World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Farmer knowledge on insect pests of Citrus and their management in Doti district, Nepal

Sudip Bhujel Magar [1,*], Kiyumma Rai Butang [1], Chiranjibi Puri [2] and Ankit Soti [1]

[1] *Tribhuvan University.*
[2] *Agriculture and Forestry University.*

World Journal of Advanced Research and Reviews, 2024, 24(03), 136–144

Publication history: Received on 20 October 2024; revised on 30 November 2024; accepted on 02 December 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.24.3.3637

Abstract

In Nepal, rising incidents of various insect pests among citrus grower farmers are a growing concern. This research aims to determine the knowledge of citrus farmers on insect pests of citrus and their management. The survey was conducted through semi-structured interviews with a heterogeneous group of farmers to analyze the citrus growers' knowledge of the identification of insect pests, damage symptoms, and their management. The efficacy study revealed that understanding of citrus insect pests and their management positively correlates with experiences year in citrus farming (P = 0.01%). Major insect pests of the field are green stink bugs, fruit flies, citrus psyllids, brown citrus aphids, and red ants, respectively. The average cultivation area is about 0.474 ha, and the average years of engagement are about 12 years, which gives in-depth potential for farmers adopting integrated pest management (IPM). Although 25.6% of the total respondents knew about the term "IPM technology," only 5.8% practiced IPM practices to date. The positive attitude and perception of citrus growers towards IPM technology in the study area depict great scope for profitable citrus production on a sustainable basis. This study highlighted a need to spread knowledge and management practices among the farmers by the government of Nepal.

Keywords: Citrus; Integrated Pest Management; Nepal

1. Introduction

Citrus is the Rutaceae family member. It contains sweet orange (*Citrus sinensis*), grapefruit (*Citrus paradisi*), tangerines/mandarins (*Citrus reticulata*), lemons (*Citrus limon*), limes, and many other species. Nepal has suitable agro-climatic conditions for quality citrus fruit production especially for mid-hill regions ranging from 800-1400m altitude [1]. Many researchers reported that suitable environments such as temperatures of 18- 21˚C with a well-distributed annual rainfall of 1250 to 1800 mm as well as well-drained loams and sandy loam soil with pH 5.5 to 6.5 are available in Nepal for citrus cultivation [2]. Citrus is being cultivated in about 60 districts in Nepal [3].

The contribution of agriculture GDP by citrus is about 7 % [4] and contributes about 22.95% of total fruit production. The total productive area of citrus in Nepal is 32,317 ha with a production of 3,06,149mt and productivity of 9.47mt/ha. Similarly, in Doti, the mainly mandarin-productive area is 313 ha with a production of 2,299 mt and productivity of 9.05 mt/ha, less than the average national yield of 9.47mt/ha[5].

The mentioned production gap is associated with several factors, but insect pests and diseases are the most dominant. Major insect pests of citrus are citrus stink bugs (*Rhynchocoris humeralis*), fruit flies (*Bactocera spps*), citrus psyllid (*Diaphorina citri*), citrus aphid (*Toxoptera citricida*), and citrus stem borer (*Stromatium barbatum*). Citrus stink bug causes extent of fruit drop by about 21%.[5] Similarly, fruit flies(*Bactocera spps*) cause a 15% yield loss of mandarin in

* Corresponding author: Sudip Bhujel Magar

Eastern Hill[6] and 97% yield loss of sweet orange in Eastern Hill by the time of harvesting [7]. However, increase in citrus production areas due to farmers and concerned organizations tend to focus on increasing production areas in Nepal.

Although citrus is one of the most important fruits in our country productivity are lowered in comparison to developed countries like China and, the USA. Presently, Nepal's citrus output cannot sufficiently and satisfactorily fulfill the nation's demand [8] so large quantities of citrus are imported from India. The incidence of disease and pests, poor planting material, poor soil status, lack of knowledge, and climatic variability associated with poor management practices reduced productivity[9]. In citrus production's declining factor, insect pests are one of the most threats in Nepal. All of these factors are responsible for the adoption gap which is directly linked with the guidance provided by various extension agencies and other sources. To comprehensively understand the farmers' knowledge of insect pests and management strategies adopted by farmers, an investigation into citrus growers in Doti was conducted.

