FARMERS' KNOWLEDGE ON INSECT PESTS OF CITRUS (*Citrus reticulata*) AND THEIR MANAGEMENT IN GULMI DISTRICT OF NEPAL

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ABSTRACT

A study was carried out to assess farmers' knowledge on insect pests of citrus and Integrated Pest management in citrus zone, Gulmi district. Survey sample size of 105 was taken from Dhurkot Rural Municipality, Chatrakot Rural Municipality and Resunga Municipality of the Gulmi district. Respondents were selected using simple random sampling technique and interviewed. The primary data were collected using pretested questionnaire. The knowledge on citrus insect pest is significantly associated positively with total citrus cultivation area (p=0.1%). The average years of engagement of 23.3 years and average mandarin cultivation area of 0.35 ha gives insight to great potentiality of farmers adopting integrated pest management. The result shows insect's severity as one of the major problems with major insect pest of citrus as fruitfly, green stink bugs, white grubs, leaf miner, aphid and rent ants. Although (74.3 %) of the total respondents were found to have knowledge about term "IPM technology", only (35.2%) practiced IPM practices till date. The positive attitude and perception of citrus growers towards IPM technology in the study area depicts great scope for profitable citrus production on a sustainable basis.

Keywords: Citrus, Integrated Pest Management, Knowledge

INTRODUCTION

Fruits contribute about 7% of total Agriculture Gross Domestic Product of Nepal (MoALD, 2017). Citrus is the important cash crop for the hill farmers of Nepal contributing 26.84% of the total fresh fruits production. The total production is 2,45,176 mt. however, the average productivity is only 9.4 mt/ha. in 2017/18 (MoALD, 2019b). The history of citrus in Nepal is not well documented but commercial cultivation started only after 1970 (NCRP, 2019). At present major citrus producing district are Illam, Paanchthar, Terathum,

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Dhankuta, Bhojpur, Sindhuli, Ramechap, Kavre, Dhading, Gorkha, Lamjung, Tanahu, Kaski, Shyangja, Gulmi, Arghakhanchi, Dailekh, Dadeldhura ((Pokhrel, 2011). The production of citrus is increased by more than two folds in last decade which is mainly contributed with increase in area of production despite of the slow growing productivity. The mid-hill region of Nepal with altitude of 1000 to 1500 meter above sea level has a comparative advantage for citrus cultivation when compared to food grain crops like rice, wheat, maize and found to be more profitable (Gauchan, 1994). The data show a citrus production surplus of 3860 mt in Gulmi (DADO, 2017). Being a leading producer of citrus in the western hill of Nepal, Gulmi has managed productivity of 11.38 mt/ha (DADO, 2017).

Gulmi is located in the sub-tropical region characterized by temperature higher than 20-degree celcius (DSWASHP, 2016). Temperature is the single most important environmental factor influencing insect behavior, distribution, development, survival, and reproduction (Petzoldt & Seaman). Therefore, higher temperature in citrus zone of Gulmi favors the increase incidence of insect pest attack. Annual crop loss due to insect and vertebrate pests is estimated at 25% to 38% (Lamsal, 2016). Citrus industry suffers 25% yield loss due to ravages of insect pests (Dhawan, Singh, Bhullar, & Arora, 2013).

Potential productivity of Citrus at field condition in Gulmi district is expected to be higher than the productivity of 9.1 MT/ha which is less than national productivity of 10 MT/ha (MoALD, 2018). The improvement in citrus fruit production and quality that a grower can achieve through choice of scion/ rootstock combinations, good irrigation management, balanced nutrition and proper pruning may easily be overwhelmed by pests, diseases and other injuries (Zekri, December 2011). Therefore, the key to successful production of citrus lies in the effectiveness of long-term pathogen- and pest-management strategies. As with many tropical and subtropical crops, citrus is host to various pathogens and pests, but it is also one of the few crops that is susceptible to a number of destructive diseases that are continuously emerging and which can severely limit or totally decimate production (Paula, *et al.*, 2009).

The government has executed Prime Minister Agriculture Modernization Project where the area is divided into super zone, zone, block and pocket. Under PMAMP, Citrus Zone Gulmi was established in 2018. The zone includes six rural municipalities: Dhurkot, Kaligandaki, Chandrakot, Madane, Chhatrakot and Gulmidurbar and two municipalities: Resunga and Musikot.

INSECT PEST OF CITRUS

CITRUS LEAFMINER: *Phyllocnictis citrella* (LEPIDOPTERA: GRACILLARIDAE)
Leafminers generally feed on new growth (Paula, *et al.*, 2009). They can cause severe damage to the leaves of trees less than three years old. Established trees are less affected. Damage is usually worst when there is new flushing growth in early autumn, depending on temperature. Citrus leafminers are naturally controlled by small parasitic wasps. Damaged leaves can be pruned out but if chemical control is required spray new foliage with horticultural oil from summer to autumn (Lacey & Broughton).

CITRUS PSYLLID: *Diaphorina citri* (HEMIPTERA: LIVIIDAE)
Psyllids cause injury resulted from the withdrawal of sap from the foliage, and transmit the organisms that cause Huanglongbing (greening disease) and also produce copious amont of honey dew promoting sooty mould (UF/IFAS, 1998). Soil application of imidacloprid reduced thinfestation levels and densities of Diaphorina citri Kuwayama on flush shoots (Sétamou, *et al.*, 2010).

CITRUS WHITEFLY: *Dialeurodes citri* (HEMIPTERA: ALEYRODIDAE)
The whitefly injures the plant by consuming large quantities of sap, which it obtains with its sucking mouth parts. This black fungus may cover the leaves and fruit so completely that it interferes with the proper physiological activities of the trees. Heavily-infested trees become weak and produce small crops of insipid fruit. Also, fruit covered with sooty mold will be retarded in ripening and late in coloring, especially the upper part, which may remain green after the lower portion has assumed the color of ripe fruit (UF/IFAS, 1998).

