Prithvi Journal of Research and Innovation
[A Peer-Reviewed, Open Access Multidisciplinary Bilingual Journal; Indexed in NepJOL]
ISSN 2705-4888 [Print]; ISSN 2705-4896 [Online]; JPPS Star-Rated Journal
Volume 3; 15 December 2021; pp. 33-43
eJournal Site: http://ejournals.pncampus.edu.np/ejournals/pjri/

---------- *ORIGINAL RESEARCH ARTICLE*

Insect Pest Management of Vegetables in Pocket Areas of Modi Rural Municipality, Parbat

Prem Raj Gautam[1]
Som Sharma[2]
[1,2]Department of Zoology, Prithvi Narayan Campus, Pokhara

Article History:
Submitted 13 October 2021
Reviewed 19 November 2021
Accepted 13 December 2021

Corresponding Author:
Som Sharma
Email: lamichahane1987@gmail.com

Article DOI:
https://doi.org/10.3126/pjri.v3i1.41630

Publisher:
Centre for Research and Innovation
Prithvi Narayan Campus
Tribhuvan University
Pokhara, Nepal
[Accredited by UGC, Nepal]

Tel.: +977-61-576837
Email: research@pncampus.edu.np
URL: www.pncampus.edu.np

ABSTRACT

Modi Rural Municipality is one of the commercial vegetable pocket areas under temperate climate. A study was carried out during July 2021 in three vegetable growing areas: Tilahar, Deupur and Bajung of Modi Rural Municipality. A total number of nine quadrates (10×10) m^2 were laid, including three replicating quadrates in each area with 500m differences from each quadrates in the sampling site. Overall, 18 farmers were interviewed to collect information about vegetables grown, insect pests that affected vegetables and their management practices. The total number of 24 insect pests were recorded belonging to five orders from 14 vegetable crops. Greater Sorensen's similarity index of insects was recorded in Tilahar and Deupur (ß=0.52) because there was similarity in environment, habitats, larval host plants and visiting plants of insects. Lower Sorensen's similarity index (ß=0.25) was recorded in Deupur and Bajung as there was less similarity in environment, habitats, larval host plants and visiting plants of insects. Insect pests and diseases on vegetables were the major problems in the study areas. The use of chemical insecticides was the means to control adopted by most of farmers while a few of them used other control methods. Insecticides on pests were applied considering fewer precautions. The study clearly indicated that the farmer's knowledge towards Integrated Pest Management (IPM) was null and thus necessary action should be taken by concerned agencies to increase rate of vegetable production, avoid the heavy use of chemicals and allied consequences.

KEYWORDS: Vegetables, Insecticides, Consequences, IPM

INTRODUCTION

Agriculture is the mainstay of Nepali people and its contribution has significant in national GDP as farmers and their agribusiness management share a viable source in the national economy. Out of 39.48% National Gross Domestic Product (CBS, 2004), horticultural crops contribute 13% with the contribution of 7.2% by vegetable crops in national economy (Thapa, 1999). Vegetable crops are efficient to generate cash even from a small plot of land in a short period of time and helps farmers to improve their livelihood (Gurung et al., 2016). Vegetables are considered as an important supplementary source of food, nutrition and economy for small to highly commercial farmers. The major factors responsible for expansion of fresh vegetable cultivation areas in and around the periphery of urban areas of the country are road accessibility, irrigation facility and good market prospect (Giri et al., 2004).

Pest is an all-harmful organism including weeds, plant pathogenic fungi and viruses that attack cultivated plants and their products. They damage the vegetables and cause heavy loss of economy. Common insect pests of vegetables are grasshopper, fruit flies, caterpillar, beetle, etc. (Alam, 1969). Pest and disease may be soil-borne or airborne and can be crop-specific or generic, so the range of potential control measures is huge (Nicholos & Hilmi, 2009). Some of the insect pests of vegetable crops become major and are gradually attaining the major pest status in different regions of the country due to changes in the ecosystem and habitats (Thapa, 1993).

