

FARMERS' PERCEPTION ON PESTILENCE AND MANAGEMENT OF CHINESE CITRUS FLY, *Bactrocera minax* (ENDERLEIN) (DIPTERA: TEPHRITIDAE) IN CITRUS ORCHARDS OF NEPAL

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ABSTRACT

This study, during period of 2018 and 2019, was conducted with an objective of assessing the farmers' perspective on the pestilence of *B. minax* on their citrus orchards and following thereby its pest management measures in the selected eight citrus growing districts of Nepal. Respondent citrus growers were male dominated (75.8%) where Brahmin and Chhetri castes (54.3%) were dominantly involved in the citrus cultivation in the survey districts. Only 25.7% respondent citrus growers had above school level education. The highest reported land holding area, 2.35 ha, was in Sankhuwasabha district followed by Dhankuta (1.72 ha) and Syanjya (1.67 ha). According to the respondents, an average of 234.12 mandarin trees in Syanjya, 159.60 sweet orange trees in Sindhuli, 9.68 lemon trees in Sindhuli, and 11.83 lime trees in Gulmi were calculated maximum acreage of different citrus fruit trees by the each citrus grower. Among the cultivated *Citrus* spp., lemon fruit found to be extremely vulnerable to Chinese citrus fly infestation. Chinese citrus fly's maggot infestation peak in fruits in orchards was observed in October in the citrus crop cycle. Twenty citrus dominated districts in Nepal found to be regularly invaded of Chinese citrus fly in citrus particularly in lemon, sweet orange and mandarin.

Key words: *Bactrocera minax*, citrus, invasion, management, Nepal

INTRODUCTION

Citrus is one of the most important horticultural cash crops in the world, with significant potential for foreign exchange and employment on both domestic and international markets (Adhikari and GC, 2020; Dorji *et al.*, 2016). Citrus, which is one of the Nepal's most popular traditional fruits, is also in great demand for fresh consumption in the local market (Adhikari and Rayamajhi, 2012). It is one of the major fruit crops in Nepal's mid-hill region, contributing to the people's nutrition security and income generation (Adhikari and GC, 2020; Pokhrel, 2011). Different types of citrus fruits are grown in most of the districts in the country, which share 27.3 percent of the total fruit cultivation. Citrus fruits cover about 27,339 hectares of

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land that produce 274,140 mt. in Nepal (MoALD, 2019/20). Among several biotic and abiotic problems which causes citrus decline in Nepal, the Chinese citrus fly (*Bactrocera minax* (Enderlein) is gradually emerging as a threat (Adhikari *et al.*, 2020c; and Bhandari *et al.*, 2017).

The Chinese citrus fly was originated in China and made its way to the eastern Nepal through Bhutan and India (Sikkim and West Bengal) (Adhikari *et al.*, 2019; Acharya and Adhikari, 2019; Adhikari and Joshi, 2019; Xia *et. al.*, 2018). Geographically, this species of fruit fly is found only in China, Bhutan, India (Sikkim and Western Bengal), and Nepal (CABI, 2020). This is one of the most peculiar fruit fly species (Xia *et. al.*, 2018; Wang and Luo, 1995; Chen and Xie, 1955) in citrus orchards as it displays typical characteristics of bigger size robust body than other fruit fly, restricted plant hosts to *Citrus* spp., univoltine life-cycle, winter diapausing pupae, and declining to para-pheromones but readily attracting to protein baits. *B. minax* is a serious pest in citrus-growing areas, causing significant citrus fruit losses in orchards (Rasid *et al.*, 2021). Occasional *B. minax* incurred citrus fruit losses (up to 100 percent) is common in sweet orange orchards in Nepal (Bajracharya, 2010). In course of *B. minax* invasion extending from eastern to western Nepal, it displayed an ominous sweet orange devastation in the sweet orange orchards in Sindhuli district since 2014 (Adhikari and Joshi, 2018) and host range observed on lemon, sweet orange, mandarin and other citrus fruits. This paper reflects the farmers' perception on the nature of pestilence of *B. minax* in their citrus orchards with their present knowledge of fruit fly management.

METHODOLOGY

STUDY AREA

Citrus growing districts of Nepal, namely Bhojpur, Dhankuta, Sankhuwasabha, Sindhuli, Ramechhap, Dolakha, Syangjya and Gulmi were considered for selecting respondent farmers for investigating their perspective on the pestilence of the Chinese citrus fly, *B. minax* in their citrus orchards and management practices against this pest. Physically, Bhojpur, Dhankuta, and Sankhuwasabha districts are located in the hilly region of Province no 1; Sindhuli, Ramechhap, and Dolakha districts are located in the hilly region of Bagmati Province; and Syangjya and Gulmi districts are situated in the hilly region of Gandaki and Lumbini Province respectively Nepal. Particularly, the information on the citrus cultivation status in the survey area presented has been obtained from the response analysis of randomly selected respondent citrus farmers for the data comparison.