2. Research Methodology

2.1. Site selection and sampling technique

The study was carried out in the Doti district of the Far Western Province, which is located in mid hill area surrounded by Kailali, Dadeldhura, Baitadi, Bajhang, and Achham. A study was conducted in Bogtang Fudsil, Badikedar, and Jurayal Rural Municipalities, focusing on Mandarin production.

Table 1 Number of Sample

S. N	Local level	Number of respondents
1	Bogtang Fudsil Rural Municipality	40
2	Badikedar Rural Municipality	40
3	Jurayal Rural Municipality	40
	Total	120

2.2. Sources of data collection and survey design

A semi-structured questionnaire was tested on 5% of respondents in the vicinity area, and the final interview schedule was adjusted. Primary data was collected through household surveys, agro-vets, focus group discussions, and interviews, while secondary data was obtained from various sources.

2.3. Method and Techniques of Data Collection and Analysis

The data were analyzed using Statistical Package for Social Science (SPSS) version 25, Microsoft Excel 2021. Qualitative data were analyzed through frequency and percentage, while quantitative data were analyzed through descriptive and analytical statistics. Analytical tools like indexing/scaling technique and correlation coefficient were used to derive different inferences needed.

2.4. Indexing

For the quantification of qualitative phenomena regarding the ranking of major insect pests and constraints of citrus farming indexing was used. The index of importance was computed by using the following formula;

Iimp= $\sum(Si \times Fi/N)$

Where

- Iimp= Index of importance
- Si= scale value
- N= Total number of respondents
- Fi= frequency of respondents.

2.5. Variables and their Management

2.5.1. Independent variables

The selected socio-demographic and production status examples of age, gender, ethnicity, religion, family size, main occupation, education level, types of agriculture, years of engagement in citrus production, and productivity were independent variables.

The respondents having different ages, family sizes, years of engagement in citrus production, and productivity were divided into three categories for each variable using the following method.

Table 2 Method for categorizing respondents using mean and S.D

S.N.	Categories	Range
1	Low	Less than mean – S.D.
2	Medium	in between mean ± S.D.
3	High	Above mean + S.D.

2.5.2. Dependent variables

Knowledge and perception of insect pests and their management by farmers were taken as primary dependent variables

3. Results and discussion

3.1. Socio-Demographic Characteristics of Respondents

The study found that the majority of respondents were male, aged between 30 and 55, with medium families and 75% being educated. The majority were from Brahmin and Chhetri communities, with a small percentage from Janjati and Dalit. Agriculture was the main source of income, followed by abroad and business. Semi-commercial, subsistence, and commercial agriculture were most prevalent.

3.2. Mandarin production status

3.2.1. Years of engagement in citrus cultivation

The survey revealed that the majority of respondents (77.5%) had been engaged in citrus cultivation for 6-16 years, with an average of 11 years.

Table 3 Distribution of respondents by years of engagement in citrus Cultivation in Doti district(2024)

Years engaged in Citrus Cultivation	Frequency	Percentage
Less than 6 years(<6 year)	8	6.7
6 to 16 year	93	77.5
More than 16 years (>16 years)	19	15.8
Total	120	100
Mean		11.72
Std. deviation.		5.04

3.2.2. Distribution of respondents by Citrus cultivation area in Doti districts

Table 4 Distribution of respondents by Citrus cultivation area in Doti districts (2024)

Mandarin Cultivation area (In hectare)	Frequency	Percent
0.108-0.84	94	78.3
>0.84	26	21.7
Total	120	100
Mean		0.474
Std. Deviation		0.366

3.3. Productivity of Mandarin in the study area

The study revealed that the majority of respondents (70.8%) had moderate productivity, with the average productivity of Mandarin in the study site being lower than the district's productivity.