Farmers use pesticides mainly on the crops like potato, tomato, cauliflower, brinjal, chilli, bean, bitter guard, etc. for controlling various insect pests (Neupane, 2003) and diseases (Shrestha, 1996). More than 150 chemical pesticides are used in Nepal (Thapa, 1997). Organochlorines, Organophosphates, Nitrochlorophenols and Pyrethroids are commonly used insecticides (Thapa, 1997). There are 324 species of plants having pesticidal properties (Rai, 2004). Neupane (2000) reported 23 species of plants with special pesticidal value in Asian farming system. Neem (Azadirachta indica), banmara (Eupatorium odoratum), dungri phool (Lantana sp.), tobacco (Nicotiana tobaccum), gandhejahar (Ageratum sp.) are some of the examples which could be used in the control on insects. Locally available chemicals such as sulfur, arsenic, wood ash, and plant extracts were used on the crops to deter pests; many of which are still used in underdeveloped countries (Gaines 1957, Banjo et al., 2003). More than 150 chemical pesticides are used in Nepal (Thapa, 1997). Organochlorines, Organophosphates, Nitrochlorophenols and Pyrethroids are commonly used insecticides (Thapa 1997). The indiscriminate pesticide use can lead to larger pest-related yield losses relative to situations where pesticides are not applied (Rahman, 2003).

Chemical pesticides cause long-term effects such as effect in soil environment, human health, ground water contamination, pesticides resistance, pest resurgence and other ecological effects, but these effects are being neglected by farmers (Thapa & GC, 2000). Similarly, due to unconscious use of synthetic insecticide, insect develop resistant to insecticides, induction of resurgence to target pests, outbreak of secondary pests and undesirable effects on non-target organism (Hagen & Franz, 1973) as well as serious environmental pollution (Devi et al., 1986)) are causing serious hazards to human health.

Insect pest management is an efficient and sustainable pest management practice that focuses on long-term prevention with the least amount of human and environmental health impacts by manipulating the entire ecosystem (Lewis et al., 1997). Though IPM has only been conceptualized for approximately 50 years, it has advanced considerably to what it is today. IPM, a process of using multiple tactics to control pests in an ecologically sound manner, is a pest control philosophy initially developed to control crops pest by understanding the pest's biology (Lewis et al., 1997). IPM has developed

and now works well for urban properties, including lawns, gardens, and structures (Prokopy, 2003). The IPM programs have become economically and environmentally sustainable, and as effective as conventional pest management programs with the benefit of low pesticides risk (Brenner et al., 2003; Williams et al., 2005).

The crucial problem the indiscriminate and haphazard use of broad-spectrum insecticides under farmer's level, which ultimate impact on the environment, thereby disturbing the natural balance with the extinction of promising natural enemies and even threatened the human existence, too. The main problem of farmers in Modi Rural Municipality is the insect pests by which they are losing their expected production. They have no idea about the major insect pest on vegetables. This study is helpful for farmers to know the major insect pests, which attack vegetables and they can increase the production of vegetables by controlling the pests. The study is also to find out the common practices and knowledge of commercial farmers in insect pest management, using safety measures during insecticide use and promoting cultural and biological methods of pest control under Modi Rural Municipality conditions.

METHODOLOGY

Modi Rural municipality is located within the Parbat District of the Gandaki Province, Nepal. It occupies 143.6 square kilometers of area. It is the main gate for the hilly districts of the western part of Nepal. It is divided into eight wards. There is a tropical and subtropical climate. Its density is 150 $km^{2.}$ It has an elevation of about 900m-2125m above sea level. It experiences a pleasant climate throughout the year.

The three sampling site were selected within Modi Rural Municipality Tilahar (Ward No. 6), Deupur (Ward No. 2) and Bajung (Ward No. 5). These areas have a plain land with fertile soil. These are located on the bank of Modi and Patikhola. Being more agricultural crops grown in these areas per year are considered as pocket areas.

In the study area, mainly agricultural sites were chosen especially focusing the vegetable sites. In the vegetable garden (10×10) m^2 replicating plots were laid. Three replicating plots with 500m differences were established in one sampling site. Three replicating plots were laid on Dimuwa, Thana and Besi phant in Tilahar. In Deupur, the plots were laid on Patichour, Tapu and Ghurunga. Similarly, in Bajung, the plots were laid on Pokhare, Modikhet and Khajara. Altogether nine number of plots were selected including three plots on each sampling sites. In each quadrates, the time of two hours was spent to record the vegetables and their pests. Overall, 18 farmers were interviewed to collect information about vegetables grown, insect pest of vegetables and their management practices. For the questionnaire survey, nine respondents were selected representing each quadrates and nine respondents were selected including three from each study sites who were commercially vegetable growing farmers.

The data were analyzed using descriptive statistics, pie charts and bar graphs. Sorensen's similarity index was used to analyze the similarity between the insect species in Tilahar, Deupur and Bajung.