SURVEY METHODS

Farmers' understanding on the pestilence of CCF and their indigenous management practices in their citrus orchards were recorded through a priori prepared questionnaire. Citrus fruit growers as respondents (n = 245) from the eight districts were interviewed and their statements were recorded. Respondents from each fruit-producing area were purposefully selected to get the relevant information. The districts were chosen based on the number of active commercial fruit farmers engaged in the citrus cultivation. Officials from the Prime Minister Agriculture Modernization Project, Project Implementation Units, Agriculture Knowledge Centers, National Citrus Research Program, Paripatle, Dhankuta and local level agriculture sections in the individual local governments were consulted to develop list of citrus fruit growers as respondents. Citrus fruit farmers' knowledge, perception, and practices (KPP) on fruit fly pests and their management were assessed using a semi-structured questionnaire with closed and open-ended questions. On years 2018 and 2019, data was collected through face-to-face interviews and orchard visit.

INVASION EXPANSION OF *B. minax*

An attempt was made to assess the status of the invasion and expansion of the Chinese citrus fly, *B. minax*, in the country through the survey, literature review which includes national and international journals, proceedings, reports, newsletters, and books. The Chinese citrus fly intrusion in a district with an occurrence year was presented in a map of the county (Fig 5.).

STATISTICAL ANALYSIS

The descriptive data were managed and analyzed using Microsoft Excel worksheet (version 97-2003) and SPSS 26 software to derive frequencies, percentages, and means to be presented in the tables and figures.

RESULTS AND DISCUSSIONS

SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

The sex distribution revealed 181 of them (75.8%) being males and 24.2 percent female. Their ethnicity reported to be Brahmin and Chhetri (54.3%), Adibasi and Janajati (42.7%) and Dalit (3.0%). This reflected that the Brahmin and Chhetri were largely involved in citrus cultivation. Regarding education level, more than half, 64.5% (156) were educated up to 10th class, 18.4% (45) of respondents were educated upto 12th class. Similarly, the survey showed that 9.8% (26) respondents were illiterates, whereas, 5.9% (15) and 1.4% (3) found to be graduate degree holders and master degree holders, respectively (Table 1). This indicated that very few higher

level educated persons were actively involved in citrus farming among the respondents. Adhikari *et al.* (2021c) reported that a majority of the citrus grower respondents were male (70.0%) and 43.3% being Brahmin in Dailekh district.

Table 1. Demographic information on citrus fruit growers in selected eight districts of Nepal, 2018/19

Demo-graphic factors (n=245)	Frequency	Percent
Sex		
Male	181	75.8
Female	64	24.2
Ethnicity		
Dalit	9	3.0
Aadibasi and Janajati	101	42.7
Brahmin and Chettri	135	54.3
Education level		
Illiterate	26	9.8
School level	156	64.5
Intermediate	45	18.4
Bachelor degree	15	5.9
Master degree	3	1.4

LAND HOLDINGS AND CITRUS CULTIVATION PROFILE

The survey revealed that farmers from Sankhuwasabha district held the highest land area 2.35 ha followed by Dhankuta (1.72 ha) and Syanjya (1.67 ha), whereas, Ramechhap district's respondents held the lowest land area (1.14 ha) (Figure 1). Similarly, respondents in Sankhuwasabha district held the highest land area under crop cultivation (1.97 ha) followed by Syanjya (1.48 ha) and Dhankuta (1.42 ha) while respondents in Dolakha district held the lowest area under cultivation (1.06 ha). Regarding the area under citrus cultivation, respondents in Sindhuli district reportedly held highest acreage (0.67 ha) followed by Ramechhap and Syanjya (0.65 ha each). At the same time, respondents in Bhojpur district found to be having the lowest area under citrus cultivation (0.16 ha) (Fig 1). The average land holding of farmers was 0.53 ha of which sweet orange cultivation occupied 0.37 ha in Sindhuli district (Parajulee *et al.*, 2021).