Table 5 Distribution of respondents according to the productivity of Mandarin in Doti districts (2024)

Productivity	Frequency	Percentage
Low (up to 4.41)	16	13.3
Moderate (4.41-7.69)	85	70.8
High (>7.69)	19	15.8
Total	120	100
Mean		6.05
Std. deviation.		1.64

3.4. Location of Orchard

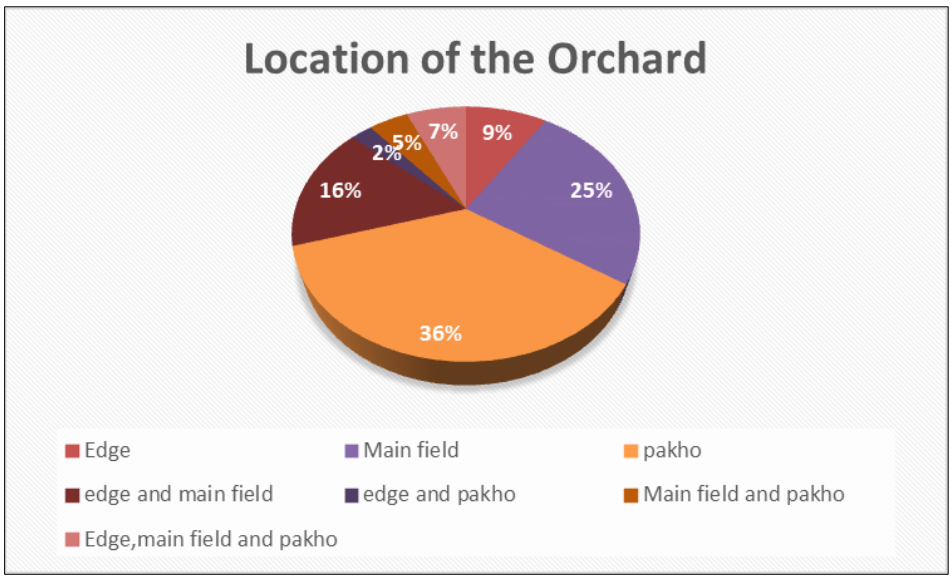

Figure 1 Chart showing different orchard locations

The study showed that about 36 percent of respondents have citrus orchards located in Pakho, 25 percent citrus orchard in the main field, 16 percent citrus orchards in edge and main field, 9 percent in edge, 7 percent cultivated citrus in edge, main field & pakho,5 percent (main field and pakho) and 2 percent orchard located in edge & pakho.

3.5. Sources of Sapling

Figure 2 Chart showing variable sources of citrus sapling

38% of respondents grow citrus trees from self-grown saplings, 35% from self-made sapling, and 27% collect from various sources, including self-grown, self-purchased, Agriculture Knowledge Centre, and Prime Minister Agriculture Modernization Project.

3.6. Constraints in Mandarin Production

The respondents in citrus production faced five main constraints: insect severity, disease severity, lack of proper fertilization and manuring, lack of irrigation facility, severe fruit drop, and hailstone impact. Insect and disease severity were the major problems.

Table 6 Ranking of Mandarin production constraints in Doti districts

Constraints	Weightage	Index	Rank
Insect and Disease severity	115	0.95	1st
Lack of irrigation facility	68.8	0.573	3rd
Lack of proper fertilization and manuring	31	0.25	5th
Severe fruit drop	91.4	0.76	2nd
Hailstone impact	50.8	0.42	4th

3.7. Farmer's Knowledge of Insect Pests of Citrus

3.7.1. Knowledge of Farmers on Harmful Insect and Beneficial Insect

A study showed respondents five beneficial insects and five harmful insects. Those who correctly identified more than three harmful insects were considered knowledgeable. The majority of respondents could identify both types of insects. 94.2% could identify the dangerous insects, while 28.3% could identify the helpful bug.

3.7.2. Knowledge of identification of citrus insect pests damage symptoms

According to the survey, 70.8 percent of the respondents could recognize the signs of insect pest damage in Mandarin, however, 29.2 percent of the respondents could not identify the signs of bug damage in citrus. The data indicates that most of the farmers who plant citrus at this research location are aware of the indications of pest damage caused by citrus insect pests.

