ASSESSING THE KNOWLEDGE, ATTITUDE AND PRACTICES OF FARMER ON THE BIOLOGY AND MANAGEMENT OF CHINESE CITRUS FLY IN BAGMATI PROVINCE OF NEPAL

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ABSTRACT

Chinese citrus fly is the major pest of sweet orange in citrus growing districts of Bagmati Province Nepal. Farmer's production constrains and production problems such as Chinese citrus fly problem in sweet orange are not well documented and studied. This study was conducted in Sindhuli, Ramechhap, Dolakha and Kavre districts of Bagmati Province in 2021 with aim to understand the farmer's perception, knowledge about CCF and their management practices using semi-structured questionnaire. Collected survey data was analyzed using the SPSS-20 and MS Excel. The survey results depicted that the intensity of Chinese citrus fly damage has been decreased in Sindhuli district with the infestation level of < 20% in sweet orange orchard. However, CCF population as well as their damage level was in increasing trend of > 50% in sweet orange orchard in Ramechhap, and > 80% in Dolakha and Kavre district. Chinese citrus fly loss has been recorded up to 25% in Mandarin orange in Dolakha and Kavre district. Maximum Chinese citrus fly loss was recorded in sweet orange orchard in October month. Farmers usefully managed the dropping fruits by collecting in plastic bags and burying in pits. Great fruit fly bait, has been used for the CCF management in three districts except in Kavre. Majority of farmers reported that chemical pesticides are less effective or sometime not-effective for this pest management. This study provides a preliminary information about sweet orange orchard management practices, general pest problems, Chinese citrus fly and future management strategy in survey districts.

Keywords: Chinese citrus fly, sweet orange orchard, Sindhuli, farmers survey.

INTRODUCTION

Sweet orange (*Citrus sinensis* Obseck) belonging to family Rutaceae is a major citrus fruit crop grown in the mid-hills of Nepal (Gautam *et al.,* 2020) occupying first rank in terms of productivity (13.18 MT/ha) followed by mandarin orange (10.19 MT/ha). Sindhuli, Ramechap, Kavre and Dolakha are the major sweet orange production districts of Bagmati province in Nepal (Adhikari, Thapa, Joshi, Du & Acharya, 2020). Among the citrus cultivating districts, Sindhuli has the highest productivity 13.69 MT/ha followed by Ramechhap (13.65 MT/ha) (MoALD, 2020). Among citrus, in terms of productivity, Sweet orange occupies first rank (10.68 MT/ha) followed by Mandarin orange, *Citrus reticulata* Blanco (10.30 MT/ha) but in terms of production it occupies second position (43,061 MT) first being Mandarin orange (177,381 MT) (MoALD, 2020). Sweet orange and mandarin oranges are cultivated in 59 districts that included six districts in terai region, 40 districts in hilly region and 13 districts in high hills (MOALD, 2020).

Farmers are facing several problems in citrus cultivation and among them Chinese citrus fly, *Bactrocera minax (*Enderlin) (Diptera: Tephritidae) is a major pest of citrus in Asia (Hong *et al.,* 2019), and sweet orange is the most preferred crop among citrus crops (Xia**,** Mia, Hou, & Ouyang, 2018). It mainly affects tight skinned citrus fruits and is currently distributed in Eastern, Central and Western region of Nepal (Adhikari, Thapa, Joshi, Du & Acharya 2022). Female fly lays eggs by inserting ovipositor inside fruit where larvae hatch and feed inside fruit till maturation and comes out for pupation in soil (Dong, Wan, Pereira, & Desneux, 2014). This is univoltine species (Dorji *et al.,* 2006) and has the ability of long-distance flight which was supposed to migrate from China to the eastern mid-hills of Nepal through India (Sharma & Dahal, 2020). *B. minax* can cause upto 97% loss in severe case of infestation (Sharma, Adhikari, & Tiwari, 2015). Infestation can be observed more frequently in the orchards located above 1100 meter above sea level (masl) and majority damage has been observed in following districts of Bagmati province of Nepal such as Ramechhap, Sindhuli and Dolakha (Chauhan *et al.,* 2019). It reduces yield and quality of fruits by laying eggs inside the fruit, and developing maggots can cause the rotting of fruits (Adhikari et al., 2020). Due to severe damage up to 100%, farmers of eastern hills were compelled to replace sweet orange with mandarin orange (Acharya & Adhikari, 2019). Survey of National Citrus Research Program (NCRP) revealed that about 2/3rd of fruit drop was due to infestation of Chinese citrus fly in Dhankuta, Bhojpur and Khotang (Gautam *et al.,* 2020).