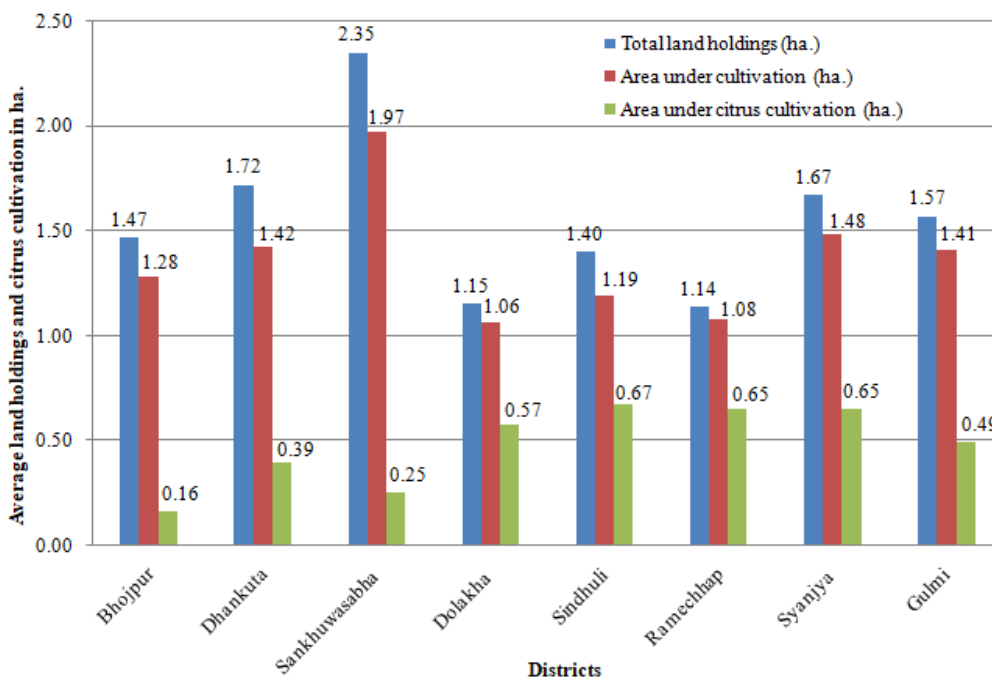


Figure 1. Land holdings and citrus cultivation in selected eight districts of Nepal

INFORMATION ON CITRUS CULTIVATION

Information on citrus cultivation has been presented in Table 2. It showed the highest average total numbers of citrus trees (241.44) and the highest average numbers of productive citrus trees 169.12 (70%) were existed in Syangjya districts. Whereas, the lowest average numbers of citrus trees (56.68) were existed in Bhojpur district, where only 68% were found productive. The maximum numbers of mandarin fruit trees were reported to be 234.12 (97%) in Syangjya, sweet orange 159.60 (70%) and lemon 9.68 (4%) in Sindhuli and lime 11.83 (6%) in Gulmi. Percentage basis citrus cultivation status of each type of citrus fruit among *Citrus* spp. survey revealed that the highest (99%) mandarin cultivation was found in Sankhuwasabha followed by Syangjya (97%) and Gulmi (91%). Similarly, sweet orange covers about 70% of citrus cultivation in Sindhuli followed by 67% in Ramechhap and 6% in Dolakha. Likewise, lemon cultivation was reported highest in Dolakha, Ramechhap, Sindhuli 4% and lime 6% in Gulmi and 5% in Ramechhap and 4% in Sindhuli and Dolakha. In Nepal, Sindhuli district is renowned for the sweet orange orchards while Syangjya district is for mandarin (Table 2). According to MoALD (2019/20), the total area (ha.) and productive area (ha.) of citrus fruits in Bhojpur, Dhankuta, Sankhuwasabha, Sindhuli, Ramechhap, Dolakha, Syangjya and Gulmi are 1706 (911), 1388 (847), 505 (230), 2463 (1074), 2004 (1121), 443 (220), 1984 (885) and 1137 (693) respectively.

Table 2. Average number of different citrus fruit tree owned by farmers at surveyed districts

Districts*	Bhojpur		Dhankuta		Sankhuwasabha		Dolakha	
Citrus trees	Mean	%	Mean	%	Mean	%	Mean	%
Mandarin	51.76	91	132.76	98	85.48	99	170.60	86
Sweet orange	2.40	4	0.32	0	0.00	0	12.80	6
Lemon	0.80	1	0.76	1	0.60	1	7.80	4
Lime	1.72	3	1.96	1	0.60	1	6.96	4
Total citrus trees	56.68	100	135.80	100	86.68	100	198.16	100
Average productive citrus trees	38.80	68	90.40	67	63.52	73	122.40	62
Districts	Sindhuli		Ramechhap		Syangjya		Gulmi	
Citrus trees	Mean	%	Mean	%	Mean	%	Mean	%
Mandarin	50.48	22	55.00	24	234.12	97	172.72	91
Sweet orange	159.60	70	152.00	67	1.24	1	3.40	2
Lemon	9.68	4	9.44	4	2.04	1	1.68	1
Lime	9.60	4	10.88	5	4.04	2	11.83	6
Total citrus trees	229.36	100	227.32	100	241.44	100	189.16	100
Total productive citrus trees	120.60	53	144.40	64	169.12	70	124.16	66

*Citrus cultivation statistics are derived from 25 respondents in each of the districts.