RESULTS

Insect Pests and Affected Vegetables

A total number of 24 insect pests were recorded from 14 different vegetables on the study sites. In Tilahar, 11 insect pests were recorded from nine vegetables. In Deupur, 10 insect pests were recorded from six vegetables and similarly 13 insect pests were recorded from nine vegetables (Table 1, 2 and 3).

Two vegetable species of family Malvacea (Okra and Radish), three species of family Solanaceae (Brinjal, Tomato and Capsicum), two species of family Fabaceae

(Sting beans and Black Eye Beans), and seven species of family Cucurbitaceae (Bitter Gourd, Snake Gourd, Sponge Gourd, Bottle Gourd, Cucumber, Pumpkin and Iskus) were major vegetables grown in the study sites. Similarly, insect pests belonging to five families Coleoptera, Diptera, Hemptera, Lepidoptera and Thysanoptera were recorded.

Table 1
List of Vegetables and Their Insect Pests in Tilahar.

Common name of insect pests	Scientific name of insect pests	Order	Infected vegetables
Leaf hopper	*Amrasca biguttula*	Hemiptera	Okra
Tomato fruitworm	*Helicoverpa zea*	Lepidoptera	Okra, Tomato
Fruit boorer(Melon fly)	*Daucus cucurbitae*	Diptera	Snake Gourd, Brinjal
Cucurbit Fruit fly	*Batrocera cucurbitae*	Diptera	Snake Gourd, Bitter Gourd
Red pumpkin beetle	*Aulacophora foveicollis*	Coleoptera	Pumpkin
Serpentine leaf miner	*Liriomyza brassicae*	Diptera	Sponge Gourd
Aphid	*Aphis gossypii*	Hemiptera	Sponge Gourd, Cucumber
Spotted beetle	*Diabrotica undecimpunctata*	Coleoptera	Bottle Gourd
Flea beetle	*Apththona flava*	Coleoptera	Brinjal
Shoot borer	*Leucinodes orbonalis*	Lepidoptera	Brinjal
Tomato leafminer	*Tuta absoluta*	Lepidoptera	Tomato
Vegetable leaf miner	*Liriomyza trifolii*	Diptera	Bitter Gourd

Table 2
List of Vegetables and Their Insect Pests in Deupur.

Common name of insect pests	Scientific name of insect pests	Order	Infected vegetables
Diamond black moth larvae	*Plutella xylostella*	Lepidoptera	Sting Beans
Cutworm caterpillar	*Agrotis ipsilon*	Lepidoptera	Sting Beans
Thrips	*Scirtothrips dorsalis*	Thysanoptera	Capsicum
Aphid	*Aphis gossypii*	Hemiptera	Bitter Gourd, Okra, Cucumber
Leaf hopper	*Amrasca biguttula*	Hemiptera	Okra
Silverleaf whitefly	*Bemisia tabaci*	Hemiptera	Cucumber
Spotted beetles	*Diabrotica undecimpunctata*	Coleoptera	Sponge Gourd
Green stingbug	*Chinavia hilaris*	Hemiptera	Tomato
Tomato leafminer	*Tuta absoluta*	Lepidoptera	Tomato
Shoot borer	*Leucinodes orbonalis*	Lepidoptera	Brinjal
Cucurbit Fruit fly	*Batrocera cucurbitae*	Diptera	Bottle Gourd

Table 3
List of Vegetables and Their Insect Pests in Bajung.

Common name of insect pest	Scientific name of insect pests	Order	Infected vegetables
Vegetable Weevil	*Listroderes cosrirostris*	Coleoptera	Radish
Cucurbit Fruit fly	*Batrocera cucurbitae*	Diptera	Bitter Gourd
Fungus beetle	*Megalodacne heros*	Coleoptera	Pumpkins
lady bird beetle	*Coccinellidae*	Coleoptera	Pumpkins
Blister beetle	*Meloidae*	Coleoptera	Sponge Gourd
Stinkbugs	*Chinavia hilaris*	Hemiptera	Black Eye Beans
Cutworm caterpillar	*Agrotis ipsilon*	Lepidoptera	Black Eye Beans
Fruit boorer	*Daucus cucurbitae*	Diptera	Brinjal
Red pumpkin beetle	*Aulacophora foveicollis*	Coleoptera	Brinjal
Squash bugs	*Anasa tristis*	Hemiptera	Iskus (Chayote)
Flea beetle	*Disonycha xanthomelas*	Coleoptera	Okra
Cabbage looper larvae	*Trichoplusia ni*	Lepidoptera	Cucumber
Tomato leafminer	*Tuta absoluta*	Lepidoptera	Tomato

The insect pest species commonness between the different pairs of study sites was estimated through Sorensen's similarity index and presented in Table 4. The value of this index was found below 0.6 in all the possible pairs.