Damage of Chinese citrus fly is in increasing trend with high loss in yield and quality of produce in midhills of Nepal. Sweet orange pest's status has not been assessed in Bagmati provice yet. The production packages as well as pest management practices of the survey districts mentioned above are not known and documented. Hence, this study has been performed to document the overall sweet orange production packages as well as Chinese citrus fly invasion and their management practices adopted by the growers.

MATERIALS AND METHODS

The study was conducted in four districts of Bagmati province i.e., Sindhuli, Ramechhap, Dolakha and Kavre districts (Table 1). The study area was selected on the basis of potentiality of sweet orange production pockets as well as Chinese citrus fly infestation.

Table 1. Location of survey site in Bagmati province in 2020/21

District	Municipality	Latitude and longitude	Altitude range (masl)	Area of district
Sindhuli	Golanjor Rural Municipality	27.2569° N, 85.9713° E	1,000 to 2,000 meters	2,491 km^2
Ramechhap	Ramechhap Municipality	27.4469° N, 86.0530° E	1,000 to 2,000 meters	1,546 km^2
Dolakha	Melunga Municipality	27.7784° N, 86.1752° E	3,000 to 4,000 meters	2,191 km^2
Kavre	Panauti Municipality	27.5285° N, 85.6435° E	1007 to 3018 meters	1,396 km^2

One municipality from each district was selected purposively as a survey location according to the potentiality of sweet orange cultivation. The population list of citrus growers was collected from Prime Minister Agriculture Modernization Project (PMAMP)

Citrus super zone (Sindhuli), Citrus Zone (Ramechhap), Municipality office (Dolakha and Kavre) and the respondents were selected using simple random sampling method. Sample size was chosen which was almost 10% of the total grower list. Informal list of farmers was made by discussion with the progressive farmers from each Municipality. A total of 200 households were surveyed comprising 50 households from each district and farmers were selected for individual household survey using simple random sampling method. Pre survey with 5 respondents of Sindhuli district was done to test the feasibility of location and for the finalization of questionnaire.

Data collection and Statistical Analysis

Semi-structured questionnaire was prepared, pre-tested and survey was carried out in January 2020. Secondary information was collected from the reports published from the Prime Minister Agriculture Modernization Project (PMAMP), Agriculture Knowledge Centers as well as other publication materials such as journals, magazines, proceedings etc. The collected information was coded, entered in Excel sheet, SPSS-20 and analyzed by using SPSS-20 and Microsoft-Excel version 2016.

Quantative data was analyzed using descriptive statistics, frequency distribution, trend analysis, mean comparison, etc. Qualitative data were taken into account to prepare the index on farmer's perception. The index of importance was computed by using formula:

$I_{imp} = \sum SiFi/N$

Where, I_{imp} = index of importance

$\sum$ = Summation

Si = i^{th} scale value

Fi = frequency of i^{th} importance given by respondents

N = total number of respondents

RESULTS AND DISCUSSION

Demographic situation

Out of total respondents, 80% of the respondents were engaged in agriculture followed by Government job (9%). Majority of respondents were engaged in agriculture which includes 80% in Sindhuli, 78% in Ramechhap, 96% in Dolakha and 66% in Kavre (Table 2). Major crop grown by the respondents is Citrus and respondents have Sweet orange, Mandarin orange and Lime in the orchards.

