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RESEARCH ARTICLE

EFFICACY OF VARIOUS INSECTICIDES AGAINST MAJOR INSECT PESTS OF SUMMER SQUASH (*Cucurbita pepo*) IN DHADING DISTRICT, NEPAL

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ABSTRACT

Red pumpkin beetle, fruit fly, flea beetle, whitefly, squash bug, melon aphid, etc. are the major insect pests of summer squash resulting in a huge loss in quality and quantity to farmers A field trial was conducted to find out the comparative efficacy of various insecticides against the major insect pests of summer squash from January to June 2020 in Dhading district, Nepal. The experiment was laid in Randomized Complete Block Design (RCBD) with four different insecticides i.e. Imidachloropid 17.8 SL @1.5ml/l, Spinosad 45SC @1ml/L, Azadiractin (Nimbecidine) 500ppm @ 5 ml/L, Jholmol @ 1:5 concentrations, and normal water spray as control as five treatments. The treatments were replicated four times and 'Anna 303' variety of summer squash was used under study. The results revealed that, among all the insecticides evaluated at all the four sprays, Imidachloropid recorded the maximum reduction in the population of red pumpkin beetle (RPB) (about 90%), other insects (about 88%) and also showed minimum leaf infestation % (28.5%), and leaf damage % per plant (15.63%) and Spinosad being at par with Imidachloropid followed by Azadirachtin and Jholmol respectively. Imidachloropid and Spinosad also showed comparatively lower fruit infestation by fruit fly i.e. 18.5% and 20.5 % respectively than other insecticides. Both Imidachloropid and Spinosad treated plots were statistically ($p<0.05$) similar and significantly superior over other treatments for yield (52.11 and 50.31Mt ha^{-1} respectively), for fruit length (37.62 and 37.12cm respectively) and fruit diameter (26.78 and 26.51cm respectively). A negative and strong correlation was found between yield and mean population of RPB and other insects, leaf infestation % per plant, leaf damage % per plant, and fruit infestation % per plant whereas fruit length and diameter showed a positive correlation with yield. The benefit-cost ratio was highest for plot treated with Imidachloropid (4.21) followed by Spinosad, Azadiractin, Jholmol, and Control. Thus, Imidachloropid was the most effective and economic in controlling the major insect pests of summer squash.

KEYWORDS

Jholmol, Insecticides, Red Pumpkin beetle, Pest.

1. INTRODUCTION

Summer squash (*Cucurbita pepo*) commonly known as Zucchini, one of the most economically important vegetable crops grown in many tropical and subtropical regions of the world (Paris H. , 1996). It is a quick-growing early yielding cucurbit cultivated throughout Nepal – recommended to both the Terai and the hilly region of Nepal. It is popular and grown worldwide particularly for oil and medical purposes as it possesses several pharmacological effects as antidiabetic, antihypertensive, antitumor, antimutagenic, immunomodulating, antibacterial, antihypercholesterolemic, intestinal antiparasitic, antalgic, and antiinflammation effects (Bannayan, Rezaei, & Alizadeh, 2011; Caili, Huan, & Li, 2006). Although it offers great importance, the production of summer squash is particularly hampered by the incidence of various insect pests (Sarwar, 2014). This might be one of the reasons for the lower yield i.e. 15.59 Mt ha^{-1} of summer squash compared to its attainable yield i.e. 40 Mt ha^{-1} (MoAD, 2017/18) as farmers are discouraged to cultivate this crop.

Summer squash is susceptible to several chewing and sucking insect pests as, Red pumpkin beetle, melon fruit fly, flea beetle, squash bug, whitefly, melon aphid, squash lady beetles which are being the most troublesome one leading to great loss in quality and yield (Kaiser & Ernst, 2018). Some insect pests may infest the crop during the whole cultivation period and may cause damage to up to 80% (Rahman & Uddin, 2016). About 50 percent of cucurbits are partially or completely damaged by those problematic insect pests (Gupta & Verma, 1992) The average economic loss caused by these insect's pests in cucurbits is around 40% (Sharma, Rana, & Shiwani, 2016)Among these pests, Red pumpkin beetle *Aulacophora foveicollis L.* and Cucurbit fruit fly viz., *Bactrocera cucurbitae* are the most damaging insect pests causing the yield losses up to 30-100% depending on the cucurbit species and season (Hassan, Uddin, & Haque, 2012; Gupta & Verma, 1992; Dhillon, Singh, Naresh, & Sharma, 2005). Red pumpkin beetle being polyphagous, both larval and adult stages are harmful to crop as they feed voraciously in leaf making irregular holes and also larvae cause damage in various ways by boring into the roots along with the underground stem portion also by feeding on the leaves and fruits line in contact with the soil (Srivastava & Butani, 1998) Similarly, fruit fly infestation causes fruit to become distorted which lead the fruit unfit for

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human consumption and reduces the market value of produce (Nasiruddin, et al., 2004). Thus, these major insect pests are becoming the major threat in summer squash cultivation.