Table 7 Knowledge of identification of insect pests, their damage and symptoms

Knowledge of Insects Pest	Coef.			Std. Err
	Harmful Insects	Beneficial Insects	Symptoms & Damage	
Age	0.256*	0.146	0.154	0.05
Gender	-0.358	0.061	0.046	0.039
Ethnicity	-0.165	-0.115	-0.131	0.029
Family size	0.046	0.061	-0.008	0.042
Education level	0.123	0.043	0.054	0.14
Main Occupation	0.09	0.127	0.057	0.086
Types of Agriculture	0.128	-0.343*	0.018	0.065
Experience in Citrus Cultivation	0.732*	0.616*	0.683*	0.047
Total Citrus Cultivation Area	0.162	0.051	-0.014	0.037
Productivity	0.021	0.047*	0.041	0.049

*Means 1% level of significance and ** means 5% level of significance

Factors such as age, family size, education level, main occupation, types of agriculture, experience in citrus cultivation, total citrus cultivation area, and productivity positively influence knowledge of harmful insects in citrus orchards. However, factors like ethnicity and gender have a negative impact. Years of experience in citrus cultivation also positively influences awareness of the damage and symptoms of citrus insect pest infestation in orchards. Overall, age, gender, education level, primary occupation, types of agriculture, experience in citrus cultivation, and productivity all contribute to the knowledge of citrus insect pest infestation.

3.8. Major mandarin insect pests of the study area

The research region faces major insect pests like fruit flies, green stink bugs, Asian citrus psyllids, leaf miners, aphids, stem borers, and rent ants, with minor nuisance insects like thrips and scale insects. Aphids, stem borer, and Asian citrus psyllids are less significant.

Table 8 Ranking of citrus insect pests by respondents in Doti district (2024)

Insets	weightage	Index	Rank
Fruit fly	94	0.78	2nd
Asian citrus psyllid	69	0.575	3rd
Green stink bug	112	0.86	1st
Aphid	55	0.45	4th
Stem borer	30	0.25	5th

3.9. Knowlwedge and Adoption of Integrated Management of Insect Pests of Citrus

3.9.1. Knowledge and Adoption of Cultural Practices

The survey found that most respondents implemented cultural practices such as training and trimming (80.83 percent) and sanitation (90 percent). Other cultural methods that were primarily practiced were timely irrigation, manuring (23.3 percent), and intercropping with leguminous crops such as beans, soybeans, and peas (69.1 percent). Only a small percentage of responders (30.8%) used rootstock, whereas 48.3% followed appropriate spacing and pit dimensions, and 18.4% plowed the summer plowing

Table 9 Adoption status of cultural practices to manage insect pests of citrus in Doti districts (2024)

Cultural practices	**Yes**	**No**
Sanitation	108(90)	12(10)
Training and Pruning	97(80.83)	23(19.17)
Intercropping with Legumes	83(69.1)	37(30.9)
Timely Irrigation and Manuring	28(23.3)	92(76.7)
Proper spacing (4m) and Pit dimension (1*1*1 cub meter)	37(30.8)	83(69.2)
Use of Resistant Stock	58(48.3)	62(51.7)
Summer Ploughing	22(18.4)	98(81.6)

3.9.2. Knowledge and Adoption of Mechanical Practices

The survey revealed that 51.8% of participants used mechanical methods for managing citrus insect pests, with hand-picking and removing fallen fruits being the most popular method, despite the lack of additional techniques.

Table 10 Adoption status of mechanical practices to manage insect pests of citrus in Doti district(2024)

Mechanical Practices	**yes**	**No**
Hand Picking and Removal of Fallen Fruits Infected with Insects	58(48.3)	62(51.7)
Use of Light Trap	12(10)	108(90)
Yellow Sticky Trap	14(11.6)	106(88.4)
Pheromone Trap	13(10.9)	107(89.1)

3.9.3. Knowledge and Adoption of Physical Practices

According to the survey, just 7.5 percent of respondents maintained the moisture content of their orchards, while 44.2 percent of respondents burned old sick trees. It has been observed that nearly all of the respondents are ignorant of physical procedures like controlling moisture and temperature to keep insects at bay. Some people, nevertheless, engaged in these activities without realizing their advantages.