Table 2. Categorization of respondents based on occupation in survey districts in 2020/21 (N=200)

Occupation	Sindhuli (%)	Ramechhap (%)	Dolakha (%)	Kavre (%)	Total (%)
Agriculture	40 (80)	39 (78)	48 (96)	33 (66)	160 (80)
Business	4 (8)	5 (10)	1 (2)	5 (10)	15 (7.5)
Government Job	5 (10)	4 (8)	1 (2)	8 (16)	18 (9)
Non-government Job	1 (2)	2 (4)	0	4 (8)	7 (3.5)

Note: Number in parenthesis indicates value in percentage

Production of Sweet orange and Mandarin orange in survey districts

The result shows that the production of sweet orange in Sindhuli was increased in 2020/21 as compared to 2019/20 (Table 3). However, citrus production area in Ramechhap and Dolakha was found decreased. There was almost similar citrus production area in Kavre covered to Ramechap and Dolakha. Due to use of AWCP production in Sindhuli in 2020/21, citrus cultivation has been increased and this result contradicts with the findings of Adhikari & Rayamajhi (2012).

Table 3. Production of sweet orange and mandarin orange in survey districts in 2020/21(N=200)

Production (Kg/ha)	Sweet Orange		Mandarin Orange	
	Sindhuli	Ramechhap	Dolakha	Kavre
Production in 2019/20	1408.34	1582.58	3270.9	135.4
Production in 2020/21	1686.79	867.44	2500.3	139.8

Ranking of problems in citrus orchard

It was found that there was highest problem of insects in all four districts followed by disease, irrigation and marketing. Problem of storage was ranked the least in all the survey districts (Table 4).

Table 4. Major problems faced by respondents in citrus cultivation in survey districts during 2020/21(N=200)

Problems	Sindhuli		Ramechhap		Dolakha		Kavre	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Insect	0.92	I	1	I	0.98	I	0.93	I
Disease	0.78	II	0.76	II	0.79	II	0.71	II
Irrigation / fertilizer	0.58	III	0.54	III	0.52	III	0.67	III
Marketing	0.34	IV	0.37	IV	0.39	IV	0.47	IV
Storage	0.29	V	0.32	V	0.3	V	0.2	V

Among the insects, most problematic insect in four districts was Chinese citrus fly. In Sindhuli, CCF was big problem followed by scales. In Ramechhap, second problematic insect was whitefly/aphid followed by scales. Farmers reported increase in problem of scales in Sindhuli and Ramechhap. However, scales were least problematic insect in Dolakha and Kavre (Table 5). Acharya and Shrestha, (2021) reported insects and diseases as major problem in citrus orchards and Nurseries. Slightly differing from the survey, the result of Ekasi (2015) shows codling moth as major pest followed by fruit fly in citrus orchard. Aidoo, Kyerematen, Akotsen-Mensah, & Afreh-Nuamah, (2016) reported hymenopteran pest as the major infesting pest in orchard followed by dipteran pest.

Table 5. Rank of major insects by the respondents in citrus orchard in survey districts in 2020/21 (N=200)

Insects	Sindhuli		Ramechhap		Dolakha		Kavre	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Citrus butterfly	0.34	V	0.34	V	0.42	IV	0.59	III
Citrus leaf miner	0.55	IV	0.51	IV	0.55	III	0.66	II
White fly/aphid	0.68	III	0.75	II	0.69	II	0.58	IV
Chinese Citrus fly	0.98	I	1	I	0.96	I	0.95	I
Mealy bugs/ scales	0.72	II	0.692	III	0.34	V	0.25	V

Farmers noticing Chinese citrus fly in the orchard

All the respondents in Sindhuli and Ramechhap had heard about citrus fruit fly that contradicts the result of Gautam et al. (2020) while more than two third of respondents in Dolakha and half of the respondents in Kavre had heard about Chinese citrus fly. Among the respondents who have heard about Chinese Citrus fly, majority of the respondents had noticed fruit fly problem in the orchard (Table 6). Farmers have noticed mainly maggot stage and adult fly in the orchard and few respondents have observed pupa stage in the soil as well.