CITRUS APHID: *Toxoptera citricida* (HEMIPTERA:APHIDIDAE)
Nymphs and adults both suck sap from tender leaves and shoots. Affected leaves turn yellow, get curled, deformed and dry up. Growth of young shoots is adversely affected. Shooty mould is produced on honeydew excreted by aphids. Aphids also act as the active vectors of Citrus Tristeza Virus (Dr.D.B.Ahuja & Dr.N.Sabir).

CITRUS OR LEMON BUTTERFLY: *Papilio demoleus* (PAPILIONIDAE:LEPIDOPTERA)
The caterpillars fed on young foliage at the nursery stage and also feed on young flushes of grown-up trees. Caterpillar feed voraciously on leaf lamina leaving behind only midrib. In case of severe infestation entire tree is defoliated (Kedar, K.M., & Bawaskar).

FRUIT FLIES: *Bactocera dorsalis* (TEPHRITIDAE:DIPTERA)
Fruit flies are one of the world's most destructive pests of most fruit and vegetable crops both in terms of production and trade (Adhikari & G.C, 2020). Fruit fly is a problem causing considerable loss in productivity of citrus and

cucurbits and management tactics include use of pheromone trap, application of chemical pesticides, and sanitation (Sharma, Adhikari, & Tiwari, 2015). Judicious use of insecticides, early harvest and removal of fallen fruits reduce fruit fly damage (Umeh, Olaniyan, & Andir, 2004). Fruit fly management tactics includes the use of pheromone trap, application of chemical pesticides and sanitation (D. R. Sharma, 2015).

SCALE INSECTS: (HEMIPTERA: COCCOIDEA)

The armoured scale damages the fruits and form blemishes at low levels of infestation and in severe cases they damage tree badly. The soft scale insects secrete honeydew on which sooty mould fungus grows (Frank, 2010).

GREEN STINK BUG (HEMIPTERA: PENTATOMIDAE)

Stink bug feeding on fruit trees can result in extensive damage, and feeding injury in the early developmental stage of the fruit results in the most damage. Feeding injury results in blemishes on the skin, yield loss, misshapen fruit, or catfacing (Kamminga, Koppel, Herbert, & Jr., 2012)

ROOT WEEVILS (COLEOPTERA: CURCULIONIDAE)

Adults feed on buds and young leaves. Damage to the root system of citrus plants by the larvae of the citrus root weevil usually results in reduced water and nutrient flow, which often causes wilting of the plant and subsequent reduction in fruit size (Paula, *et al*., 2009).

INTEGRATED PEST MANAGEMENT IN CITRUS

IPM is an approach which assess the pest situation, evaluates the merits of pest management options and then implements a system of complementary management actions within a defined area (H.S.Abd, De, & Jirli, 2015).

Cultural method

Cultural practices include those practices that reduce pest establishment, reproduction, dispersal and survival by using healthy production practices. It includes practices like field sanitation, crop rotation, mixed cropping, intercropping, use of pure seed, deep ploughing, use of recommended spacing, fertilizer dose, appropriate method of irrigation etc. It includes summer deep ploughing to expose soil inhabiting stages of insect, pathogen and nematode population. Only certified seeds and resistant rootstocks should be used. IPM package also recommends use of *Trichoderma* spp with organic matters to improve soil health and management of certain soil borne disease. For the management of citrus white fly and scaly bug intermingling branches should be pruned and spacing trees at closed distances should be avoided so that sunlight can reach through the canopy from all sides (Ragunathan, 2001).

Mechanical method

Mechanical methods comprise of the direct action of killing the pests or blocking the entry of the pests to the crop of interest. It includes the practices like hand picking and killing, rouging, pit digging, use of dummy, light traps, pheromone traps etc. Installation of light trap can be done to attract and kill the insects such as borers, bugs, beetles, whitefly, fruit fly etc. Spraying of 2% starch is recommended in souty mould affected orchard (Ragunathan, 2001)

Biological method

Biological method uses the natural enemies such as parasites, predators, pathogens and competitors to control pests and their damage.

- Conservation
  Conserve predators viz., *Amblyscius tetranychivorus, Chrysoperla carnea, coccinellids, Cryptolaemus montrouzieri, Mallada boninsis Menochilus sexmaculatus,* spiders and parasitoids viz., *Apanteles, Aphytes proclia Leptomastix dactylopii* etc.
- Augmentation
  Monitor the incidence of citrus black/white flies and aphids and release 10-15 eggs or first instar larvae *of Chrysoperla* or *Mallada* per plant. Avoid spraying with insecticides for at least one week after the release of bio-control agents (Ragunathan, 2001).

Chemical Method

Need based, judicious and safe applications of pesticides are the most vital triplicate segments of chemical control measures under the ambit of IPM. It involves developing IPM skills to play safe with environment by proper crop health monitoring, observing ETL and conserving natural biocontrol potential before deciding in favour of use of chemical pesticides as a last resort (Ragunathan, 2001).

Systemic and contact chemical insecticides are used to kill insects according to their feeding habit. Commonly used chemical pesticides are Malathion, Dichlrovos, Immidachloropid, Chloropyrifos which are sold in different trade names (Ragunathan, 2001).

Legislative method

Legislative method includes phyto-sanitary and quarantine measures to control the arrival of new insect pests from another infested area to the area for the interest.