CHINESE CITRUS FLY (*B. minax*) INCURRED FRUIT DAMAGE

The status of Chinese citrus fly (*B. minax*) incurred fruit damage/loss % in selected eight districts of Nepal in 2018 is presented in the Fig. 2. According to the citrus grower respondents' observations and experience on fruit damage by maggots of the fruit fly in different kinds of citrus fruits, lemon fruit was reported highly prone to Chinese citrus fly followed by sweet orange and mandarin. The respondents of Sankhuwasabha, Dolakha, Syangjya and Gulmi reported a maximum of 95% fruit loss in lemon. Similarly, a maximum of 90% fruit loss in sweet orange was reported from Dolakha and Gulmi, whereas, a maximum of 25% of fruit loss in mandarin was reported from Sankhuwasabha and Dolakha. Dhankuta, Bhojpur, and Khotang districts reported Chinese citrus fly incurred sweet orange losses ranging from 60 to 70% (NCRP, 2006).

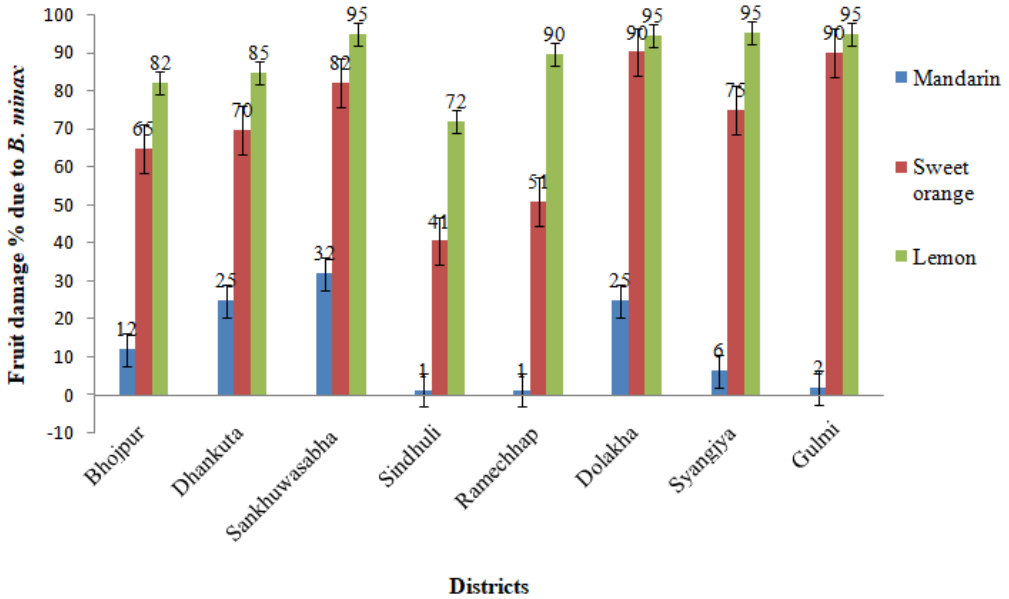


Figure 2. Status of Chinese citrus fly incurred citrus fruit-wise damages as perceived by farmers in surveyed districts of Nepal

SEASONAL FRUIT DAMAGE IN THE ORCHARD DUE TO CFF

Farmers’ observations on the extent of fruit damage period at different season in the orchard are shown in Fig. 3. Mostly, the problems of Chinese citrus fly maggots were observed in citrus orchards during September to November. The severity of problem was observed maximum in October at majority of the surveyed districts followed by November and September. A similar life stage and damage pattern of maggot was reported in Sindhuli (Adhikari *et al.*, 2021a).