Table 6. Farmers noticing Chinese citrus fly in survey districts in 2020/21(N=200)

Districts	Heard of CCF		Noticed CCF	
	Yes (%)	No (%)	Yes (%)	No (%)
Sindhuli	50(100)	0	50(100)	0
Ramechhap	50 (100)	0	50 (100)	0
Dolakha	49(98)	1(2)	44(88)	6(12)
Kavre	40(80)	10(20)	26(52)	24(48)

Note: Number in parenthesis indicates value in percentage

Month of highest infestation of CCF recorded by the farmers

Majority of respondents reported highest infestation at the month of october while least of the farmers revealed highest infestation at month of August (Table 7). The result was similar with Chauhan *et al.,* (2019) which reported highest loss during the harvest time of sweet orange. Some respondents reported highest infestation at the month of September as well.

Table 7. Percentage of respondents recording CCF infestation in the orchard in survey districts in 2020/21 (N=200)

Months	Sindhuli (%)	Ramechhap (%)	Dolakha (%)	Kavre (%)	Total (%)	Chi Sq.value
August	4(8.5)	2(4.2)	0	1(4.5)	7(4.7)	22.8 at p = 0.007
September	20(42.6)	11(22.9)	16(51.6)	6(27.3)	53(35.8)	
October	23(48.9)	35(72.9)	15(48.4)	13(68.5)	86(59.5)	

Note: Number in parenthesis indicates value in percentage, p is the probability of occurrence

Loss of sweet orange in Orchard of survey districts

Nearly half of the respondents in Sindhuli revealed the loss due to Chinese citrus fly to be less than 20% while remaining other revealed 20-40% and very few reported 40-60% infestation. In Ramechhap there was similar percentage of respondents who reported all different infestation ranges. Among sweet orange growing respondents in Dolakha (22), and Kavre (39), half of growers in Dolakha reported 60-80% infestation while in Kavre half of growers reported >80% respondents. Few of the sweet orange growers reported 40-60% infestation in their orchard. In Ramechhap, only one fifth of respondents had >80% infestation of sweet orange in the orchard which differs from Chauhan *et al.* (2019) which reported 100% infestation upto the harvest period. Similarly, in Sindhuli, the loss was reported 0-20% by majority of respondents which is found similar with Adhikari *et al.* (2020) which revealed infestation was higher (56.7%) in 2017. Differing form this, Adhikari *et al.* (2020) reported higher infestation (35%) in Sindhuli in 2018. This decrease in infestation loss in Sindhuli and Ramechhap was due to the application of AWCP(Figure 1).