This research is an attempt to picture the knowledge level of farmers regarding the insect pests of mandarin and their management practices which would help concerned stakeholders and institutions to run insect pest management technology feasible in this region. The major objective of this

study was to assess farmer's knowledge on insect pests of citrus and their management in Gulmi Specific objectives:

1. To assess various socio-demographic condition and citrus production status of citrus growers in Gulmi
2. To find out the knowledge of farmers on insect pest and analyze their relationship with various attributes of socio-demographic characters. Rape seed production,
3. To identify major citrus production constraints in Gulmi
4. To identify major insect pest of citrus in Gulmi
5. To find out the knowledge and perception of farmers on the application of IPM practices in citrus cultivation.

METHODOLOGY

SELECTION OF SITE

Gulmi is located in mid hill area of western region, province 5 surrounded by Palpa, Argakhanchi, Baglung, Parbat and Pyuthan. The area of this district is 1149 square kilometer. The district is at an altitude range of less than 1000 masl and greater than 2000 masl. The mean annual temperature ranges from 0 degree Celcius to more than 20 degree celcius (DSWASHP, 2016). Gulmi is leading district for citrus production in western hill of Nepal. It has total area of 1543 ha of citrus cultivation which majorly include mandarin, sweet orange, and lime, a productive area of 843 ha with production of 9695 Metric ton and yield of 12 Mt/ha (DADO, 2017). This study was conducted in citrus zone area of Chatrakot Rural Municipality, Resunga Municipality and Dhurkot Rural Municipality of Gulmi district, a potential area for mandarin production as prioritized as zone by PMAMP project.in year 2020. The selection was based on high citrus production and farmer's engagement in citrus cultivation and orchard management.

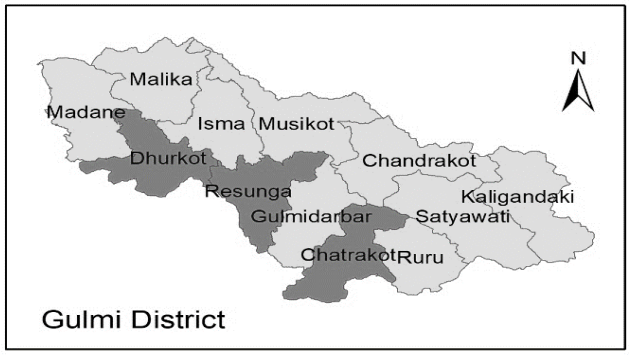

Figure 1: Study site for field survey at Gulmi District

SELECTION OF POPULATION AND SAMPLE

Sampling framework of households was prepared from preliminary field visit and data of citrus zone profile obtained from the Project Implementation Unit, Gulmi office. A total of 105 sample households were drawn from the sampling frame prepared by citrus zone using simple random sampling technique. The sampling was done using random number table in Microsoft Excel 2015. The number of the household to be surveyed is decided by using Raosoft sample size calculator, using following information:

Total number of households (Population size): 3000
Confidence level: 90%
Margin of error: 10%
Response distribution: 50%

RESEARCH DESIGN

Preliminary field visits

Preliminary field visits were conducted prior to the survey to collect information about the farming techniques, socio-cultural settings, demographic and topographic features of the study area. Five households and its citrus orchard from each municipality were visited randomly. The information collected was used while preparing the interview schedules, designing sampling framework and applying sampling techniques.

Key Informant Interview (KII)

A total of 10 concerned stakeholders like progressive farmers, members of the executive operating committee of the citrus zone, local leaders and members of the community-based organizations, etc. were selected as key informants of citrus production in the study area. The first-hand knowledge of citrus production and use of management practices to control insect pest of citrus was used for the purpose of verifying the information obtained from the household survey.

Focus Group Discussions (FGDs)

Three focus group discussion was conducted with representatives of farmers' groups and and other progressive farmers of the three municipality of citrus zone. It was conducted before designing the questionnaires to know the scenario of Integrated Pest Management adopted by farmers for various insect pest. The information was used to design questionnaire for the study.

PRE-TESTING OF QUESTIONNAIRES

The questionnaire was pre-tested before field survey for checking the reliability and validity and then necessary adjustment were made as per the requirements after administering the questionnaire to the 5% farmers of vicinity area.

QUESTIONNAIRE SURVEY

A questionnaire survey was conducted among respondents with questions seeking socio-demographic information, production status, major constraints in citrus production, and knowledge on insect pest, integrated pest management and other related information from citrus growing farmers.

SOURCES OF INFORMATION

PRIMARY DATA

Primary data was collected using research designs; questionnaire survey, focus group discussion, key informant interview and field visits. The primary method was used to collect the data and share experience and knowledge of the community.

SECONDARY DATA

Different secondary sources of data as given below were reviewed during the study for relevant information.

i. Documents and publications of MOAD, AICC, NPC, NARC, PM-AMP for area, production and productivity data.
ii. Reports and publications of various concerned NGO's and INGO's like FAO for insect pest of citrus and their management technique
iii. Journal articles of AFU, TU and other reputed national and international universities and journals

DATA ANALYSIS TECHNIQUES

The data were analyzed using Statistical Package for Social Science (SPSS) version 25, Microsoft excel 2015.

Following statistical measures were used for the data analysis

a. Frequency and percentage
b. Correlation
c. Scaling technique
    - Scale of Importance
    - Likert scale for measuring perception

SCALING TECHNIQUE

Scale of Importance

Constraints were assessed by group discussion. Respondents were asked to rank the problems in mandarin cultivation and reasons with most significant reasons followed by less significant ones. As well as they were asked to rank insects based on its severity. The data was collected and based on it, frequencies and weighted index were calculated accordingly. The reasons were ranked by using seven-point scales for problems in mandarin cultivation

and nine-point scales in insect severity. Scale value of 0.85, 0.7, 0.56, 0.42, 0.27, 0.13 and 0.012 was given to most important reasons followed by less significant for problems in mandarin cultivation. Scale value of0.89, 0.79, 0.66, 0.55, 0.44, 0.33, 0.22, 0.1 was given to most important reasons followed by less significant for insect severity. The index of importance was computed by using following formula;

- I_{imp} =$\sum\frac{SiFi}{N}$

Where I_{imp}= Index of importance

∑= Summation

S_i= i_{th}scale value

F_i= Frequency of i_{th} importance given by respondent

N= total number of respondents

Likert scale for measuring perception

Respondents were given six statements about the IPM practice and were asked to answer in five terms as strongly agree-5, agree-4, neutral-3, disagree-2 and strongly disagree-1 with code value as 5 type likert scale. The data was collected and based on it, frequencies, percentage and standard deviation were calculated accordingly. The standard deviation data corresponds to the code value and determine the perception in five above mentioned terms.

