wikipedia/commons/a/ac/administrative_map_of_bihar.png

RESULTS AND DISCUSSION

Studying the socio-economic background,perceptions of crop threats, and management strategies of banana farmers was vital.Understanding how their income, resources, and education influenced farming decisions was crucial. Examining their views on insect and disease threats provided insight into their knowledge and attitudes. Analyzing management practices, including chemical methods, revealed strategies to mitigate crop risks. By comprehensively assessing these factors, one could develop targeted interventions to support farmers in managing pest and disease pressures while improving their socio-economic status.

Table 1: Socio-economic profile of Banana farmers

Socio-economic profile	Districts		Chi-square	V Cramer
	Bhagalpur(n_1)	Khagaria (n_2)		
	Percent (%)	Percent (%)		
1. Age(in Years)				
20-28	26	25	p=0.718	V=0.625
>28-36	23	20		
>36-44	23	27		
>44-52	13	16		
>52-60	7	6		
>60-68	5	4		
>68	3	2		
Mean	13.22	12.14		
SD	38.72	38.59		
CV	34.15	31.45		
2.Level of Education				
Illiterate	9.0	14.0	p=0.422	V=0.227
Functional literate	5.0	9.0		
1 – 5 (primary)	8.0	11.0		
6 – 8 (upper primary)	13.0	9.0		
9 – 10 (secondary)	19.0	31.0		
11 – 12 (senior secondary)	21.0	17.0		
UG (under graduation) and above	25.0	9.0		
3. Experience in banana cultivation				
1-7	29	19	p=0.968	V=0.550
7-13	11	21		
13-19	30	26		
19-25	10	20		
25-31	9	4		
31-37	7	6		
>37	4	4		
Mean	9.92	9.58		
SD	15.11	16.54		
CV	65.65	57.92		
4. Area under banana cultivation (In Acres)				
1.25-2.45	12.0	11.0	p=0.464	V=0.448
2.45-3.65	29.0	34.0		
3.65-4.85	32.0	40 .0		
4.85-6.05	21.0	11.0		
>6.05	6.0	4.0		
SD	1.28	1.73		
Mean	3.98	3.79		
CV	39.02	46.38		
5. Annual Income from Banana cultivation (Rs. in lakhs)				
<2.4	18.0	16.0	p=0.494	V=0.5
>2.4-3.8	35.0	45.0		
>3.8-5.2	31.0	26.0		
>5.2-6.6	9.0	4.0		
>6.6-8.0	7.0	3.0		
SD	1.47	1.30		
Mean	3.9	3.58		
CV	37.69	36.31		

n_1=100 n_2=100

SD= Standard Deviation, **CV**= Coefficient of Variation

Upon reviewing table 1, it was evident that 26% of farmers in Bhagalpur district fall within the age range of 20 to 28 years, whereas in Khagaria district, 27% of farmers were aged between 36 and 44 years. The coefficient of variation (CV) for age was 34.15 for Bhagalpur and 31.45 for Khagaria. In terms of education, 25% of respondents in Bhagalpur had undergraduate or higher education levels, while 31% of farmers in Khagaria had secondary education.Regarding banana cultivation experience, 30% of Bhagalpur farmers had 13 to 19 years of experience, with a CV of 65.65, whereas 26% of Khagaria farmers had 13 to 19 years of experience, with a CV of 57.12. Additionally, 32% of Bhagalpur farmers cultivate bananas on 3.65 to 4.85 acres of land, with a CV of 39.02, compared to 40% of Khagaria farmers on similar land, with a CV of 46.38. The CV of annual income for Bhagalpur and Khagaria farmers is 37.69 and 36.31, respectively (Table 1).The study observed that 32% of farmers in Khagaria and 30% of farmers in Bhagalpur received training in horticulture. However, in terms of plant protection, 33% of farmers in Khagaria and 28% of farmers in Bhagalpur received training (see Figure 1).