Table 4
Sorensen's Similarity Index between Different Study Sites.

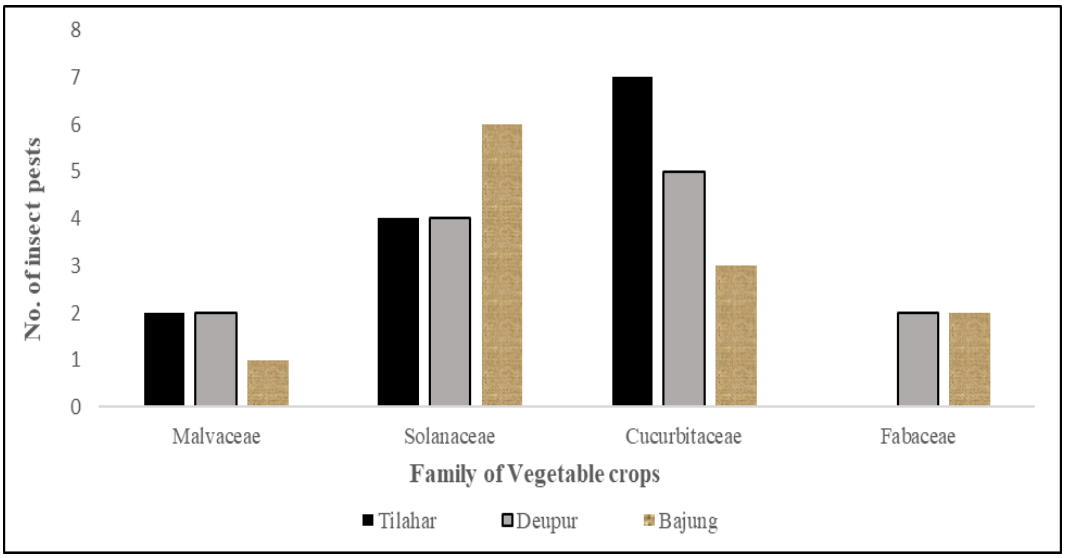
Study sites	Sorensen's similarity index	Percentage
Tilahar and Deupur	0.52	52
Tilahar and Bajung	0.32	32
Deupur and Bajung	0.25	25

Major Insect Pests on the Study Sites

Figure 1 represents a number of insect pests with the family of vegetable in the study sites. In Tilahar, three families of vegetables were grown belonging to three families: Malvaceae, Solanaceae and Cucurbitaceae. Cucurbits were mostly affected by seven insect pests, family Malvacea were affected by two insect pests and family Solanacea were affected by four insect pests. In Deupur, four families of vegetables such as Fabaceae, Cucurbitaceae, Solanaceae and Malvaceae were grown, which were affected by insect pest number two, five, four and two respectively. Similarly, in Bajung, four families of vegetable were grown. Family Cucurbitaceae were affected by six insect pests, Solanaceae were affected by three insect pests, Fabaceae were affected by two insect pests and family Malvaceae were affected by only one insect pest. The cucurbits crops were highly affected in the study sites.

Figure 1

No. of Insect pests with the family of vegetable in the study sites.