There are various methods for controlling these insect pests including physical, chemical, cultural, and biological methods. However, Chemical pesticides are being used enormously despite their adverse effects (Jasmine, Prasai, Pant, & Jayana, 2008). Study shows that the highest quantity of pesticides is used in vegetables i.e.89 percent (1.604 a.i. kg/ha) followed by cereals, cash crops, pulses and fruits (Sharma, 2015). Farmers are using chemical pesticides in the higher rate and in a haphazard way for the management of the insect pests without considering about pesticide residue, pest resistance, the resurgence of pest, destruction of beneficial insects and environmental pollution, detrimental effects on the fertility of the soil and human health (Abang, Kouame, Abang, Hanna, & Fotso Kuate, 2013). Also, the old and traditional insecticides have become ineffective for the management of major insect pests of cucurbits and are unfit for sustainable vegetable production, thus substitution of the hazardous chemical pesticide must be done.

Several types of research have been carried out in the respect of either chemical or botanical pesticides in the crop (Asim, Amjad , Maqsood, & Syed Sartaj, 2017; Ratnakar, Vijayaraghavendra, Srinivasa, Reddy, & Padmasri, 2016; Mahato, 2017). But few studies have taken both methods in the research and compared them meaningfully. So, this research has the objective to compare them with respect to efficacy and profitability.

2. Materials and Methods

2.1 Experimental location

The experiment was conducted in Tallobesi, Nilkantha Municipality-7, Dhading. The research site is situated within the latitudes 27°54'46.66'' N and 84°54'17.84'' E longitude with an elevation of about 487m above sea level and lies in the sub-tropical zone of Nepal. The soil texture in the study area is sandy loam. The experiment was conducted from January to May.

2.2 Experimental Design

The experiment was conducted in Randomized Complete Block Design (RCBD) with 5 treatments and each treatment was replicated 4 times. Each plot contained 5 rows and each row accommodated 5 plants. Five plants were taken randomly as the sample plant from the middle 8 plants.

2.3 Treatment Details

For the research, the following 5 treatments were selected including the untreated control.

T_1- Spinosad 45SC @ 1ml/l

T_2- Azadiractin (Nimbicidine) 300ppm @5m/l

T_3- Botanical pesticide 'Jholmal' @ 1:5 concentrations

T_4- Imidachloropid @1.5 ml/lit

T_5- Control (Water spray)

Jholmol is a botanical pesticide prepared by mixing the leaf extract with cow urine, fresh cow dung, and spices (half kg leaves of each: neem, ashuro, tulsi, tomato, titepati, bojho, sayapatri, godawari, and khirro was chopped and kept on a plastic drum over 60 days along with 100g of each fresh garlic, chili, and zinger.

The insecticides were applied with the help of the knapsack sprayer. The first application of insecticides was done after 10 days of transplanting and subsequent applications were made at 10 days' intervals. Precautions were taken to avoid drift to the adjacent plots.

2.4 Plant Material

'Anna 303' variety of summer squash was sown under protected conditions in poly-bags of size 4×5 inch. One seed per polybag was sown and kept inside the poly house. Regular watering was carried out as required. After complete germination of the seed, seedlings at 5 leaf stages were transplanted into the individual pit's main field maintaining the spacing of 1×1m. Appropriate intercultural operations and crop management techniques were applied accordingly.

2.5 Climatic condition during the experimental observation

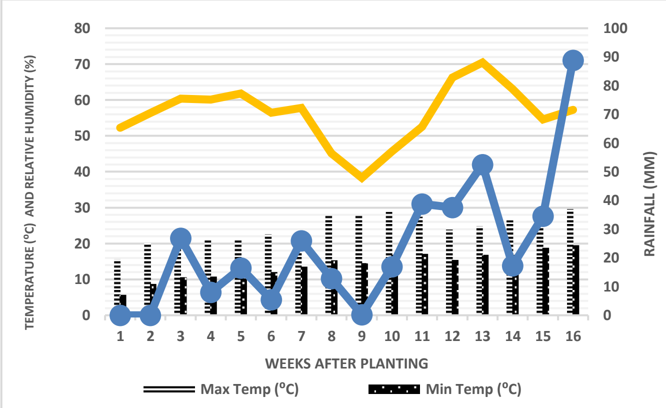

Figure 1: Graph showing weekly average maximum and minimum temperature, rainfall and humidity variation during the crop period.