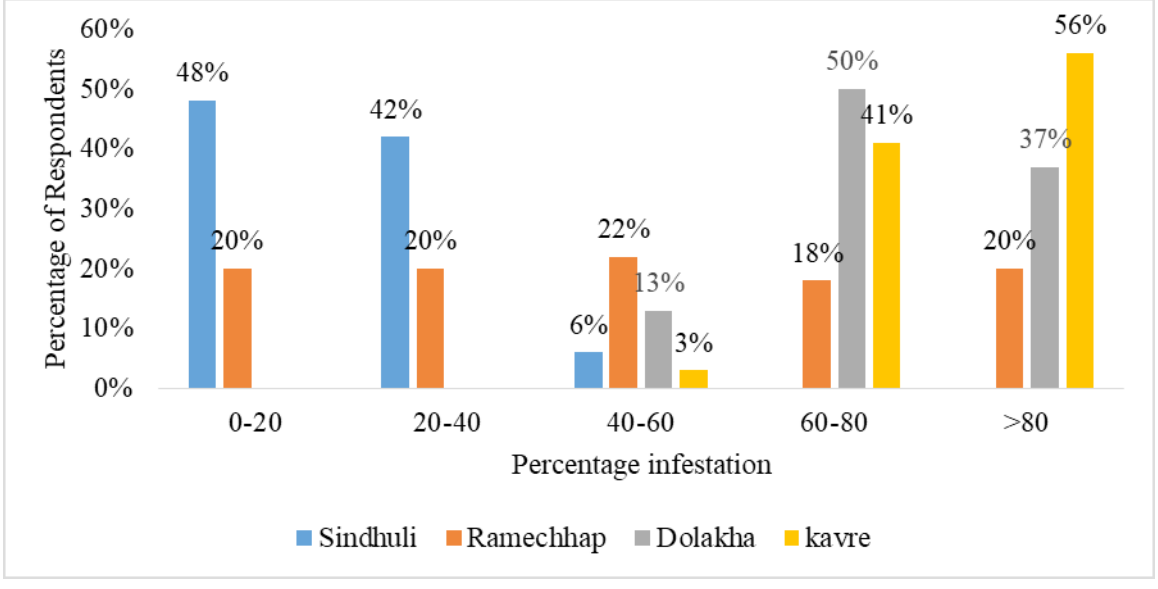

Figure 1. Loss of Sweet orange in the orchard in Survey districts in 2020/21

Loss of mandarin orange

According to Figure 2, half of the respondents in Kavre district reported less than 20% infestation in orchard while one third of respondents reported 20-30% infestation. In Dolakha, one third of respondents reported 20-30% infestation. Comparing two districts, there was higher infestation in Dolakha. None of the respondents reported 100% infestation (Figure 2). Differing from the result of survey, infestation of Chinese citrus fly in mandarin orange was found higher (35-75%) in (Rashid *et al.,* 2021).

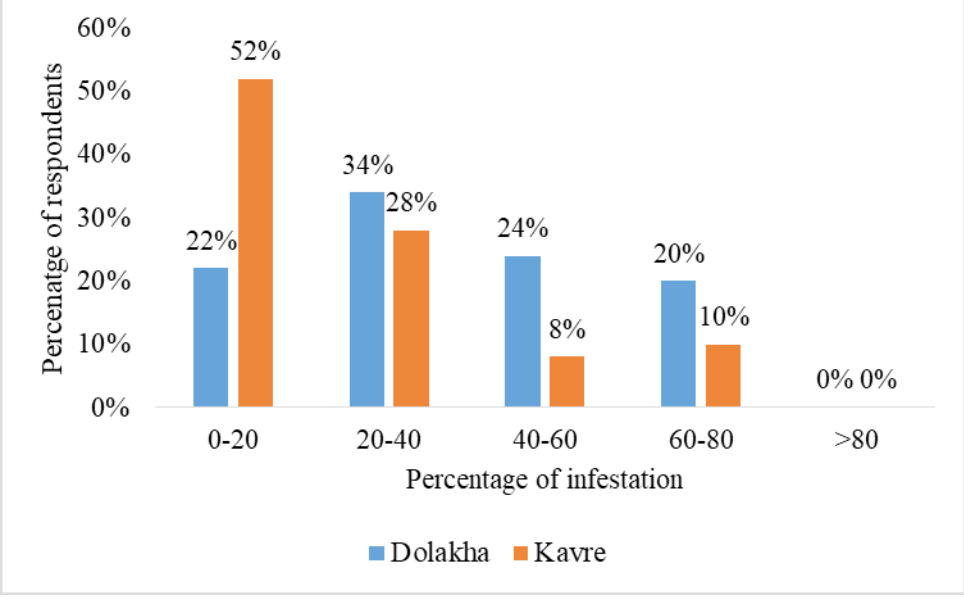

Figure 2. Loss of mandarin orange in citrus orchard in survey districts in 2020/21