VARIABLES AND THEIR MANAGEMENT

INDEPENDENT VARIABLES

The selected socio-demographic and production status like 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 size, years of engagement in citrus production and productivity were divided into three categories for each variable using the following method.

Table 6: 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.

DEPENDENT VARIABLES

Knowledge and perception on insect pest and their management by farmers were taken as the primary dependent variable.

RESULTS AND DISCUSSION

SOCIO DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Distribution of Respondents by Gender, Age, Ethnicity and Religion

The study conducted on study area showed different data than district average with male higher (68.6 percent) and female lower (31.4 percent). However, 57 percent female and 43 percent male reside in Gulmi district (CBS, 2011). The average age of respondents was 47.28 years. Two types of religions: Hindu religion (98.1 percent) and Buddhism religion (1.9percent). The district profile also shows Hinduism (97 percent) as a major religion while Buddhism is followed by 3 percent (NepalMap, 2011). The study conducted on study area showed that majority of the respondents (48.6 percent) in the study area were Bhramin followed by Chhetri (39.4 percent), Dalit (6.7 percent) and Janjati (5.7 percent). However, the district profile shows Bhramin (25%), Chhetri (23%), Janjati (23%) and Dalit (26%) and others (3%) (NepalMap, 2011).

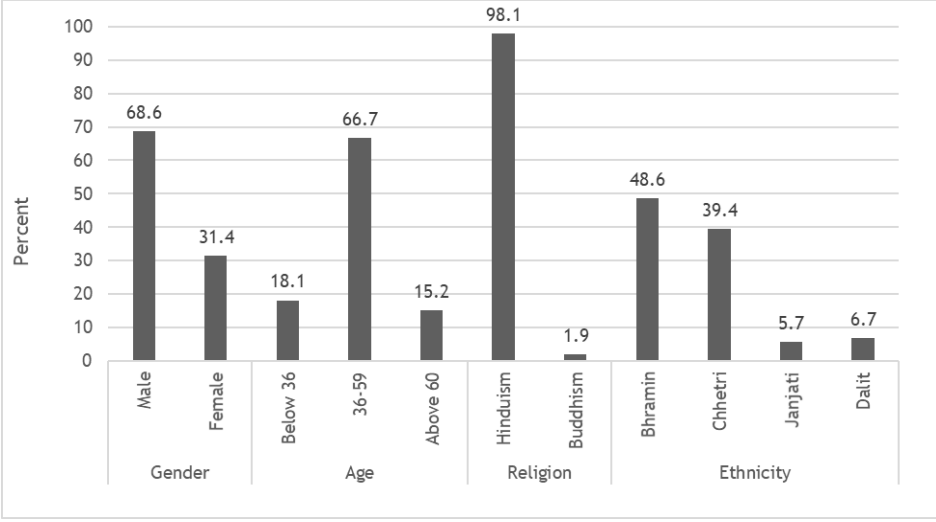

Figure 1. Distribution of respondents by gender, age, religion and ethnicity

Distribution of respondents by family size, level of education, main occupation and type of agriculture

The average family size in the study area is 5.87 whereas the district profile shows the average family size as 4.32 (NepalMap, 2011).

The study showed that majority of the respondents (32.4 percent) acquired certificate level education followed by primary level education (23.8

percent), secondary level education (21.9 percent), no education or illiterate (18.1 percent) and few (3.8 percent) acquired university level. The result shows the education level different than district education level as primary (41 percent), secondary (21 percent), certificate level (10%) and university (1%) (NepalMap, 2011).

The study showed that the major occupation of the respondents of the study site was agriculture (61 percent). The second major occupation in the study site was service (24.8 percent) followed by trade (17.1 percent). The agricultural sector provides employment opportunities to 65.6% of the total population of Nepal (AICC, 2019). This shows less adoption of agriculture as main occupation than the national data.

The study showed that type of agriculture adopted by most of the respondent is semi commercial (34.3 percent) and subsistence (34.3 percent) whereas (31.4 percent) of total respondent adopted commercial agriculture. This shows that people in the study site adopt all three types of agriculture nearly in the equal ratio.

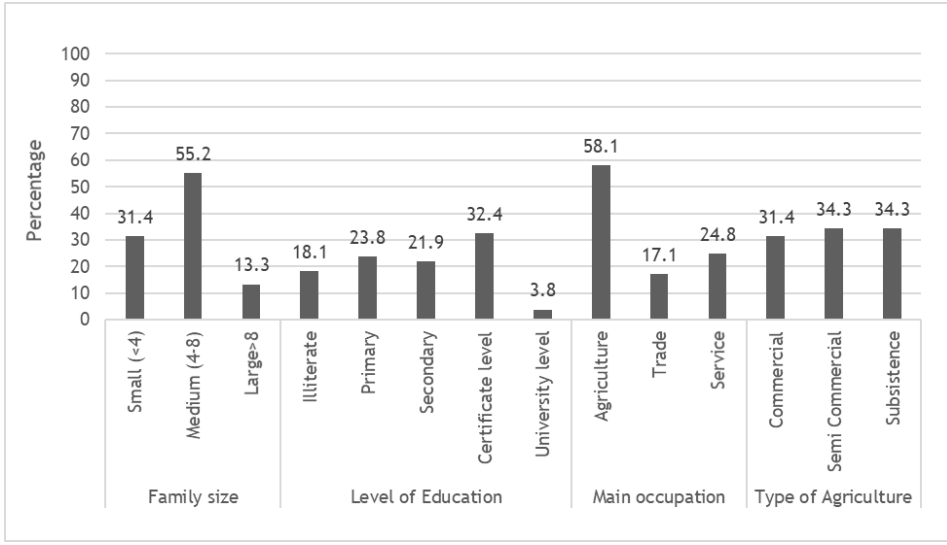

Figure 2. Distribution of respondents by family size, level of education, main occupation and type of agriculture