The total rainfall of 382 mm was received during the entire period of crop experimentation. The highest rainfall was recorded during the 16th week after planting: later stage of crop development (88mm). The maximum temperature during the research period ranges from 16-30ºC. It was highest during the later weeks after planting at the stage of fruiting and lowest during the earlier week at the vegetative stage. Similarly, the Minimum temperature during the experimentation period ranges from 6-18ºC. Relative humidity ranges from 40-70% during the research period.

2.6 Method of the recording observations

For recording the observation related to the morphology and insect infestation from the field, five sample plants were selected from each plot and were tagged and the data were collected from the plant. For the comparison of the effectiveness of the treatment on the Red pumpkin beetle, fruit fly, and other insects of summer squash, data on the following parameters were recorded on the field.

1) No. of red pumpkin beetle and other insects per plant

The number of Red Pumpkin Beetle and other insects per plant was manually counted just before spray and after 24hr of spray, third, sixth, and ten days of spray.

2) Percentage reduction of red pumpkin beetle and other insects

The percent reduction of red pumpkin beetle and other insect's population for each treatment was calculated by the formula similar to that used by (Thapa, Bista, Bhatta, Bhandari, & Sapkota, 2019).

$$\% \text{ Reduction} = \frac{Pr - Po}{Pr} \times 100$$

(Where, Pr = Pre count plant^{-1} and Po = Post count plant^{-1})

3) Leaf infestation percentage

The total leaves and number of infested leaves per plant were recorded from the sample plant before spray and on the 6th and 10th day of spray and the average % was assessed for all the treatments at all the four spray.

$$\text{Leaf infestation \%} = \frac{\text{Total number of leaves} - \text{Number of infested leave}}{\text{Total number of leaves}} \times 100\%$$

4) Leaf damage percentage in the infested leaf

The infested area on the individual damaged leaves was recorded and expressed in percentage.

5) Percentage of fruit damage/infested

The number of fruit damaged by fruit fly was also recorded at each harvest and the percent fruit infestation was computed using the following formula

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$$\% \text{ Fruit damage} = \frac{\text{Number of infested fruits}}{\text{Total number of observed fruits}} \times 100$$

6) Average Fruit length, diameter, and Yield

The length and diameter of the fruit of the sample plant were measured with the scale and Vernier caliper respectively and average fruit length and diameter were calculated. Fruits harvested from the selected plants were taken and weighed and expressed in terms of Mt ha^{-1}

2.6.1 Economic analysis

2.6.1.1 Cost of cultivation

The cultivation cost of crops was calculated based on local charges for different agro-inputs viz., labor, fertilizers, insecticides, and other necessary materials and explained as the total cost of NRs.ha^{-1}.

2.6.1.2 Gross and net return

The per-unit price of fruit based on the local market was multiplied with the total fruit yield of each plot to determine gross return and expressed in NRs. ha^{-1} for all replications and treatments. And the Net return was calculated by deducting the cost of cultivation from the gross return and expressed in NRs. ha^{-1}.

2.6.1.3 Benefit-cost (B: C) ratio

It was calculated by the following formula.

B: C ratio = Gross return / Cost of cultivation

The recorded data were subjected to standard statistical analysis

2.6.2 Statistical analysis

The data collected were processed by Ms. Excel and analyzed using R-studio. Duncan's Multiple Range Test (DMRT) was employed to find out the significant differences between the mean values at a 5% level of significance. The significance was determined using the following format of the ANOVA table.

3. Results and Discussion

3.1 Diversity of insects

Numerous insects of diverse order and family were found in the research field. The highest number of red pumpkin beetle belonging to the order coleopteran and family Chrysomelidae were reported in the field which indicated that the red pumpkin beetle to be the major pests of cucurbits. Similar findings were observed by (Rashid, Khan, Arif, & Javed, 2014) and (Fayyaz, Kausar, Saeed, & Akhtar, 2016) where they reported the red pumpkin beetle to be the major pest of cucurbits. Besides the red pumpkin beetle, several other insects like black cucurbit beetle, melon fly, squash vine borer, melon aphid, whitefly, squash bug, cucurbit stink bug, and grasshopper were observed in the research field. The presence of these insects is in agreement with the results of (Sarwar, 2014) who studied insect pests of summer vegetables including pumpkin.

3.2 Effect on insect population (Number of Red pumpkin beetle and other insects per plant) before and after 1st, 2nd, 3rd, and 4th spray

The effect of the application of different treatments on the no. of red pumpkin beetle (RPB) and other insects per plant at different dates of subsequent spray are shown in Table 1, 2, 3, and 4 respectively. The average no. of RPB and other insects per plant was found to be 3.3 and 2.56 respectively before the first spray and the no. of RPB and other insects per plant were not significantly different among the treatments (Table 1).