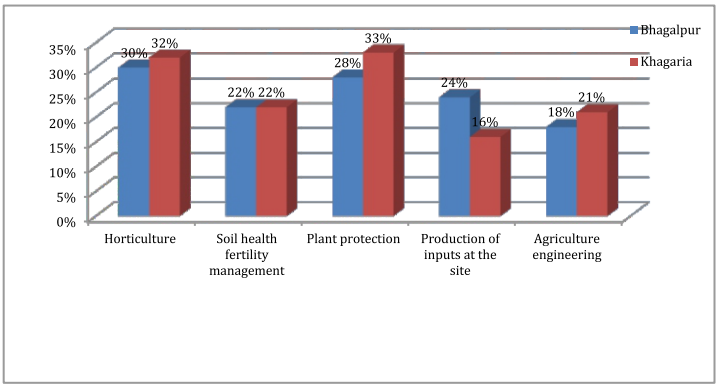

Figure 2: Training Received by the farmers of Khagaria & Bhagalpur

Table 3: Respondents perception on seriousness of different insect pests of banana crop

SI. No	Name of the pest	Most serious		Serious		Least serious		BGP		KGR		Overall Wt. mean	Overall rank	Spearman's rank correlation coefficient
		BGP (%)	KGR (%)	BGP (%)	KGR (%)	BGP (%)	KGR (%)	Wt. mean	Rank	Wt. mean	Rank			
1	Banana rhizome weevil *(Cosmopolites sordidus)*	9	3	8	25	23	16	0.66	4th	0.50	3rd	0.58	3rd	1 (significant at 5%)
2	Banana stem weevil *(Odoiporuslongicollis)*	10	9	27	9	43	40	1.27	2nd	0.85	2nd	0.86	2nd	
3	Banana aphid *(Pentalonianigronervosa)*	14	2	19	6	5	10	0.90	3rd	0.29	4th	0.31	4th	
4	Banana scarring beetle *(colaspishypochlora)*	60	32	17	35	9	20	2.23	1st	1.86	1st	2.04	1st	

n_1=100 n_2=100
N(overall)=200

BGP= Bhagalpur KGR= Khagaria n_1= Sample Size of Bhagalpur , n_2= Sample Size of Khagaria

Table 3 presents the respondents' perceptions regarding the severity of various insect pests. A three-point scale was utilized, and a weighted mean was computed based on the different values assigned to each response. Subsequently, rankings were established according to these weighted means. The findings revealed that the Banana Scarring Beetle ranked first with a weighted mean of 2.04, followed by the Banana Stem Weevil (Olivier) in second place with a weighted mean of 0.86. The Banana Rhizome Weevil secured the third position with a weighted mean of 0.50, while the Banana Aphid came fourth with a weighted mean of 0.31. Additionally, Spearman's rank correlation was employed to assess the strength and direction of the relationship between two ranked variables. The Spearman's rank correlation coefficient was found to be 1, indicating a strong congruence in the pattern of insect infestation between the two districts' rankings. However, when comparing the weighted means, the perceived severity of the Banana Scarring Beetle was higher (2.23) in Bhagalpur compared to Khagaria district (1.86), and a similar trend was observed for other pests as well.

Table 4: Respondents perception of the seriousness of different diseases of banana crop

SI. No.	Name of the diseases	Most serious		Serious		Least serious		BGP		KGR		Overall Wt. mean	Overall rank	Spearman's rank correlation coefficient
		BGP (%)	KGR (%)	BGP (%)	KGR (%)	BGP (%)	KGR (%)	Wt. mean	Rank	Wt. mean	Rank			
1	Panama wilt (*Fusarium oxysporum f. sp. cubense*)	13	36	24	31	42	21	1.87	1st	1.61	1st	1.74	1st	1 (significant at 5%)
2	Sigatoka leaf spot	18	16	28	22	17	8	1.25	2nd	0.84	2nd	1.05	2nd	
3	Anthracnose (*Colltotrichum*)	18	16	6	6	5	2	0.45	4th	0.34	4th	0.40	4th	
4	Bacterial wilt (*Ralstonia solanacearum*)	24	15	6	35	4	5	0.48	3rd	0.42	3rd	0.45	3rd	

n_1=100 n_2=100
N(overall)=200

BGP= Bhagalpur KGR= Khagaria n_1= Sample Size of Bhagalpur, n_2= Sample Size of Khagaria
The respondents' perceptions regarding the severity of various diseases were assessed. A three-point scale was employed, and a weighted mean was calculated based on the different values assigned to each response. Subsequently, rankings were determined according to these weighted means. Table 4 revealed that Panama wilt was ranked first with a weighted mean of 1.74, followed by Sigatoka leaf spot in second place with a weighted mean of 1.05. Bacterial wilt secured the third position with a weighted mean of 0.45, while Anthracnose ranked fourth with a weighted mean of 0.40. Additionally, Spearman's rank correlation was utilized to evaluate the strength and direction of the association between two ranked variables. The Spearman's rank correlation coefficient was found to be 1, indicating a strong congruence in the pattern of disease infestation between the rankings of the two districts. However, when comparing the weighted means, the perceived severity of Panama wilt was higher (1.87) in Bhagalpur district compared to Khagaria district (1.61), and a similar trend was observed for other diseases as well (Table 4).