MANDARIN CULTIVATION STATUS

YEARS OF ENGAGEMENT IN CITRUS CULTIVATION

Results indicated that most of the respondents (64.8 percent) were engaged in mandarin cultivation for 26 years followed by engaged for less than 10 years (19 percent) and for more than 37 years (16.2 percent).

Table 1: Distribution of respondents by years of engagement in mandarin Cultivation in Gulmi district (2020)

Years engaged in Mandarin Cultivation	Frequency	Percent
Less than 10	20	19
26	68	64.8
More than 37	17	16.2
Total	105	100
Mean		23.3
Std. deviation		13.50

The average years of engagement in mandarin cultivation from field survey was 23 years.

Distribution of respondents by Mandarin cultivation area

The distribution of mandarin cultivation area of respondents was categorized into three groups as small, medium and large by using mean and standard deviation. Small size mandarin cultivation area consists of less than 0.01 ha of land; medium size farm (0.01-0.69) ha and large size farm more than 0.69 ha of land. The study showed that majority of the respondents owned medium size mandarin cultivation area (85.7 percentage) followed by large (percentage).

Farm size does have an effect on technology adoption (Urquhart, 1999). On the one hand, the intensity of management required for IPM is easier to attain on a smaller farm (Urquhart, 1999). Larger farms (of around 6000ha) in general tend to be more chemically-oriented in their approach (Urquhart, 1999). However, larger farms generally also have more resources available to implement biological control measures, although intensive management is more complicated because of their size (Urquhart, 1999).

Table 2. Distribution of respondents by mandarin cultivation area in Gulmi district (2020)

Mandarin Cultivation area (In hectare)	Frequency	Percent
>0.01 to <0.69	90	85.7
More than 0.69	15	14.3
Total	105	100
Mean		0.35
Std. Deviation		0.34

The result indicated that eighty six percent respondents had medium size land holding. The average size of mandarin cultivation area of respondents was 0.35 hectare.

PRODUCTIVITY OF MANDARIN IN THE STUDY AREA

The study showed that majority of the respondents (77.1 percent) had moderate productivity followed by high productivity (17.1 percent) and low productivity (5.7 percent). The average productivity of mandarin in the study site was 6.83 mt/ha. The average productivity of mandarin in Gulmi district is 11.38 mt/ha (DADO, 2017). This shows that the productivity of study site is less than the district's productivity.

Table 3: Distribution of respondents according to the productivity of mandarin in Gulmi district

Mandarin productivity (Mt/ha)	Frequency	Percent
Low (up to 0.23)	6	5.7
Moderate (0.23-13.46)	81	77.1
High (13.46)	18	17.1
Total	105	100
Mean		6.83 Mt/ha
Standard deviation		6.62 Mt/ha

Constraints in Mandarin production

The eight most important constraints faced by the respondents in mandarin production were insect severity of fruit fly, white grubs, red ants, green stink bugs and disease severity of root rot, citrus greening, shooty mould, lack of proper fertilization and manuring, lack of irrigation facility, higher wages, severe fruit drop and hailstones impact as shown in table. Table indicates that insect's severity was the major problem as obtained from field survey followed by disease severity and lack of irrigation facility. While hailstones impact being the least problem.

Table 4: Ranking of mandarin production constraints in Gulmi district

Problems	Rank	Index	Weighted Mean
Insect severity	I	0.895	94
Disease severity	II	0.672	70.571
lack of proper fertilization and manuring	VI	0.234	24.665
Lack of Irrigation facility	III	0.413	43.368
Higher wages	IV	0.350	46.788
Severe Fruit drop	V	0.309	32.499
Hailstones Impact	VII	0.227	23.91

FARMER'S KNOWLEDGE IN INSECT PEST OF CITRUS

KNOWLEDGE ON IDENTIFICATION OF HARMFUL AND BENEFICIAL INSECT

During the study five each of harmful insects: Citrus leafminer (*Phyllocnictis Citrella*), Citrus butterfly (*Papilio demoleus*), Fruit flies (*Bactocera dorsalis*), Green stink bug, White grubs and beneficial insects: Ladybird beetle (*Coccinella septumpunctata*), Ground Beetle, Syrphid Fly, Tiger Beetle and

Spider were shown to respondents. Respondents identifying more than three insects each of harmful and beneficial were considered able to identify them. The majority of the respondents (75.2 percent) were able to identify the harmful insects while rest of 24.8 percent respondents were unable to identify harmful insects. Whereas 53.3 percent respondents could identify the beneficial insects and 46.7 percent of the respondents could not identify the beneficial insect. This data shows that majority of the respondents had knowledge to identify the insects and pest.