After the first spray, the treatment differed significantly ($P < 0.05$) in reducing the no. of RPB and other insects per plant at all the dates of observation (1, 3, 6, and 10 DAS respectively). Among the four insecticides, Imidachloropid showed significantly minimum no. of RPB and other insects per plant at all the dates of spray and proved to be superior among the other treatments. Spinosad was found to be statistically similar to Imidachloropid. Azadirachtin and Jholmol, both were statistically similar ($P<0.05$) with each other and they were also superiorly significant from the untreated control. The highest control of these insects may be due to being both systemic and contact in nature with a novel or non-conventional mode of action to combat highly resistant insect pests (Elbert , Nauen, & Leicht, 1998).

Similar results were obtained in second (Table 2), third (Table 3), and fourth spray (Table 4) in which Imidachloropid was significantly superior in suppressing the population of RPB and other insects followed by Spinosad, Azadirachtin, and Jholmol respectively. Thus, considering the percentage reduction of RPB and other insects at all the four sprays, Imidachloropid recorded a greater % reduction of both RPB and other insect's populations over the other treatments as shown in figure 2. A similar finding was reported by Iftikhar, et al., (2018) where Imidachloropid was found highly effective against the RPB *(A. foveicollis)*. Similarly, the result is also in accordance with Purohit, (2010) where Imidachloropid was found to be most effective recording the maximum reduction in the population of RPB and other insects; whitefly and jassids of cucumber. Likewise, several experiments is in accordance with the present finding as they also proved Imidachloropid to be the most effective insecticide against the several sucking pests like jassids, thrips, whitefly, watermelon bug, etc. (Afif, Muhammad, Akbar, & Tofique, 2016; Aljedani, 2018; Khan & Lohar , 2007).

Table 1: Effect of treatments on No. of RPB and other insects per plant during the First spray

Treatment	Insect population during the First spray									
Insecticide	BS		1 DAS		3 DAS		6 DAS		10 DAS	
	RPB	OI	RPB	OI	RPB	OI	RPB	OI	RPB	OI
Imidachloropid	3.50	2.35	0.15[a]	0.15[a]	0.55[a]	0.55[a]	1.92[a]	0.70[a]	1.95[a]	0.85[a]
Spinosad	3.30	2.55	0.15[a]	0.40[a]	0.60[a]	0.78[a]	1.98[a]	0.93[a]	2.50[ab]	1.35[b]
Azadirachtin	2.95	2.55	0.55[b]	1.00[b]	1.05[b]	1.45[b]	2.73[b]	1.68[b]	2.85[b]	1.95[c]
Jholmol	3.25	2.50	0.63[b]	1.28[b]	1.35[b]	1.75[c]	3.00[c]	1.85[b]	3.25[b]	2.30[c]
Control	3.50	2.85	3.60[c]	3.60[c]	3.90[c]	3.30[c]	3.90[d]	3.65[c]	4.80[c]	3.80[d]
F-test	ns	nS	***	***	***	***	***	***	***	***
LSD(0.05)	0.41	0.71	0.24	0.28	0.42	0.55	0.23	0.26	0.75	0.43
SEm(±)	0.13	0.23	0.08	0.09	0.14	0.18	0.07	0.08	0.24	0.14
CV%	7.96	17.93	15.58	14.36	18.29	22.98	5.41	9.44	15.81	13.65
Grand Mean	3.3	2.56	1.02	1.28	1.49	1.57	2.71	1.76	3.07	2.05

SEm: Standard error of means. LSD: Least significant difference. CV: Coefficient of variation. Means followed by the same letter in a column are not significantly different by DMRT at 5% level of significance. ns= Non-significant, *=significant at 5% probability level, **= significant at 1% probability, ***=significant at 0.1% probability BS= before spray DAS= Days before spray RPB= Red pumpkin beetle per plant OI= Other insects per plant

Table 2: Effect of treatments on No. of RPB and other insects per plant during the Second spray

Treatment	Insect population during the Second spray									
Insecticide	BS		1 DAS		3 DAS		6 DAS		10 DAS	
	RPB	OI	RPB	OI	RPB	OI	RPB	OI	RPB	OI
Imidachloropid	1.95^{a}	0.85^{a}	0.08^{a}	0.05^{a}	0.40^{a}	0.40^{a}	1.18^{a}	1.00^{a}	1.45^{a}	1.20^{a}
Spinosad	2.50^{ab}	1.35^{b}	0.15^{a}	0.33^{a}	0.90^{ab}	0.75^{ab}	1.55^{a}	1.05^{a}	1.80^{a}	1.43^{a}
Azadirachtin	2.85^{b}	1.95^{c}	0.55^{b}	0.75^{b}	1.10^{bc}	1.15^{b}	2.08^{b}	1.80^{b}	2.30^{b}	2.40^{b}
Jholmol	3.25^{b}	2.30^{c}	0.63^{b}	0.95^{b}	1.60^{c}	2.20^{c}	2.43^{b}	2.30^{c}	2.80^{c}	2.50^{b}
Control	4.80^{c}	3.80^{d}	4.05^{c}	3.80^{c}	3.65^{d}	3.25^{d}	3.65^{c}	3.95^{d}	4.20^{d}	3.70^{c}
F-test	***	***	***	***	***	***	***	***	***	***
LSD(0.05)	0.75	0.43	0.19	0.39	0.50	0.53	0.48	0.34	0.50	0.45
SEm(±)	0.24	0.14	0.06	0.13	0.16	0.17	0.16	0.40	0.16	0.15
CV%	15.81	13.65	11.46	21.41	21.28	22.13	14.40	12.62	12.85	13.10
Grand Mean	3.07	2.05	1.09	1.18	1.53	1.55	2.18	2.02	2.51	2.25