Intensity of pest reported by respondents comparing previous year

Most of the farmers in Ramechhap, Dolakha and Kavre revealed that the intensity of pest is in increasing trend however they are hopeful that the pest is in controllable condition if suitable measures are applied. In Sindhuli, there is decrease in pest condition (Table 8). The result of the study supports the result of Adhikari *et al.* (2020) which revealed that there was less loss due to Chinese citrus fly in 2019 (15%) in comparison to 2018 (35%).

Table 8. Intensity and controllable condition of pest reported by respondents in survey districts (N=200)

Districts	Intensity of Pest				Controllable condition of pest	
	Increased (%)	Decreased (%)	Constant (%)	No idea (%)	Difficult to control (%)	Controllable (%)
Sindhuli	2(4)	47(94)	1(2)	0	27(54)	23(46)
Ramechhap	32(64)	3(6)	6(12)	9(18)	23(46)	27(57)
Dolakha	33(66)	0	9(18)	8(16)	8(16)	42(84)
Kavre	29(58)	1(2)	8(16)	12(24)	16(32)	34(68)

Note: Number in parenthesis indicates value in percentage, p is the probability of occurrence

Management practices of CCF

Protein bait application was mostly used method of management in Sindhuli, Ramechhap and Dolakha but in Kavre, application of protein bait for management of pest was least done. This result of management practice supports the result of Adhikari et al. (2020) where 70% of respondents used orchard sanitation as management practice first being the use of lure. In contrary to this, respondents mainly preferred orchard sanitation for the

management of pest (Gautam et al., 2020). Vargas, Piñero. and Leblanc (2015) focused on bait spray as major component in the management of fruit fly(Table 9).

Table 9. Rank of management practices of pest applied by respondents in survey districts in 2020/21 (N=200)

Management practices	Sindhuli		Ramechhap		Dolakha		Kavre	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Chemical method	0.41	IV	0.43	IV	0.59	III	0.64	II
Orchard sanitation	0.78	II	0.71	II	0.68	II	0.58	III
Use of trap	0.55	III	0.58	III	0.28	V	0.33	IV
Use of botanicals	0.33	V	0.32	V	0.39	IV	0.65	I
Great fruit fly Protein bait	0.92	I	0.82	I	0.96	I	0.2	V

Management of fallen fruits in orchard

Table 10 shows that most of the respondents use plastic bag to keep fallen rotten fruits in Sindhuli while in Ramechhap they feed to livestock. Similarly, in Dolakha they bury in pit and in Kavre there is no management for rotten fruits, they leave rotten fruits in the orchard. This result differs from Gautam *et al.* (2020) that majority of respondents dumped in the pit for the management in Sindhuli. Management practice of fallen fruits of Dolakha was burying in the pit which supports the management practice of Sindhuli district as reported by Gautam *et al.* (2020).

Table 10. Rank of management practices of fallen rotten fruits in orchard in survey districts in 2020/21(N=200)

Management of fallen fruits	Sindhuli		Ramechhap		Dolakha		Kavre	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Keeping in plastic bags	0.86	I	0.49	V	0.56	III	0.71	II
Burying in pit	0.75	II	0.57	III	0.86	I	0.65	III
Mixing in biogas	0.60	III	0.51	IV	0.54	IV	0.63	IV
Feeding to livestock	0.31	VI	0.91	I	0.59	II	0.58	V
Collection and burning	0.59	IV	0.46	VI	0.49	VI	0.38	VI
Dipping in water tank	0.58	V	0.65	II	0.37	VII	0.34	VII
Leave as it in orchard	0.23	VII	0.22	VII	0.53	V	0.96	I

Time and application of Great fruit fly bait

All the respondents from Ramechhap and Sindhuli used Great fruit fly bait which differs from Gautam *et al.* (2020) where only one third of respondents of Sindhuli district used Great fruit fly bait trap for management and sprayed before the appearance of adult while farmers from Dolakha used after the appearance of adult Fly. None of the respondents from Kavre used Great fruit fly bait (Table 11).