Table 11 Adoption status of physical practices to manage insect pests of citrus in Doti district (2024)

Physical practices	**yes**	**No**
Burning of Old Infected Trees	53(44.2)	67(55.8)
Moisture Maintenance	9(7.5)	111(92.5)

3.9.4. Knowledge and Practices of Botanical Practices

Table 12 Adoption status of biological practices to manage insect pests of citrus in Doti district (2024)

Biological practices	**yes**	**No**
Bio-pesticide	5(4.1)	115(95.9)
Bio-fertilizer	13(10.8)	107(89.2)
Natural Enemy Conservation	23(19.1)	97(80.9)
Local practices	47(39.2)	73(60.8)

A survey revealed that 42.3% of participants used botanical techniques to manage pest mandarin insects, while 57.7 percent did not. The majority (39.2%) used traditional methods like dousing mandarin trees in cow urine, using ash,

and using firewood smoke. Biofertilizers like Jholmol were used by 10.8%, while 4.1% used biopesticides like EM. Only 19.1% protected pollinators and other natural enemies by refraining from using pesticides and safeguarding their nests.

Frequency of application

According to the study, 45.2 percent of the mandarin growers who used a chemical method to control insect pests only used pesticides when the insects attacked, compared to 45.6 percent of respondents who used pesticides once a year and 12.2 percent of respondents who used pesticides twice a year. This demonstrates that the research location uses fewer pesticides.

Table13 Frequency of application of chemical pesticides in Doti district (2024)

Pesticide application	Frequency	Percent
Once a Year	26	45.6
Twice a year	7	12.2
At a time of insect attack (June- Sep) or fruiting stage	24	42.2
Total	57	100

3.10. Protective wearing

The study found that none of the applicators adhered to all safety precautions that were advised, indicating that a greater proportion of farmers are at risk of pesticide-related illnesses. While none of the respondents wore spectacles, all of them wore sandals. As protective clothing against pesticide application, however, only 57.9 percent used coveralls, 40.3 percent used boots, 50.8 percent used gloves, and 78.9 percent used masks.

Table 14 Status of protective wear during pesticide application in Doti district (2024)

Types of Protective Wearing	Yes	No
Boots	23(40.3)	34(59.7)
Gloves	29(50.8)	28(49.2)
Mask	45(78.9)	12(21.1)
Full slaves	33(57.9)	24(42.1)

3.11. Safety Measures

According to the results of the field study, most respondents do not adhere to fundamental safety precautions.91.3 percent of respondents wash their hands after using pesticides, 84.2 percent read the label before spraying, and 57.9 percent are concerned about potential health risks associated with pesticides. In contrast, 10.5% of respondents ingested while spraying, and 14% of respondents engaged in unhealthy behaviors including reusing containers. This demonstrated the careless use of pesticides and the disregard for safety precautions while applying pesticides.

Table 15 Safety Measure followed by respondents while pesticide application in Doti district (2024)

Safety measures	Yes	No
Consume while Spraying	6(10.5)	51(89.5)
Reuse Container	8(14)	49(86)
Wash after pesticide operation	52(91.3)	5(8.7)
Watch the label before spray	48(84.2)	9(15.8)
Alert on possible danger to health	33(57.9)	24(42.1)

3.12. Knowledge on disposal of used pesticide container

The survey showed that farmers have far more knowledge and practices in disposal of used pesticide container.40.4 percent of respondents had pesticide containers left in the field, 77.2 percent were burned in the soil, and 70.1 percent of pesticide containers were thrown into the bush. Whereas, 10.6 percent washed and used within a household of pesticide container.

Table 16 Status of methods of disposal of used pesticide containers in Doti district (2024)

Disposal method	Yes	No
Left in the field	23(40.4)	34(59.6)
Washed and used within a household	6(10.6)	51(89.4)
Burned in the Soil	44(77.2)	13(22.8)
Thrown into the bush	40(70.1)	17(29.9)

3.13. Knowledge of IPM

The respondents' knowledge about IPM is about 25.6 percent, whereas their practice of IPM is about 5.8 percent.

4. Conclusion

The study reveals that citrus cultivation knowledge is significantly influenced by previous years of experience, with the green stink bug being the most prevalent pest. Growers need training, investment funding, and pesticides to manage insect pests effectively. Monitoring pest populations during peak periods is crucial, and extension workers and entomology experts are needed. Despite 25.6 percent being aware of IPM technology, only 5.8% have used it. IPM programs are needed to disseminate knowledge.

Compliance with ethical standards

Acknowledgments

The authors would like to thank my friends for their continued support sincerely.

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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