SEm: Standard error of means. LSD: Least significant difference. CV: Coefficient of variation. Means followed by the same letter in a column are not significantly different by DMRT at 5% level of significance. ns= Non- significant, *=significant at 5% probability level, **=significant at 1 % probability, ***= significant at 0.1% probability, BS= before spray, DAS=Days before spray, RPB= Red pumpkin beetle, OI= Other insect pests per plant

Table 3: Effect of treatments on No. of RPB and other insects per plant during the Third spray

Treatment	Insect population during the Third spray									
Insecticide	BS		1 DAS		3 DAS		6 DAS		10 DAS	
	RPB	OI	RPB	OI	RPB	OI	RPB	OI	RPB	OI
Imidachloropid	1.45^{a}	1.20^{a}	0.10^{a}	0.00^{a}	0.25^{a}	0.10^{a}	0.90^{a}	0.85^{a}	0.90^{a}	1.13^{a}
Spinosad	1.80^{a}	1.43^{a}	0.15^{a}	0.18^{a}	0.55^{b}	0.40^{a}	1.00^{a}	0.95^{a}	1.20^{b}	1.45^{b}
Azadirachtin	2.30^{b}	2.40^{b}	0.50^{b}	0.70^{b}	1.05^{c}	1.00^{b}	1.73^{b}	1.95^{b}	1.75^{c}	2.95^{c}
Jholmol	2.80^{c}	2.50^{b}	0.55^{b}	0.75^{b}	1.25^{c}	1.30^{b}	1.95^{c}	2.20^{c}	1.95^{d}	3.13^{c}
Control	4.20^{d}	3.70^{c}	4.13^{c}	3.63^{c}	3.65^{d}	3.60^{c}	3.80^{d}	4.00^{d}	4.00^{e}	3.90^{d}
F-test	***	***	***	***	***	***	***	***	***	***
LSD(0.05)	0.50	0.45	0.25	0.40	0.26	0.43	0.17	0.14	0	0.20
SEm(±)	0.16	0.15	0.08	0.13	0.09	0.14	0.06	0.05	0.05	0.06
CV%	12.85	13.10	15.00	24.45	12.61	21.72	6.01	4.58	0	4.94
Grand Mean	2.51	2.25	1.09	1.05	1.35	1.28	1.88	1.72	1.96	2.51

Sem: Standard error of means. LSD: Least significant difference. CV: Coefficient of variation. Means followed by the same letter in a column are not significantly different by DMRT at 5% level of significance. ns= Non- significant, *=significant at 5% probability level, **=significant at 1 % probability, ***= significant at 0.1% probability, BS= before spray, DAS=Days before spray, RPB= Red pumpkin beetle, OI= Other insect pests per plant

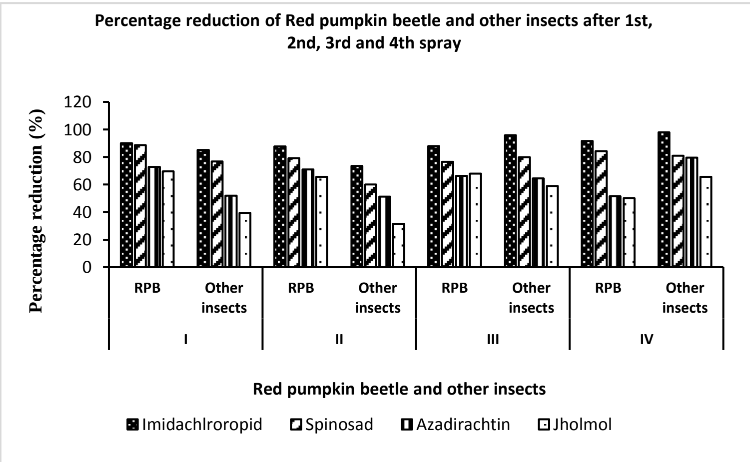

Figure 2: Percentage reduction of Red pumpkin beetle and other insects under different treatments