KNOWLEDGE ON IDENTIFICATION OF MANDARIN INSECT PESTS DAMAGE SYMPTOMS

The study showed that 56.2 percent of the respondents could identify insect pest damage symptoms in mandarin while rests of 43.8 percent were unable to identify insect wise damage symptoms in Mandarin. This data shows that majority of the mandarin growing farmers of this study site are well acquainted with the mandarin insect pest damage symptoms of mandarin

Table 5: Knowledge on identification of insect pests and their damage and symptoms

Knowledge on Insects Pest	Coef.			Std. Err
	Harmful Insects	Beneficial Insects	Symptoms and Damage	
Age	0.174	0.174	0.260	1.925
Sex	-0.267	-0.466**	-0.540**	0.079
Ethnicity	-0.358**	-0.03	0.023	0.106
Religion	0.111	0.098	0.097	0.025
Family size	0.88	0.191	0.162	0.104
Education level	0.136	0.255	0.165	0.190
Main Occupation	0.123	-0.147	-0.163	0.128
Types of agriculture	-0.276	-0.527**	-0.552**	0.121
Years of engagement in citrus cultivation	0.280	0.240	0.193	2.333
Total citrus cultivation area	0.227	0.289	0.329*	1.206
Productivity	0.256	0.214	0.218	797.683

The knowledge on harmful insect of citrus orchard is positively influenced by age, religion, family size, education level, main occupation, years of engagement in citrus cultivation, total citrus cultivation area and productivity while negatively influenced due gender, ethnicity, types of agriculture followed by respondents. The knowledge on harmful insects of citrus orchard

is negatively influenced with ethnicity of respondents is found significant at 5% level of significance

The knowledge on beneficial insect of citrus orchard is positively influenced by age, religion, family size, education level, years of engagement in citrus cultivation, total citrus cultivation area and productivity while negatively influenced due gender, ethnicity, main occupation and types of agriculture followed by respondents. The knowledge on beneficial insects of citrus orchard is negatively influenced with gender and types of agriculture which is found significant at 5% level of significance.

The knowledge on damage and symptoms of citrus insect pest infestation in orchard is positively influenced by age, religion, ethnicity, family size, education level, years of engagement in citrus cultivation, total citrus cultivation area and productivity while negatively influenced due gender, main occupation and types of agriculture followed by respondents. The knowledge on damage and symptoms of citrus insect pest infestation of citrus orchard is negatively influenced with gender and types of agriculture which is found significant at 5% level of significance. Whereas, the knowledge on damage and symptoms of citrus insect pest infestation of citrus orchard is positively influenced with total citrus cultivation area which is found significant at 10% level of significance which must be due to larger the cultivation area more the farmers are likely to get acquainted with damage and symptoms of insect pest

MAJOR MANDARIN INSECT PESTS OF THE STUDY AREA

The major insect pest found in the study area are fruitfly, green stink bugs, white grubs, leaf miner, aphid and rent ants. The minor insect pest found were thrips, scale insects and citrus tem borer Respondents ranked fruit fly as the first and green stink bugs as the second most detrimental insect pests on mandarin field as shown in table. These were closely followed in rank by white grubs, leaf miner, aphid, red ants in descending order. Other insect pests included thrips, scale insects and least ranked being citrus stem borer. This is different from in case of Mediterranean countries as reported by survey of the situation of citrus pest management on Mediterranean countries. Major key-pests, i.e., reported as key-pests in at least 50% of the countries, include the medfly (*Ceratitis capitata)*, the citrus red scale (*Aonidiella aurantia*) the citrus leafminer (*Phyllocnistis citrella)* and the citrus mealybug (*Planococcus citri)* (Franco, Garcia-mari, Ramos, & Besri, 2006).

Table 6: Ranking of mandarin insect pests by respondents in Gulmi district (2020)

Insects	Rank	Index	Weighted Mean
Fruit Fly	I	0.775	81.43
Green stink Bugs	II	0.665	69.83
Leaf Miner	IV	0.494	51.93
White Grubs	III	0.658	69.1
Scale Insects	VIII	0.199	28.52
Aphid	V	0.487	51.19
Thrips	VII	0.227	20.98
Citrus stem borer	IX	0.021	2.26
Red ants	VI	0.396	41.59

KNOWLEDGE AND ADOPTION OF INTEGRATED MANAGEMENT OF INSECTS PEST OF CITRUS

KNOWLEDGE AND ADOPTION OF CULTURAL PRACTICES

It was observed from the study that majority of respondents adopted the cultural practices like sanitation (90.48 percent) and training and pruning (89.5 percent). The other cultural practices mostly followed were intercropping with leguminous crops like beans, soyabeans and peas (61.9 percent), timely irrigation and manuring (61 percent). Few of the respondents were found to follow summer ploughing (32.4 %), proper spacing and pit dimension (26.7%) and growing attractant plants like marigold and sunflower (24.8%). While very few used resistant stock; *Trifoliata Orange* (*Poncirus trifoliata*) (2.9 %). This is different than the study where 54% of the citrus farmers used certified sour orange rootstocks in Morrocco (Lahlali, Jaouad, Moinina, & Belabess, 2021).

Table 7: Adoption status of cultural practices to control mandarin insect pests in Gulmi district (2020)

Cultural practices	Yes	No
Sanitation	95(90.48)	10(9.52)
Training and pruning	94(89.5)	11(10.5)
Intercropping with leguminous crops	65(61.9)	40(38.1)
Timely Irrigation and Manuring	64(61)	41(39)
Summer Ploughing	34(32.4)	71(67.6)
Proper spacing (4 meter) and Pit Dimension (1*1*1 cube meter)	28(26.7)	77(73.3)
Timely Irrigation and Manuring	64(61)	41(39)
Growing attractant plants	26(24.8)	79(75.2)
Use of Resistant stock	3(2.9)	102(97.1)

KNOWLEDGE AND ADOPTION OF MECHANICAL PRACTICES

The study showed that about 88.6 percent of respondent adopted mechanical practices. The mostly used mechanical practice to control citrus insect pest was hand picking and removal of fallen fruits infected by fruit fly (84.8 percent). Whereas very few adopted other mechanical practices like use of protein bait of 1 kilogram of local jaggery, pumpkin with 5 ml of malathion for fruit fly (16.2 percent), use of pheromone traps (9.5 percent), use of sticky traps (7.6 percent) and only (1 percent) used light traps among the total respondents. The result reveals the poor use of mechanical practices to control insect pest because of unfamiliarity of practices and use of such practices.