Table 11. Time of application of Great Fruit Fly Bait in survey districts in 2020/21 (N=200)

Districts	Use of Great Fruit Fly Bait		Time of application of Bait	
	Yes (%)	No (%)	Before appearance of adult (%)	After appearance of adult (%)
Sindhuli	50(100)	0	50(100)	0
Ramechhap	46(92)	4(8)	50(100)	0
Dolakha	50(100)	0	0	50(100)
Kavre	0	50(100)	-	-

Note: Number in parenthesis indicates value in percentage

Use and effectiveness of insecticide

Half of the respondents in Sindhuli used insecticides for the pest management which is similar with the result of Gautam et al. (2020) but they found that the insecticide was ineffective. The result is similar with the result of Liu *et al.* 2015. Few respondents from Dolakha and Kavre used insecticide but none of them reported effectiveness for the pest control (Table 12). Farmers mainly used Imidacloprid, Cypermethrin, Spinosad etc. for the management of pest in their orchard. Shi *et al.* (2019) found Imidacloprid effective for repelling female adults while Spinosad was effective for repelling male adult Fly. Farmers also used cow urine, neem leaves etc. for the management of the pest. Sharma and Dahal, (2020) reported that neem caused larval mortality and delayed in pupation.

Table 12. Use of insecticide and its effectiveness in survey districts in 2020/21(N=200)

Districts	Use of insecticide		Effectiveness of insecticide		
	Yes (%)	No (%)	Yes (%)	No (%)	In some extent (%)
Sindhuli	25(50)	25(50)	4(17.4)	12(52.2)	7(30.4)
Ramechhap	22(44)	28(56)	5(22.7)	6(27.3)	11(50)
Dolakha	1(2)	49(98)	-	1(100)	-
Kavre	13(26)	37(74)	-	9(69.2)	4(30.8)

Note: Number in parenthesis indicates value in percentage

Reason behind the loss in the orchard

Majority of respondents from all the surveyed district revealed that the loss was due to less knowledge on the management of the pest. Since, larva of the pest feeds inside the fruit and completes larval period inside the fruit, the spraying of pesticide for management is ineffective (Zhou *et al.,* 2012). Few respondents of Sindhuli and Dolakha blamed concerned authority for the loss (Table 13).

Table 13. Reason behind the production loss in citrus orchard in survey districts in 2020/21(N=200)

Reason of loss	Sindhuli(%)	Ramechhap(%)	Dolakha(%)	Kavre(%)	Total	Chi Sq.value
No idea about management	25(50)	21(42)	37(74)	27(54)	110(55)	
Pesticide doesn't work properly	7(14)	13(26)	1(2)	4(8)	25(12.5)	
Concerned authority doesn't give attention	3(6)	8(16)	12(24)	17(34)	40(20)	50.135 at p = 0.000
Management done but no control	15(30)	8(16)	0	2(4)	25(12.5)	

Note: Number in parenthesis indicates value in percentage, p is the probability of occurrence

CONCLUSION

The findings of the study are mainly focused on evaluating the farmers knowledge, attitude and practices on the citrus pest management in general and Chinese citrus fly management in particular. Survey findings indicates that Chinese citrus fly is a major problem in sweet orange cultivation. In addition, use of protein bait for the management is mostly used management practice and field sanitation is done at some extent. Insecticides are not effective pest management strategy but still farmers are using such chemicals. The Chinese citrus fly infestation is the greatest in sweet orange compared to the mandarin orange. Infestation is higher at October month which is fruit harvesting period however farmers are still hopeful in controllable condition of pest.

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