Table 4: Effect of treatments on No. of RPB and other insects per plant during the Fourth spray

Treatment	Insect population during the Fourth spray									
Insecticide	BS		1 DAS		3 DAS		6 DAS		10 DAS	
	RPB	OI	RPB	OI	RPB	OI	RPB	OI	RPB	OI
Imidachloropid	0.90^{a}	1.13^{a}	0.00^{a}	0.00^{a}	0.15^{a}	0.05^{a}	0.53^{a}	0.20^{a}	0.60^{a}	0.75^{a}
Spinosad	1.20^{b}	1.45^{b}	0.15^{a}	0.15^{ab}	0.23^{b}	0.40^{a}	0.85^{a}	0.55^{b}	0.78^{a}	0.95^{b}
Azadirachtin	1.75^{c}	2.95^{c}	0.45^{b}	0.35^{b}	1.25^{c}	0.85^{b}	1.83^{b}	1.03^{c}	1.60^{b}	2.05^{c}
Jholmol	1.95^{d}	3.13^{c}	0.60^{b}	0.70^{c}	1.35^{c}	1.45^{c}	1.90^{b}	1.50^{d}	1.80^{b}	2.35^{d}
Control	4.00^{e}	3.90^{d}	4.00^{c}	3.60^{d}	4.40^{d}	3.60^{d}	3.93^{c}	3.53^{e}	4.00^{c}	3.95^{e}
F-test	***	***	***	***	***	***	***	***	***	***
LSD(0.05)	0	0.20	0.22	0.25	0.60	0.35	0.60	0.35	0.55	0.14
SEm(±)	0.05	0.06	0.07	0.08	0.19	0.11	0.20	0.11	0.19	0.05
CV%	0	4.94	13.93	6.89	26.37	18.00	21.59	16.62	21.96	4.64
Grand Mean	1.96	2.51	1.04	0.96	1.48	1.27	1.80	1.36	1.78	2.01

SEm: Standard error of means. LSD: Least significant difference. CV: Coefficient of variation. Means followed by the same letter in a column are not significantly different by DMRT at 5% level of significance. ns= Non-significant, *=significant at 5% probability level, **= significant at 1% probability, ***=significant at 0.1% probability BS= before spray DAS= Days before spray RPB= Red pumpkin beetle per plant OI= Other insects per plant

3.3 Effect on Average leaf infestation and leaf damage % per plant at different spray

The effect of different insecticides in leaf infestation % and leaf damage % per plant at different spray is shown in table 5.

At first spray, minimum leaf infestation % was observed in Imidachloropid treated plots (33.21%) which were statistically at par with spinosad (34.39%). Azadirachtin and Jholmol were also statistically similar to each other and both significantly superior from untreated control (47.33%). Similar results were obtained in 2nd,3rd, and 4th spray in which Imidachloropid was significantly superior over the rest of the treatments. Spinosad was found to be statistically similar to Imidachlropid at 2nd and 3rd spray. Azadirachtin and Jholmol were also statistically similar to each other at 2nd and 3rd spray. Likewise, leaf damage % was also observed minimum for Imidachloropid at all the four sprays followed by Spinosad, Azadirachtin, and Jholmol respectively. Imidachloropid and Spinosad were seen statistically at par during 1st spray. Also, Azadirachtin and Jholmol both were statistically similar to each other at 1st, 2nd, and 4th spray respectively. Viewing this result, it is concluded that minimum leaf infestation and leaf damage % were observed due to the minimum incidence of RPB and other insects i.e.. These findings are in accordance with (Osman, Uddin, & Adnan, 2013) as they also found the minimum percent of leaf infestation in the chemical treated plots since they were highly effective in reducing the beetle population. A similar finding was reported in (Lakshmi, Ramchandra Rao, & Arjuna Rao, 2005) as they also observed minimum leaf damage percentage in musk melon, *Cucumis melo* in the plots treated with Carbaryl 0.2% which was most effective in reducing red pumpkin beetle population.

Table 5: Effect of treatments in average leaf infestation and leaf damage % per plant at different spray

Treatment Insecticide	Average leaf infestation and leaf damage % at different spray							
	1st spray		2nd spray		3rd spray		4th spray	
	Average LI %	Average LD %	Average LI %	Average LD %	Average LI %	Average LD%	Average LI %	Average LD%
Imidachloropid	33.21a	21.13a	29.24a	13.88a	26.43a	13.38a	26.79a	14. 13a
Spinosad	34.39a	22.54a	30.92a	20.00b	28.43a	17.00b	29.77b	17.50b
Azadirachtin	41.90b	27.56b	38.63b	28.38c	37.34b	28.50c	37.40c	27.88c
Jholmol	40.74b	28.60b	39.64b	29.38c	36.37b	30.83d	40.81d	28.13c
Control	47.33c	40.03c	51.98c	55.88d	50.76c	64.38e	55.25e	65.50d
F-test	***	***	***	***	***	***	***	***
LSD(0.05)	1.87	1.67	1.85	2.17	4.39	1.69	2.74	1.40
SEm(±)	0.61	0.54	0.60	0.71	1.43	0.55	0.89	0.46
CV%	3.07	3.88	3.15	4.78	7.95	3.55	4.68	2.97
Grand mean	39.51	27.97	38.08	29.5	35.87	30.82	38.00	30.63