Table 8: Adoption status of mechanical practices to control mandarin insect pests in Gulmi district (2020)

Mechanical practices	Yes	No
Hand Picking and Removal of fallen fruits infected with insects	89 (84.8)	16(15.2)
Use of Light traps	1(1)	104(99)
Yellow Sticky traps	8(7.6)	97(92.4)
Use of Protein Bait	17(16.2)	88(83.8)
Use of Pheromone Traps	10(9.5)	95(90.5)

KNOWLEDGE AND ADOPTION OF PHYSICAL PRACTICES

The study showed that 63 percent of the respondents practiced burning of old infected trees whereas only 4 percent of the respondents practiced moisture maintenance in orchard. It has been seen that almost all of the respondents do not have knowledge of physical practices like maintaining temperature and moisture in order to control insects. However, some performed such practice without knowing the benefits of them.

Table 9: Adoption status of mechanical practices to control mandarin insect pests in Gulmi district (2020)

Physical Practices	Yes	No
Burning of old Infected Trees	63 (60)	42(40)
Moisture Maintenance in Orchard	4(3.8)	101(96.2)

KNOWLEDGE AND ADOPTION OF BOTANICAL PRACTICES

The study showed that 38.1 percentage of respondents adopted Botanical practices whereas 61.9 percentage of respondents did not adopt any botanical practices. The data in the table shows the moderate adoption of botanical practices to control mandarin insect pests in the study area.

Majority of the respondents (92.5 percentage) adopted local practices like spraying cow urine around the mandarin trees, using ash to control insect pests, using smoke from the firewood used for cooking feed for cows and buffaloes to control insect pest and applying *Titepate (Artemesia dubia)* and *Asuro* (*Justicia adhatoda)* as mulch to control insect pest of citrus.

(82.5 percent of the respondents used bio pesticides like EM, a microbial consortium, and 35 percent respondents used bio-fertilizers like *Jholmol* for insect pest control.

Whereas only 27.5 percent of the respondents conserved natural enemies like pollinators by discarding the application of chemicals and protecting their nest.

Environmental benefits of a switch from chemical to biological pest management are well known and have served as a major stimulus for the development of IPM technology. They include reduced pesticide pollution of land and water, improved functioning of ecosystems, and reduced effects on land and aquatic fauna (Urquhart, 1999)

Table 10: Adoption status of biological practices to control mandarin insect pests in Gulmi district (2020)

Biological practices	Yes	No
Bio-pesticides	33(82.5)	7(17.5)
Bio-fertilizers	14(35)	26(65)
Conservation of natural enemies	11(27.5)	29(72.5)
Local practices	37(92.5)	3(7.5)

KNOWLEDGE AND ADOPTION OF CHEMICAL PRACTICES

THE STUDY SHOWED THAT ONLY 28.6 PERCENTAGE OF TOTAL RESPONDENTS ADOPT CHEMICAL METHOD FOR CONTROL OF INSECT PESTS.

Frequency of application

The study showed that most of the mandarin growers (93.3 percent) of those who adopt chemical method to control insect pest in the study site applied pesticide only at the time of insect attack and 3.3 percent of the respondents applied pesticides once a year and 3.3 percent of the respondent applied pesticides twice a year. This shows the less use of the pesticide in the study site.

Table 11: Frequency of application of chemical pesticides in Gulmi district (2020)

Pesticide application	Frequency	Percent
Once a Year	1	3.3
Twice a Year	1	3.3
At the time of insect attack (June-September)	28	93.3
Total	30	100

Protective wearing

The research revealed that none of the applicators followed all the recommended safety measures which have shown that higher number of farmers is exposed to the pesticide risks and health hazards. All of the respondents used sandals while none used spectacles. Whereas (43.33 percent) used masks, 30 percent used boots, 26.67 percent used gloves and only 16.67 percent used coverall as protecting wearing against pesticide use.

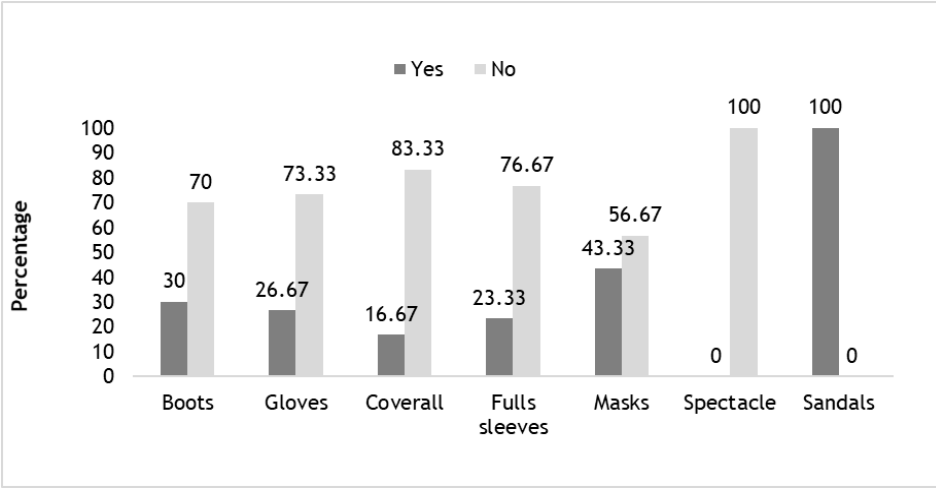

Figure 1. Use of protective wears during pesticide application in Gulmi.