Table 5: Insecticide used against each identified target pest and their percentage of use

Active ingredients	Banana pests				Total (N=200)	% of respondents used
	Banana corm weevil	Banana stem weevil	Banana aphid	Banana scarring beetle		
Acephate 50 % + Imidacloprid 1.8% SP (LANCER GOLD)	23 (11.5 %)	-	17 (8.5 %)	111 (55.5 %)	151	75.5
Carbaryl 50 % WP (DEVICARB)	13 (6.5 %)	20 (10 %)	-	-	33	16.5
Monocrotophos 36 % SL (MONOSUN)	51 (25.5 %)	48 (24 %)	35 (17.5 %)	42 (21 %)	176	88.4
Dimethoate 30 % EC (ROGOR)	19 (9.5 %)	-	19 (9.5%)	-	38	19
Chloropyriphos 50 %+Cypermethrin 5 % EC (SUPER D)	24 (12 %)	48 (24 %)	28 (14 %)	54 (27 %)	154	77
Fenvalerate 20 % EC (TATAFEN)	-	-	-	120 (60 %)	120	60
Cypermethrin 25 % EC (SUPER KILLER-25)	-	-	-	73 (36.5 %)	73	36.5

N(overall)=200

The insecticide used for each of the identified targets and their percentage of use and it was noted that a total of 7 insecticides had been listed. The most commonly applied insecticide was Monocrotophos and it was used by 88.4 % respondents, followed by Chloropyriphos 50 % + Cypermethrin 5 % EC (77 % of respondents), Acephate 50 % + Imidacloprid 1.8 % SP (75.5 % of respondents), Fenvalerate (60 % of respondents), Cypermethrin 25 % EC (36.5% of respondents), Dimethoate (19 % of respondents) and Carbaryl (16.5 % of respondents)(Table 5).