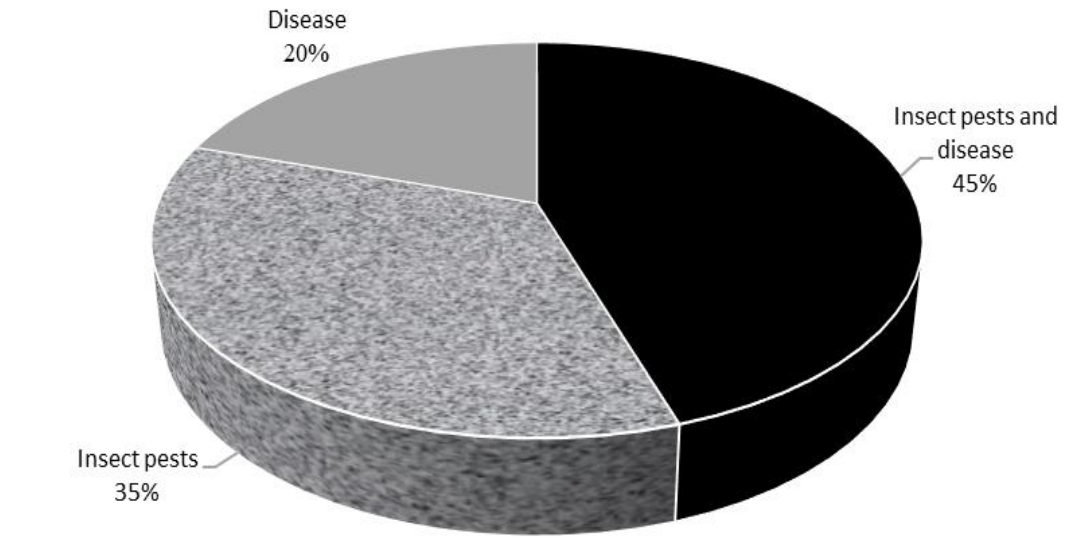


Major Problems of Growing Vegetables

Among various problem of growing, insect pests and disease ranked highest level by 45% damaging vegetables, while 35% respondents marked insect pests as major problem in vegetable production. Similarly, 20% respondents responded disease as a major problem in the fields of study sites (Figure 2).

Figure 2

Major Problems of Vegetable Cultivation

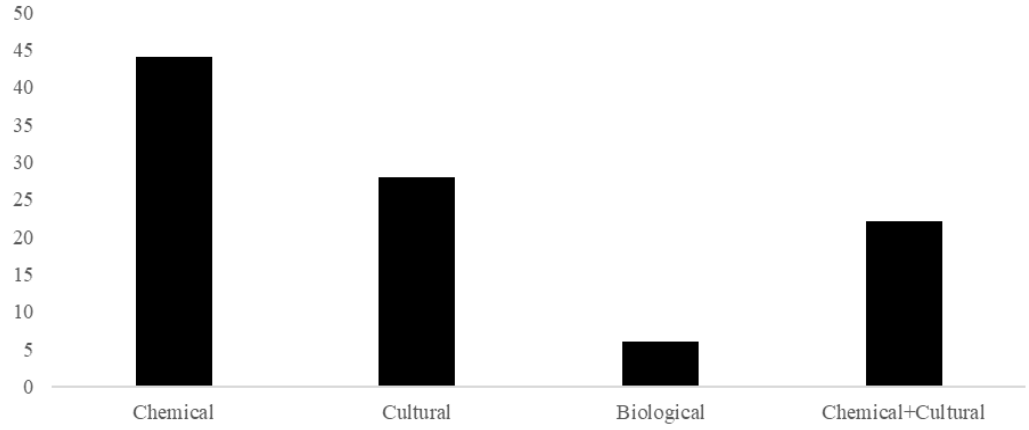


Pest Management Aspects

Different pest management practices like chemical, cultural, biological and other mixed methods were used in the study sites. In all sites, the majority of farmers responded that they have been practiced heavy use of chemical insecticides. About 44% of the respondents used chemical pesticides, 28% used cultural methods to control pesticides, 22% used both chemical and cultural methods and only 6% used biological methods to control pests. There were no any respondents to use biological control methods in combination with methods of insect control (Figure 3).

Figure 3

Percentage of Control Measures against Insect Pests of Vegetables Used by Farmers



The chemical method was commonly practiced on vegetable growing areas. This may be due to their quick action on insect pests. Table 5 shows commonly practiced pesticides group included systemic organophosphate insecticide and systemic insecticide. The insecticides under these groups were cypermethrin, dichlorovs, imidacloprid, dimethoate, etc. Imidacloroprids were mostly used due to its effectiveness and scentless properties.

Table 1

List of Insecticides Used by Farmers

Trade name	Pesticide group	Type of pesticide
G-Sunami	Chloropyriphos 50% + Cypermethrin 5% EC	Insecticide
Anumite	Cypermethrin 10% EC	Insecticide
Bloom	Dichlorovs 76% EC	Insecticide
Cohigan	Imidachloropid 17.8% SL	Systemic insecticide
Admire	Imidachloropid 70% SL	Systemic insecticide
Pollard	Imidachloropid 30.5% SC	Insecticide
Dimethoate	Dimethoate 30% EC	Organophosphate insecticide
Dursban	Chloropyriphos 76% EC	Insecticide
looper	Imidachloropid 70% EC	Insecticide