Source: Field Survey 2020

Safety Measures

The field survey showed that majority of the respondent does not follow basic safety measures. 63.33 percent of the respondent shower after each spray and 86.67 percent of respondents change cloth after spray. While only 26.67 of the respondents watch label before spray. Whereas 80 percent of the respondents practice Unhealthy practices such as reuse of the containers and 20 % of the respondents consume while spraying. This showed the poor practice in pesticides handling and ignorance in following safety measures while pesticide application.

Table 12: Safety Measure followed by respondents while pesticide application in Gulmi district (2020)

Safety measures	Yes	No
Consume while spraying	6(20)	24(80)
Shower after each spray	19(63.33)	11(36.67)
Change cloth after spray	26(86.67)	4(13.33)
Reuse container	24(80)	6(20)
Watch label before spray	8(26.67)	22(73.33)

Figures in parenthesis indicate percentage

Knowledge on pesticide hazard

It was observed from the research that all respondents who use chemical methods were aware of the health hazards and environment hazards. Most of the farmers experienced health hazards like vomiting, headache, fever, dizziness, skin rashes, shortness in breath and allergies. The environmental hazards as faced by respondents were water contamination, loss in population of beneficial insects like honey bee and so on.

KNOWLEDGE ON IPM

INFORMATION ON IPM

The study showed that 74.3 percent of the respondents had heard about the IPM while 25.7 percent of the respondents had not heard about IPM. Majority of the respondents (75.6 percent) knew IPM from fellow farmers, 10.3 percent of respondents knew from leader farmers, 7.7 percent of respondents knew from relatives and rest 6.4 percent knew from different media.

Table 13: Source of information on IPM received by respondents in Gulmi district (2020)

Source of information on IPM	Frequency	Percent
Fellow farmers	59	75.6
Relatives	6	7.7
Media	5	6.4
Technicians	8	10.3
Total	78	100

TRAINING ON IPM

The study showed that (40 percent) respondents had taken training on IPM while rest of 60 percent of respondents had not taken any training on IPM. Almost everyone who had taken training on IPM is by project organized by Food and Agriculture Organization of United States.

ADOPTION STATUS OF IPM

The survey showed that 35.2 percent practice IPM strategies whereas 64.8 percent of respondents did not practice IPM strategies. The major reason behind less adoption were found to be complex strategies, poor excess to trainings and higher IPM input costs. Likewise, survey on the situation of citrus pest management in Mediterranean finds that the complex IPM strategies, the increased risk, the production costs, the lack of effective alternative tactics to pesticides and the lack of accurate and practical pest monitoring methods were among the considered major problems/constrains for the development of citrus IPM in Mediterranean countries (Franco, Garcia-mari, Ramos, & Besri, 2006). Majority of the respondents (90.5 percent) think that IPM practices are relevant and effective while only 9.5 percent think that IPM practices are not relevant and effective.

PERCEPTION ON IPM

Respondents were given several statements about IPM as:

Statement 1: Following IPM practices is efficient in reducing pest infestation.

Statement 2: IPM protects environment and maintains balanced ecosystem.

Statement 3: IPM increases farmers income and reduce the cost in buying pesticides.

Statement 4: IPM produces quality fruit with no chemical residue.

Statement 5: IPM practices are difficult and time and energy consuming.

Statement 6: IPM practices require more resources.

Table 15: Respondent's degree of perception on various statement of IPM

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	Mean1	Mean2	St Deviation
1	43%	43%	4%	10%	1%	4.17	18.30	3.76
2	64%	26%	6%	5%	0%	4.49	20.77	4.04
3	16%	39%	31%	13%	0%	3.58	13.66	3.17
4	29%	61%	10%	0%	0%	4.18	17.84	3.70
5	17%	39%	30%	13%	0%	3.60	13.81	3.20
6	8%	65%	26%	2%	0%	3.78	14.66	3.3

The standard deviation is more inclined towards code value 3.2 to 4.04 that represents neutral to agree side of statement. The agreement on statement shows the positive perception of farmers towards the statements.

CONCLUSION

The knowledge of insect pest of citrus is greatly affected by the citrus cultivation area of farmers because farmer is more likely to get acquainted with types of insects and their damage symptoms in larger area than smaller area. The average years of engagement of 23.3 years and average mandarin cultivation area of 0.35 ha gives insight to great potentiality of farmers adopting integrated pest management. It is because, based on local experience and the intensity of management IPM is much easier to attain on a smaller farm. This study concludes that insect severity is one of the prominent factors that affect the citrus production significantly whereas fruitfly (*Bactocera dorsalis)* is more prominent in terms of infestation in Gulmi. Other major insect pest of citrus in the study area includes green stink bugs, white grubs, leaf miner, aphid and rent ants. (74.3 %) of the total respondents were found to have knowledge about term "IPM technology" but only (35.2%) practiced IPM practices till date. Although the knowledge among c growing citrus farmers on the insect pest of citrus was found to be satisfactory, there is immaculate need of knowledge on IPM technology. Use of improved varieties, propagation by grafting using *Trifoliate* rootstock, use of pheromone trap, protein bait that has been less applied in the field should be enhanced by making the IPM inputs easily available. Farmers should be encouraged to substitute chemical practices by integration of cultural practices like proper spacing and pit dimension and use of grafted plants and biological practices like use of biopesticides *Beauveria* spp. and *Metarhizium* spp with various awareness programs, demonstration programs through FFS. The positive attitude and perception of citrus growers towards IPM technology found through this research depicts great scope of application of IPM technology in increasing production on a sustainable basis.

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