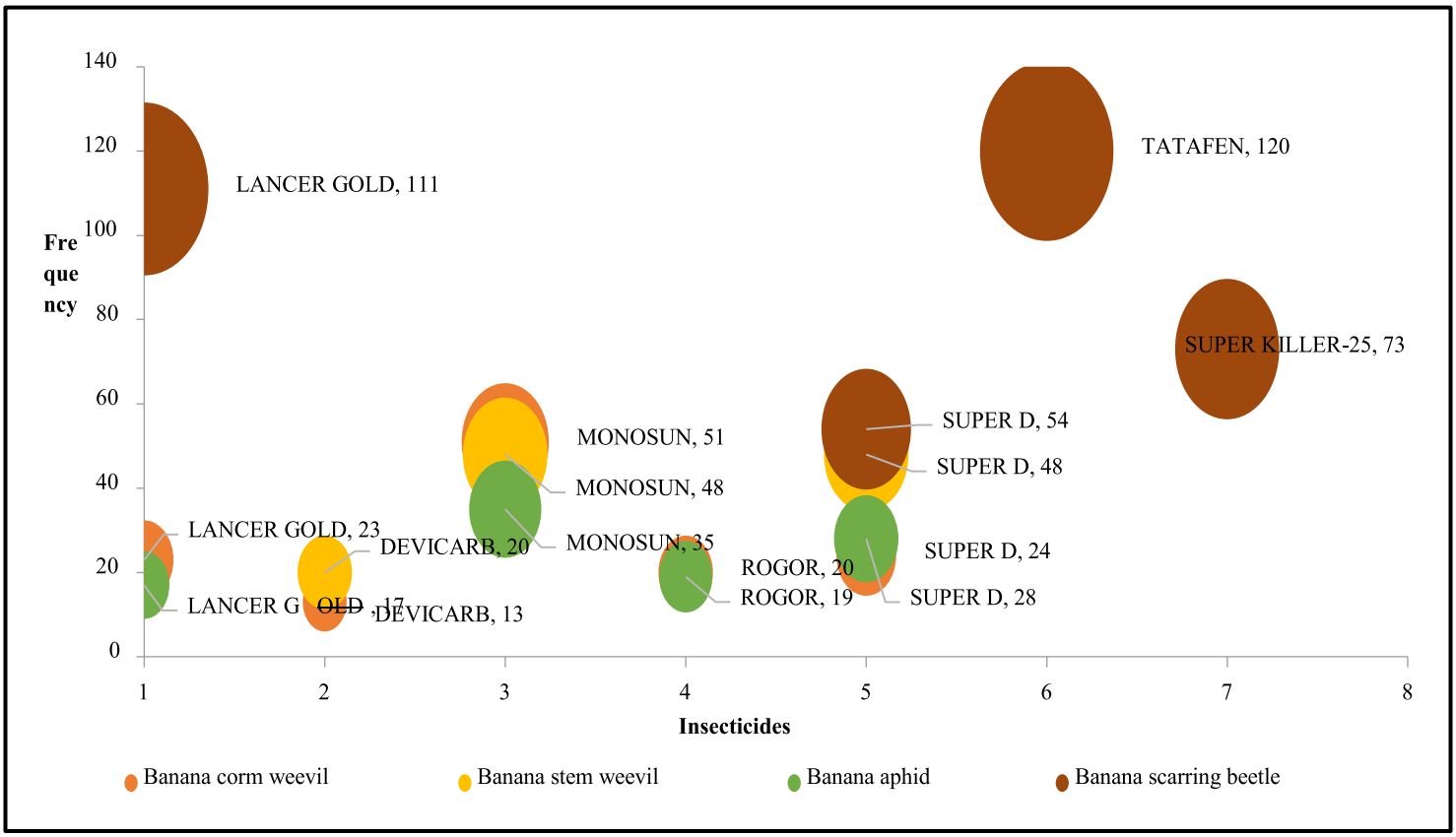

Figure 3: Use of insecticides against targeted insect pest

Table 6: Pesticide usage in management of different diseases of banana

Active ingredients	Banana diseases				Total (N=200)	% of respondents used
	Panama wilt	Sigatoka leaf spot	Anthracnose	Bacterial wilt		
Propiconazole 25 % EC (TILT)	-	28 (14 %)	1 (0.5 %)	-	29	14.5
Mancozeb 75 % WP (ABIC)	-	20 (10 %)	-	-	20	10
Carbendazim 50 % WP (YAMATO)	60 (30 %)	43 (21.5 %)	11 (5.5 %)	-	114	57
Copper oxychloride 50 % WP (BLITOX)	-	34 (17 %)	-	-	34	17

N(overall)=200

The table displays the fungicides utilized for each identified target along with their respective percentages of usage. Four fungicides had been outlined. The most frequently employed fungicide was Carbendazim and 57% of respondents used it, followed by Copper oxychloride (17% of respondents),Propiconazole (14.5% of respondents), and Mancozeb (10% of respondents) (Table 6).