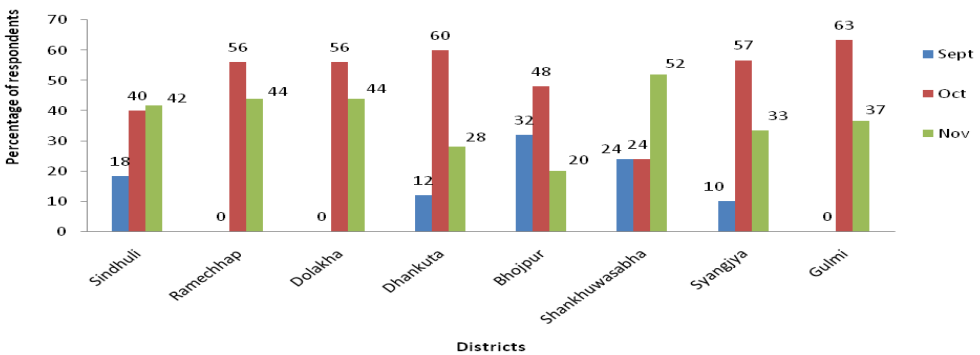


Figure 3. Status of season-wise Chinese citrus fly incurred citrus fruit damages within the citrus crop cycle in surveyed districts of Nepal

KNOWLEDGE OF CITRUS GROWERS ON THE MANAGEMENT MEASURES

Different ten management measures of Chinese citrus fly were asked to assess the knowledge status of respondents in selected eight districts. In all surveyed districts, most of the respondents had know-how on chemical insecticides, orchard sanitation, cultural measures, pheromone lure/trap, botanicals, food/protein bait and exclusion measures (Fig 4). Very few respondents in Sankhuwasabha and Dolakha districts knew the biological measures while a few citrus grower respondents from Bhojpur and Sankhuwasabha districts shared their know-how on post-harvest fruit treatment measures. None of the respondents in districts were aware of sterile insect technique. Obviously, the Chinese citrus fly was never attracted to para-pheromones (Xia et. al., 2018; Wang and Luo, 1995; Chen and Xie, 1955). Hence, application of protein bait as spray on tree and sanitation of infested fruit from orchards as cultural measure were applied in area-wide control program (AWCP) that remarkably achieved success to minimize the fruit loss due to this pest in Sindhuli district (Adhikari *et al.*, 2021b and Adhikari *et al.*, 2020a, 2020b).

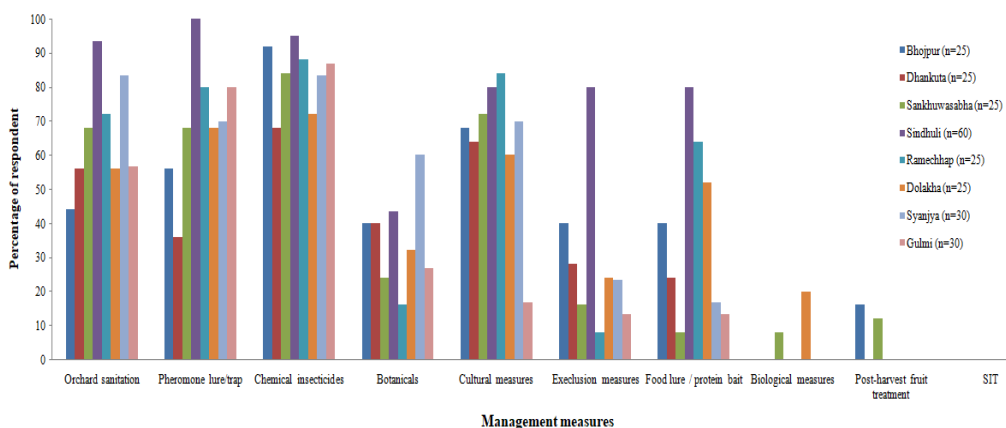


Figure 4. Knowledge status of citrus growers on the management measures of *B. minax*

EXPANSION OF *B. minax* INVASION IN CITRUS ORCHARDS OF NEPAL

The Chinese citrus fly, *Bactrocera minax*, was collected from sweet orange in Helambu, Sindhupalchok district, Nepal in December 1984, which was initially identified as *Bactrocera tsuneonis* (Joshi and Manandhar, 2001). Dr. Gary J. Steck, Curator of Diptera, Florida State Collection of Arthropods, Florida, USA corrected the insect specimen, *Bactrocera tsuneonis* preserved in the National Entomological Research Centre, Nepal Agriculture Research Council, Khumaltar, Lalitpur to *B. minax* (instead the previously identified as *Bactrocera tsuneonis*) on September 26, 2007. Similarly, in the same lot, he identified the fruit fly specimens collected from sweet oranges in Dhankuta on April 27, 2007 to *B. minax* (Poudel *et al.*, 2016; Joshi, 2019). Poudel and Regmi (2008) reported the invasion of *B. minax* in sweet orange and lemon in Bhojpur district. National Citrus Research Program (NCRP), Paripatle, Dhankuta in 2014 reported presence of Chinese citrus fly in Myagdi, Gulmi and Parvat districts. Similarly, NCRP (2016) reported citrus fruits infested of similar fruit fly species from Sindhuli, Ramechhap, Solukhumbu districts. In course of progressing survey, Chinese citrus fly maggots infested fruits were observed and reported from Dhankuta, Bhojpur, Sankhuwasabha, Sindhuli, Ramechhap, Dolakha, Syangja, Gulmi, Taplejung, Terhathum, Khotang, Okhaldunga, Kavre, Lamjung, Baglung, Arghakhachi districts. Thus, this study confirmed the invasion of Chinese citrus fly in citrus orchards of twenty districts of Nepal (Fig. 5).