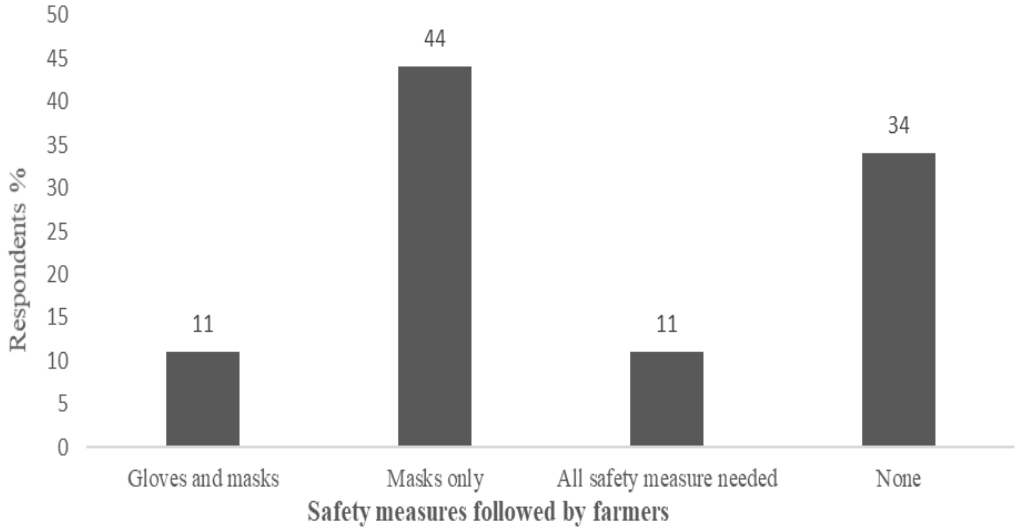
EC= Emulsifiable Concentrate, SC= Suspension Concentrate, SL= Soluble Concentrate

Safety Gears during Application of Pesticides

Almost all the farmers of Tilahar, Deupur and Bajung used sprayers for the application of pesticides whereas protective gears against pesticides were not in use among them except use of full pants, full shirts and shoes. Out of total 18 respondents interviewed, 44% were found using mask only, 34% did not use any safety gears, 11% were found using all safety measures and 11% were found using gloves and masks (Figure 4). The cultural methods included crop rotating, interplanting, timing of date to avoid pests, soil preparation etc. Similarly, biological control of pest included using Neem oil, washing with chili powder and detergents and Jholmol, which is considered as bioliquid fertilizer.

Figure 4

Percentage of Respondents Using Safety Measures.



DISCUSSION

The mostly grown vegetables were cucurbits in the study areas. Cucurbits are considered as most important and popular vegetables used in various forms. Bitter gourd, snake gourd, sponge gourd, bottle gourd, cucumber, pumpkin and iskus (chayote) were major cucurbits vegetables found during this study because they are mostly grown in summer season vegetables. Similarly, okra, radish of family Malvaceae and brinjal, tomato and capsicum of family Solanaceae also prefer warm climate. Among the various factors, insect pests have been regarded as the most important biotic constraints contributing the loss of 35% on vegetables (Atwal, 1986). The cucurbits were mostly affected by Aphids (*Aphis gossypii*), Fruit flies (*Batrocera cucurbitae*), spotted beetle (*Diabrotica undecimpunctata*), (Anonymous, 2004) also found caterpillar of order Lepidoptera, Aphids, fruit flies and beetles as the common destructive pest of cucurbit vegetables. Tomato, brinjal and capsicum were seriously affected by tomato leafminer (*Tuta obsoluta*), fruit borer (*Dacus cucurbitae*) and Thrips (*Aulacophora foveicollis*) respectively. Beans were infested by caterpillars of lepidoptera diamond black moth (*Plutella xylostella*) and cutworms (*Agrotis ipsilon*). (Kunjwal & Srivastava, 2018) found *Plutella xylostella* as a major caterpillar of vegetables including Asia.

Greater Sorensen's similarity index in Tilahar and Deupur (ß=0.52) represents that there was similarity in environment, habitats, larval host plants and visiting plants of

Insects. Lower Sorensen's similarity index (ß=0.25) in Deupur and Bajung represents less similarity in environment, habitats, larval host plants and visiting plant of insects.