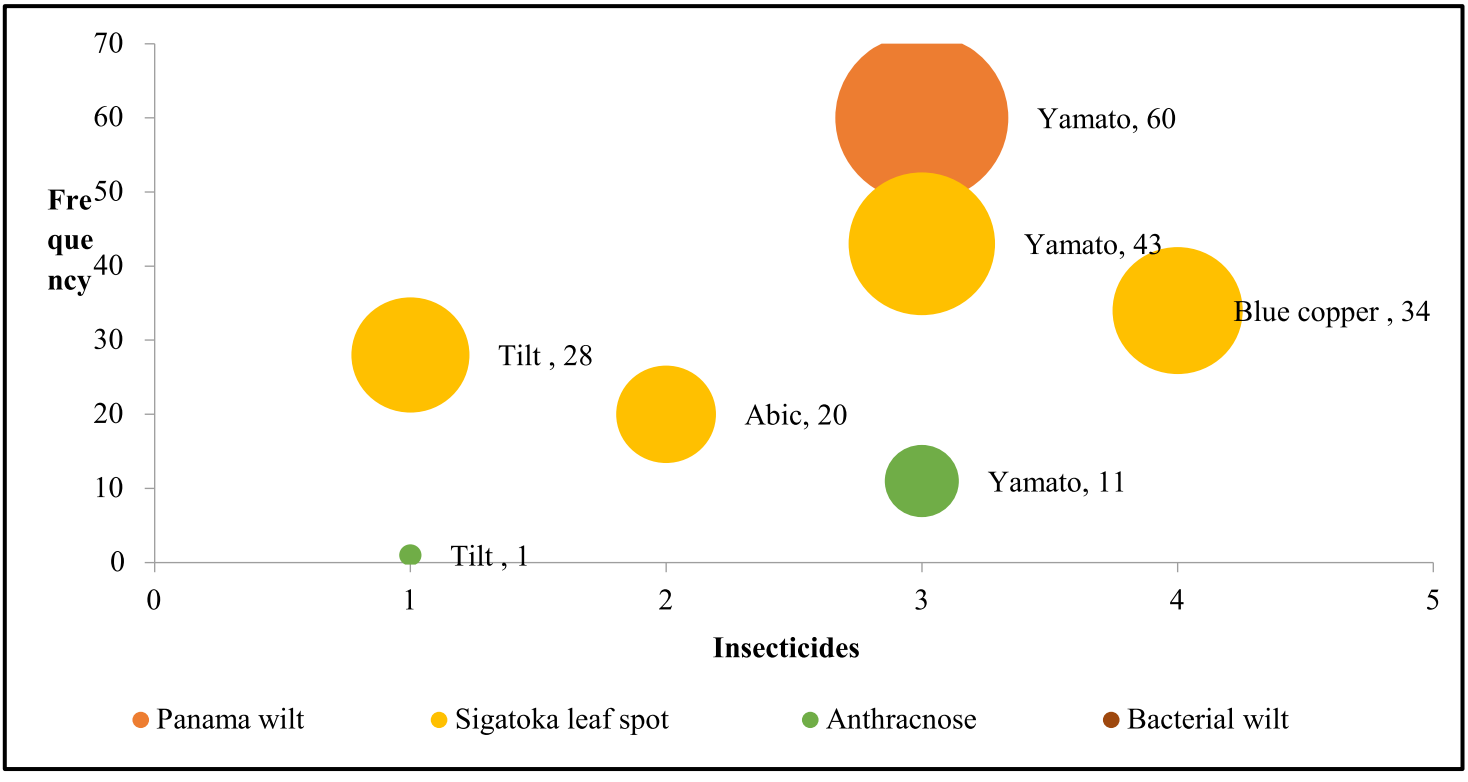

Figure 4: Use of fungicides against the targeted disease

Table 7: Relationship of the main criteria used by the farmers for the selection and adoption of the plant protection product

Choice of product	Districts		Test	
	Bhagalpur (%)	Khagaria (%)	Chi-square	Cramer's V
Price	2.0	4.0	p=0.736	V=0.123
Efficacy	39.0	26.0		
Advisor	0.0	8.0		
Diagnostic	8.0	11.0		
Price-Efficacy	39.0	27.0		
Efficacy-Advisor	10.0	16.0		
Price-Diagnostic	5.0	6.0		
Price-Advisor	1.0	2.0		

n_1=100 n_2=100

The choice of plant protection products were of major importance for pest and disease control. Different criteria were assessed during this survey (Table 7). To understand the farmers' decision-making regarding the choice of the phytosanitary products, the chi-square test was conducted and the results indicated there was no significant difference in the choice of the product between the two regions (P>0.05, V=0.123). The majority of farmers in the Bhagalpur region (39 % of respondents) chose plant protection products based on their efficiency, while farmers in the Khagaria region (26 % of respondents) relied on efficacy and efficacy advisors respectively.

CONCLUSION

There were significant demographic and agricultural practice differences between Bhagalpur and Khagaria districts. In Bhagalpur, a notable proportion of farmers fall within the younger age bracket of 20 to 28 years, while Khagaria had more farmers aged between 36 and 44 years. Education levels were slightly higher in Khagaria, with more farmers having attained secondary education. Bhagalpur, however, boasts a higher percentage of farmers with extensive banana cultivation experience. Despite these variations, both districts exhibit similar levels of income variability. When it comes to agricultural training, a comparable percentage of farmers in both districts had received horticultural training, but a higher percentage of Khagaria farmers had undergone plant protection training.In terms of pest and disease perception, both districts rank the Banana Scarring Beetle as the most serious insect pest, and Panama wilt as the most severe disease. However, Bhagalpur farmers perceive these issues to be more severe compared to their counterparts in Khagaria.The majority of farmers in the Bhagalpur region chose plant protection products based on their efficiency, while farmers in the Khagaria region relied on efficacy and efficacy advisors respectively.

Based on these findings, targeted training programs focusing on plant protection practices could be beneficial for Bhagalpur farmers. Additionally, effective banana disease management strategies, particularly for Panama wilt, were crucial for both districts, with special attention to Bhagalpur where the severity is perceived to be higher. Promoting the use of widely applied fungicides like Carbendazim, while emphasizing proper application and integrated pest management, could aid disease control efforts. Continuous monitoring and collaboration between agricultural stakeholders were essential for timely intervention and further research to explore the underlying reasons for perception differences would provide valuable insights for tailored interventions. The future scope of study based on this research may be Integrated Pest and Disease Management in banana cultivation and Market and Value Chain Analysis of Banana.

Declarations Conflict of Interest: "We declare that we do not have any conflicts of interest to disclose in relation to this research. Our involvement in this study is solely motivated by a commitment to scientific inquiry and the pursuit of knowledge."

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