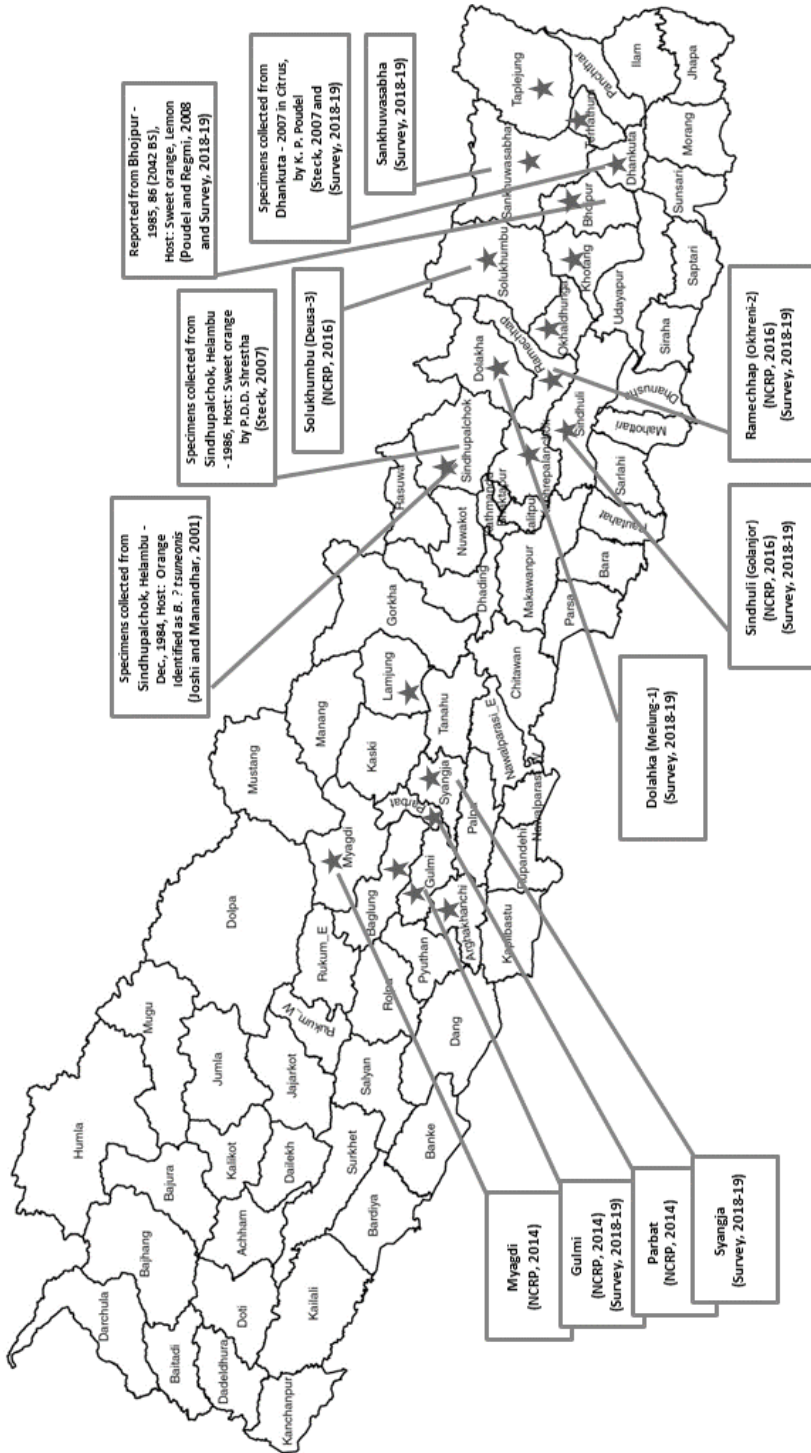


Figure 5. Expansion of invasive Chinese citrus fly in citrus orchards of Nepal

CONCLUSIONS

Respondents were male dominated, 75.8%, and Brahmin and Chhetri castes were dominantly involved, 54.3%, in the citrus cultivation in the survey districts. Among the respondents, only a few higher level educated persons involved in the citrus farming. The highest reported land holding area, 2.35 ha, was in Sankhuwasabha district followed by Dhankuta (1.72 ha) and Syanjya (1.67 ha). According to the respondent citrus growers, the citrus cultivation area in Sindhuli district was highest in acreage (0.67 ha) followed by 0.65 ha in each of Ramechhap and Syanjya districts. Based on the information derived from respondents in each of the districts, among the respondents, a maximum numbers of mandarin fruit trees, 234.12, were found cultivated in Syanjya district, 159.60 sweet orange trees in Sindhuli district, 9.68 lemon trees in Sindhuli district and 11.83 lime trees in Gulmi district. Among *Citrus* spp., lemon fruit reported to be highly prone to the Chinese citrus fly damage. The severity of Chinese citrus fly problem was reported to be highly escalated in October in the crop cycle. Most of the respondent citrus growers had know-how on chemical insecticides, orchard sanitation, cultural measures, pheromone lure/trap, botanicals, food/protein bait and exclusion measures, generally, applied in the fruit fly management. This study confirmed the invasion status of the Chinese citrus fly in citrus orchards of twenty districts in Nepal.

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REFERENCES

- Acharya U. K. and Adhikari, D., 2019. Chinese Citrus Fly (*Bactrocera minax*) management in mid hills of Nepal. The Journal of Agriculture and Environment. Vol: 20, June, 2019. pp. 47-56.
- Adhikari, A. Dhital, P. R. Ranabhat, S. and Koirala, S., 2021c. An assessment of mandarin (*Citrus reticulata* Blanco.) orchard management practices in Dailekh, Nepal. Archives of Agriculture and Environmental Science, 6(3), 341-346, <https://dx.doi.org/10.26832/24566632.2021.0603012>
- Adhikari, D. and Rayamajhi, D. B., 2012. Status of Sweet Orange Production in Sindhuli District of Nepal. Nepalese Horticulture. Nepal Horticulture Society, Vol.: 9:104-109.

- Adhikari, D. and Joshi, S. L., 2018. Occurrences and field identities of different species of fruit flies in sweet orange (*Citrus sinensis*) orchards in Sindhuli, Nepal. *Journal of Natural History Museum, Nepal*. 30, 47-54.