In this study, the highest number of pest were recorded from the vegetables were order Coeloptera. These feed on leaves, stem and fruit of vegetables causing complete defoliation (Falak & Mian, 2013). Although they were recorded as highest number, level of infestation in crops was minor except flea beetle which seriously affected okra. Lady bird beetle were recorded in few number in the study areas. Only a species of thrips belonging to order Thysanoptera was recorded in capsicum. (Capinera, 2001 & Jamian et al., 2019) also found Thrips as a major pest of chilies.

The majority of respondents were found using pesticide frequently. But the knowledge about pest biology, types of pesticide, and their mode of action, safety gears are still lacking. Almost all the time, the pesticides are recommended by agro-vet owners and technician (mainly agro-vet owners). Most of farmers were using pesticide on the basic of their own experience, hit and trial method too. The farmers usually have incomplete information about the effective use of insecticides. Improper handling of pesticides and proper vegetable selection per climate was found on farmers. This is due to lack of information, training, and regular monitoring by related agricultural organizations in the study area.

Prudent et al. (2007) reported the background knowledge including conceptual and technical about pest management practices and recommended training program that plays an important role in pest management and effective pesticide use.

The majority of the farmers are unaware of pesticide labels, their effects, safety gears and other potential long-term effects on personal health and environment. The proper protective gears against pesticide were not found in use among majority of respondents except use of full pant, full shirt and shoes. The respondent's concerns with using safety device are all young farmers. Most of farmers of Modi Rural Municipality are not clear on pest biology, types of pesticide and their mode of action. Cultural and biological methods are best methods of pest control to be practiced by farmers in this area as practiced by Prudent et al. (2007).

CONCLUSION

The study shows that a total number of 24 insect pests were recorded belonging to five orders from 24 vegetable crops representing four families Fabaceae, Cucurbitaceae, Solanaceae and Malvaceae were recorded in nine quadrates (10×10) m^2 each were recorded.

Among the insects recorded, the highest number of species were recorded from insect order Coeloptera and least numbers were recorded from order Thysanoptera. Greater Sorensen's similarity index of insects was recorded in Tilahar and Deupur (ß=0.52) and lower Sorensen's similarity index (ß=0.25) in Deupur and Bajung. Cucurbit fruit fly (*Batrocera cucurbitae*), Aphids (*Aphis gossypii*), caterpillars of order lepidoptera diamond black moth (*Plutella xylostella*) and cutworms (*Agrotis ipsilon*) and spotted beetles (*Diabrotica undecimpunctata*) were most dominant pests in the study areas.

Insect pest management practices like chemical, cultural, biological and other mixed methods were practiced in the study sites. In all sites, the majority of farmers responded that they have been practiced heavy use of chemical insecticides. Biological control of pests was least practiced. Only few respondents used safety gears during application of pesticides.

RECOMMENDATIONS

The technical knowledge necessary for the selection of appropriate vegetables according to seasons and pest control methods are needed for farmers. Biological deterrents mixed with organic oils, soaps and sprays or traditional and eco-friendly techniques (*Urtica dioica* (sisnu) soaked solution, Titepati (*Artemisia vulgaris*) soaked solution, garlic soaked solution, a spray of shampoo with little kerosene, sprinkling urine of cow and other different locally prepared organic pesticide called "Jaibikbishadi" should be used if the infestation is still in its early stages rather than high dose of pesticides. Full safety measures should be adopted by farmers during the use of insecticides. The practice of efficient, sustainable, economically feasible and bio-friendly pest management technique that focuses on long-term prevention on pests should be done. Further research work related to vegetable production and pest management should be done along with the farmer's participation.

ACKNOWLEDGEMENTS

This paper is built upon our research project conducted with the Centre for Research and Innovation, Prithvi Narayan Campus, Pokhara. We are thankful to the centre for providing us with the research grant. We are also thankful to the respondents who answered our questions.

REFRENCES

Alam, M.Z. (1969). Insect pests of vegetable and their control. *Public agriculture Information Service Department, Dacca*, 4-5.

Banjo, A.D., Lawal, 0.A., Fapojuwo, O.E., & Songonuga, E.A. (2003). knowledge and perception of horticultural insect pest problems in southwestern Nigeria.Afr. J. Biotechnology 2: 434-437.

Brenner, B.L., Markowitz, S., Rivera, M., Romero, H., Weeks, M., Sanchez, E., Deych, E., Garg, A., Godbold, J., Wolff, M. S., Landrigan, P.J., & Berkowitz, G. (2003). Integrated pest management in an urban community: A successful partnership for prevention. *Environ. Health Persp, 111,* 1649-1653.