SEm: Standard error of means. LSD: Least significant difference. CV: Coefficient of variation. Means followed by the same letter in a column are not significantly different by DMRT at 5% level of significance. ns= Non-significant, *=significant at 5% probability level, **= significant at 1% probability, ***=significant at 0.1% probability BS= before spray DAS= Days before spray LI %= Leaf infestation % LD= Leaf damage %

3.4 Effect on average fruit infestation per plant

The application of treatments showed a highly significant result in average fruit infestation per plant (Table 6). Among all the treatments, Imidachloropid recorded a significantly lower percentage of fruit infestation (18.51%) which was statistically at par with Spinosad (20.05%). Azadirachtin (34.94%) and Jholmol (35.78%) were found to be statistically similar to each other. Maximum fruit infestation by fruit fly was observed in the control plots in which no chemicals were sprayed. Purohit, (2010) on his experiment, assessment of novel insecticides against pests of cucumber also observed Imidachloropid, statistically superior in terms of mean fruit infestation percentage and concluded it to be most effective against *Bactrocera cucurbitae* which helps to corroborate this present finding. Bhowmik, Mandal, and Chatterjee, (2014) while working on chemical management of melon fruit fly in found that spray with spinosad @ 60 a.i./ha was most effective in reducing the fruit infestation by melon fruit fly which was similar to our present finding. Our present finding is also in accordance with Waseem, Nagangoud, Patil, Prabhuraj, and Husaain, (2009) where they reported Imidachloropid and spinosad to be the most effective chemical insecticides against the melon fly, *Bactrocera cucurbitae* as both treatments recorded minimum fruit damage.

3.5 Effect on yield and yield attributes

Data on average fruit length, diameter, and fruit yield were significantly different amidst the treatments (Table 6). The fruits of maximum length were observed in the Imidachloropid treated plots (37.63cm) which were statistically similar to Spinosad (37.12cm) followed by Azadirachtin (34.47cm) and Jholmol (34.33cm) respectively. Similarly, the fruits of Imidachloropid treated plots were observed to have maximum diameter i.e. 26.78cm followed by the fruits of Spinosad (26.51cm), Azadirachtin (24.24cm), and Jholmol (24.17cm) respectively. The minimum diameter of the fruit was recorded in the control plot. The highest yield of fruit was recorded in Imidachloropid treated plots i.e. 52.11 Mt ha^{-1} followed by Spinosad (50.31 Mt ha^{-1}), Azadirachtin (42.74tons/ha), and Jholmol (39.73 Mt ha^{-1}) respectively, and least under control plots (28.91 Mt ha$^{-1)}$. The superior yield and yield attributes resulted due to the minimum infestation of red pumpkin beetle and other insects, minimum leaf damage and severity percentage, and minimum fruit fly infestation which is the direct result of the greater efficacy of the insecticides evaluated.

The above findings are supported by the findings of (Pareek & Kavadia, 1988) who also observed the greater yield of muskmelon due to lower infestation of red pumpkin beetle and the fruit fly damaging the fruit. Similar findings were observed by Lakshmi, Ramchandra Rao, and Arjuna Rao, (2005) were one of the insecticides evaluated was the most effective in reducing the beetle population as well as in reducing the leaf damage thus resulting in increasing the yield of pumpkin crop. Mahato, (2017) in her experiment also observed that the highest yield in the plots with the most effective insecticides that were able to suppress the major insect's pests of cucumber.

Table 5: Effect of treatments on average fruit infestation per plant, the average length of fruit, the average diameter of fruit, and average yield (tons/ha) of fruit

Treatment Insecticides	Average fruit infestation %, Average length, diameter, and Yield(tons/ha) of fruit			
	Average fruit infestation %	Average Length of fruit (cm)	Average diameter of fruit (cm)	Average Yield (Mt ha$^{-1)}$
Imidachoropid	18.51a	37.63a	26.78a	52.11a
Spinosad	20.05a	37.12a	26.51b	50.31a
Azadirachtin	34.94b	34.47b	24.24c	42.74b
Jholmol	35.78b	34.33b	24.17c	39.73c
Control	68.31d	32.45d	23.12d	28.91d
F-test	***	***	**	***
LSD(0.05)	1.97	0.93	0.074	2.43
SEm(±)	0.64	0.30	0.30	0.79
CV%	3.59	1.71	0.60	3.69
Grand Mean	35.52	35.20	24.96	42.76

SEm: Standard error of means. LSD: Least significant difference. CV: Coefficient of variation. Means followed by the same letter in a column are not significantly different by DMRT at 5% level of significance. ns= Non-significant, *=significant at 5% probability level, **= significant at 1% probability, ***=significant at 0.1% probability

3.6 Economics of insecticides

The economic analysis of different treatments in the summer squash is shown in Table 7.