- Adhikari, D. and Joshi, S. L., 2019. Chinese citrus fly in Citrus cultivation. *Prime Minister Agriculture Modernization Project. Project Implementation Unit (Junar Superzone), Sindhuli, 2019. Accessed from <https://sindhulijunar.pmamp.gov.np/sites/default/files/Bactrocera%20minax%20book%20final.pdf>.*
- Adhikari, D. and GC, Y. D., 2020. Opportunity to Export Citrus Fruit from Nepal to China: Activities Accomplished on Plant Quarantine Concerned. *International Journal of Agriculture Innovations and Research*. Volume 8, Issue 5, ISSN (Online) 2319-1473
- Adhikari, D. Thapa, R. B. Joshi, S. L. and Du, J. J., 2021b. Area-Wide Control Program in management of Chinese citrus fly, *Bactrocera minax* (Enderlein) (Diptera: Tephritidae), in citrus orchards, Sindhuli, Nepal. *The Journal of Agriculture and Environment*. Vol: 22, June, 2021. pp. 41-50.
- Adhikari, D. Thapa, R. B. Joshi, S. L. Du, J. J. and Achrya, U. K., 2020a. Receded Sweet Orange Losses from Chinese Citrus Fly, *Bactrocera minax* (Enderlein) in Sindhuli Citrus Orchards: Lesson from Area Wide Control Program. *Proceeding of National Horticulture Seminar Kirtipur, Kathmandu. February 6-7, 2020.*
- Adhikari, D. Thapa, R. B. Joshi, S. L. Du, J. J. and Joshi, Y. D., 2021a. Diapause intensity of Chinese citrus fly, *Bactrocera minax* (Enderlein) in Sindhuli, Nepal. *International Journal of Entomology Research*. 6:37-41.
- Adhikari, D. Thapa, R. B. Joshi, S. L. Liang, X. H. and Du, J. J., 2020b. Area-Wide Control Program of Chinese Citrus Fly *Bactrocera minax* (Enderlein) in Sindhuli, Nepal. *American Journal of Agricultural and Biological Sciences*. Vol. 15. 2020. pp. 1-7. DOI: 10.3844/ajabssp.2020.1.7
- Adhikari, D. Joshi, S. L. Thapa, R. B. Du, J. J. Sharma, D. R. and GC, Y. D., 2019. Status and management of fruit fly in Nepal. *National Plant Protection Workshop, 2019, Hotel Le-Himalaya, Lazimpat, Kathmandu.*
- Adhikari, D., S.L. Joshi, R. B. Thapa, V. Pandit and D. R. Sharma. 2020c. Fruit fly management in Nepal: A case from the plant clinic. *Journal of Biological Control*, 2020:34(1):8-14, DOI: 10.18311/jbc/2020/22833
- Bajracharya, A.S.R., 2010. Management of citrus fruit fly *Bactrocera minax* with cover spray in sweet orange orchard. *Annual Technical Report 2065-66. Agriculture Research Station, Pakhribas, Dhankuta, Nepal. 73-74 pp.*