Capinera, J.L. (2001). Order Thysanoptera-Thrips. In Capinera, J.L. (Ed.), *Handbook of Pests* (pp. 535–550). Academic Press.

CBS. (2004). Statistical pocket book of Nepal. National Planning Commission Secretariat, Central Bureau of Statistics, Ramsahapath Kathmandu, Nepal. 294 p.

Devi, D.A., Mohandas, N., & Vistakshy, A. (1986). Residues of Fenthion, Quinphos and Malathion in paddy grains following surface treatment of gunny bags. *Agricultural Research Journal of Kerala, 24*(2), 37-46.

Gaines, J.C. (1957). Cotton insects and their control in the United States. *Ann. Rev. Entomol, 2,* 319-338.

Giri, Y.P., Mainali, B.P., Aryal, S., Paneru, R.B., Bista, S., & Maharjan, R. (2004). Use of insecticides on vegetable crops in Dhading district. In B.B. Khatri, B.P. Sharma, P.P. Khatiwada, K.P. Paudyal, B.R. Khadge & H.N. Regmi (Eds.), *Proceedings of the 4th national workshop on Horticulture. Advances of horticultural research in Nepal* (pp. 390-304). March 2-4, 2004. Horticulture Research Division and National Agriculture Research Institute, Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur.

Gurung, B., Regmi, P.P., Thapa, R.B.; Gautam, D.M., Gurung, G.M., & Karki, K.B. (2016). Impact of PRISM approach on input supply, production and produce marketing of commercial vegetable farming in Kaski and Kapilvastu District of Western Nepal. *Res. Rev. J. Botan. Sci. 5*, 34–43.

Hagen, K. S., & Franz, J.M. (1973). A history of biological control. In Smith, R. F., T. E. Mittler, & C. N. Smith (eds.). *History of Entomology: Annual Reviews* (pp. 433-476). Palo Alto, California, USA.

Jamian, S., Ismail, S.I., Hata, E.M., Saad, N., & Sani, I. (2019). Case study: First report of thrips infestation and gray mold disease on hydroponically grown lettuce in Perak Malaysia. In *Proceedings of the ISSAAS international congress* (p. 99). Selengor.

Lewis, W.J., Lenteren, J.C., Phatak, S.C., & Tumlinson, J.H. (1997). A total system approach to sustainable pest management. *Proc. Natl. Acad. Sci., 94*, 12243-12248.

Neupane, F. P. (2003). Status of botanical pesticides in Nepal. In F.P. Neupane (ed.) *Proceedings of National Seminar on Integrated Pest Management in Nepal* (pp. 77-100), September 25-26, 2002. Himalayan Resources Institute, Kathmandu, Nepal.

Nichols, M., & Hilmi, M. (2009). Growing vegetables for home and market. *Rural Infrastructure and Agro-Industries Division Food and Agriculture Organization of the United Nations*, *11*, 19-36

Prokopy, R.J. (2003). Two decades of bottom-up, ecologically based pest management in a small commercial apple orchard in Massachusetts. *Agr. Ecosyst. Environ, 94*, 299-309.

Prudent, P., Loko, S., Deybe, D., & Vaissayre, M. (2007). Factors limiting the adoption of IPM practices by cotton farmers in Benin: a participatory approach. *Exp. Agr., 43*, 113-124.

Rahman, S. (2003). Farm level pesticide use in Bangladesh: Determinants and awareness. *Agriculture Ecosystem and Environment, 95*, 241-252.

Rai, M. (2004). *Study on pests of Tea and Estate, Ilam, Nepal*. M.Sc. Dissertation. Tribhuwan University, Kirtipur, Kathmandu, Nepal.

Thapa, P.K. (1999). *Economics of vegetable seed production in Nepal*. Udaya Publication.

Thapa, R. B., & GC, Y. D. (2000). Integrated management of soil insect pests in the mid hill of Nepal. *SSMP Documents, 44*, 1-61.

Thapa, R.B. (1993). Studies on the insect pests of cabbage, cauliflower and radish at IAAS, Rampur. In F.P. Neupane (ed.), *IAAS Research Report (1985-1991)* (pp. 83-88). Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal.

Thapa, R.B. (1997). An overview of pesticide pollution in Nepal. *Nepalese Horticulture, Nepal Horticulture Society, 1*.

Williams, G.M., Linker, H.M., Waldvogel, M.G., Leidy, R.B., & Schal, C. (2005). Comparison of conventional and integrated pest management program in public schools. *J. Econ. Entomol., 98*, 1275-1283.