- Bhandari, K. Ansari, A. R. Joshi, S. L. Subedi, H. P. and Thakur, M. K., 2017. Fruit fly (Diptera Tephritidae) diversity in citrus fruits in eastern hills of Nepal. Proceedings of the Ninth National Horticulture Workshop, Nepal.
- CABI, 2020. *Bactrocera minax* (Chinese citrus fly) Datasheet. Wallingford, UK: CAB International.
- Chen, S.X. and Xie, Y.Z., 1955. Taxonomic Notes on the Chinese Citrus Fly *Tetradacus citri* Chen. Acta Entomologica Sinica , 5: 123-126.
- Dorji, K. L. Lakey, S. Chopel, S. D. and Tamang, B., 2016. Adoption of improved citrus orchard management practices: a micro study from Drujegang growers, Dagana, Bhutan. Agric & Food Secur (2016) 5:3. DOI 10.1186/s40066-016-0050-z
- Joshi, S. L., 2019. *Bactrocera minax* (Enderlein) (Diptera: Tephritidae) and its invasion in Nepal. Prime Minister Agriculture Modernization Project, Project Management Unit, Khumaltar, Lalitpur. June 13, 2019.
- Joshi, S. L. and Manandhar, D. N., 2001. Reference insects of Nepal. Entomology Division, Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal. 1-122 pp.
- MoALD, 2019/20. Statistical information on Nepalese Agriculture 2076/77 (2019/20). Ministry of Agriculture and Livestock Development, Kathmandu, Nepal.
- NCRP, 2006. Annual report. National Citrus Research Program, Paripatle, Dhankuta, Nepal.
- NCRP, 2014. Annual report. National Citrus Research Program, Paripatle, Dhankuta, Nepal.
- NCRP, 2016. Annual report. National Citrus Research Program, Paripatle, Dhankuta, Nepal.
- Parajulee, D. Kandel, A. Panta, S. and Devkota, K., 2021. Economic Analysis of Sweet Orange in Sindhuli District of Nepal. Int. J. Soc. Sc. Manage. 8(3): 396-400. DOI: 10.3126/ijssm.v8i3.38504
- Poudel, K. P. Shrestha, T. N. and Regmi, C., 2016. Citrus Research and Development in Nepal, 113-144 pp. Six Decades of Horticulture Development in Nepal. Silver Jubilee Special. Nepal Horticulture Society, Lalitpur, Nepal.
- Pokhrel, C. N., 2011. Analysis of market chain of mandarin in Nepal: A case of Lamjung district. Master's Degree Thesis in Agriculture Production Chain Management Specialization "Horticulture Chain" Van Hall Larenstein University of Applied Sciences Wageningen, The Netherlands
- Poudel, K. P. and Regmi, C., 2008. Diseases and Insects of Citrus Fruits. Nepal Agricultural Research Council. Horticulture Research Division, Khumaltar, Lalitpur, Nepal.
- Rasid, M. A. Dong, Y. A. Andongma, A. Chen, Z. Wang, Y. Xu, P. P. Li, P. Yang, Clarke, A. R. and Niu, C., 2021. The Chinese citrus fly, *Bactrocera minax* (Diptera: Tephritidae): A review of its biology, behaviour and area-wide management. In: J. Hendrichs, R. Pereira

- and M. J. B. Vreysen (eds.), Area-Wide Integrated Pest Management: Development and Field Application, pp. 143-159. CRC Press, Boca Raton, Florida, USA. © 2021 IAEA.
- Wang, X.J. and Luo, Y.L., 1995. Advanced Study on *Bactrocera minax*. Chinese Bulletin of Entomology, 32, 310-315.
- Xia, Y. Ma, X.L. Hou, B.H. and Ouyang G.C., 2018. A Review of *Bactrocera minax* (Diptera:Tephritidae) in China for the Purpose of Safeguarding. Advances in Entomology, 6: 35-61. <https://doi.org/10.4236/ae.2018.62005>.