While working on the economics of insecticides, the highest incremental benefit was recorded in Imidachloropid (Rs.794220/ha) followed by

Spinosad (Rs.725260/ha), Azadirachtin (Rs.606090/ha), and Jholmol (Rs.548390/ha) respectively. Although the cost of Spinosad and Imidachloropid was comparatively higher than those of Azadirachtin and Jholmol, the yield obtained from those Imidachloropid and spinosad treated plots were significantly higher with a relatively higher total income as compared to those of Azadirachtin and Jholmol which counterbalanced the higher cost accompanied with its use. Thus, the incremental cost-benefit ratio was recorded highest in treatment Imidachloropid (4.21) and spinosad (3.58) followed by Azadirachtin (3.43) and Jholmol (3.22) respectively.

Table 7: Effect of insecticides on the total cost of cultivation (NRs. ha-1), gross return (NRs. ha-1), net return (NRs. ha-1), and B: C ratio

Treatments Insecticides	Total cost of cultivation (NRs. 000 ha^{-1})	Gross return (NRs. 000 ha^{-1})	Net return (NRs. 000 ha^{-1})	B: C ratio (NRs. 000 ha^{-1})
Imidachoropid	246.16	1042.20^{a}	794.22^{a}	4.21^{a}
Spinosad	280.99	1006.25^{a}	725.26^{b}	3.58^{b}
Azadirachtin	248.98	854.75^{b}	606.09^{c}	3.43^{b}
Jholmol	246.16	794.55^{c}	548.39^{d}	3.22^{c}
Control	243.66	578.15^{d}	334.49^{e}	2.3^{d}
F-test		***	***	***
LSD(0.05)		48.60	48.60	0.19
SEm(±)		15.77	15.77	0.062
CV%		3.69	5.24	3.68
Grand Mean	253.49	855.18	601.69	3.37

SEm: Standard error of means. LSD: Least significant difference. CV: Coefficient of variation. Means followed by the same letter in a column are not significantly different by DMRT at 5% level of significance. NS= Non-significant, *=significant at 5% probability level, **= significant at 1% probability, ***=significant at 0.1% probability

4. Relationship of Yield and Other Various Parameters

Correlation and regression analysis were employed to determine the relationship of yield with other parameters.

The result also showed a negative and strong correlation between the mean RPB and other insects population with yield i.e. with increment in the population of RPB and other insects, the yield decreases (Fig 3 and Fig 4). Similarly, the quadratic response between squash yield and average leaf infestation and leaf damage % per plant was found in the research with the coefficient of the determination being 0.9291which means that 92.92% of the yield was affected by the average leaf infestation and leaf damage % per plant and also negative and strong correlation (r=0.9291) was observed between yield and leaf infestation and leaf damage percentage (Fig 5 and Fig 6). Bardner, Maskwell, & Ross, (1970); Gould & Graham, (1969); Wilson, Treece, Shade, Day, & Strivers, (1969) also showed similar findings where linear regression yield on pest number, injuries, or injured plants was calculated. A similar relationship was observed between yield and average fruit infestation per plant (Fig 7) which was also supported by Miah Rubel, (2019) where a strong negative correlation between fruit infestation percentage and yield of squash was found. Likewise, the result showed a positive and strong correlation between fruit length and diameter with the yield (Fig 8 and Fig 9) and was in accordance with the findings of (Miah Rubel, 2019)

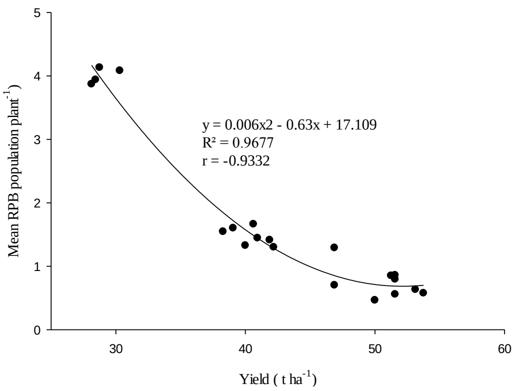

Figure 3: Relationship of yield and mean RPB population plant-1

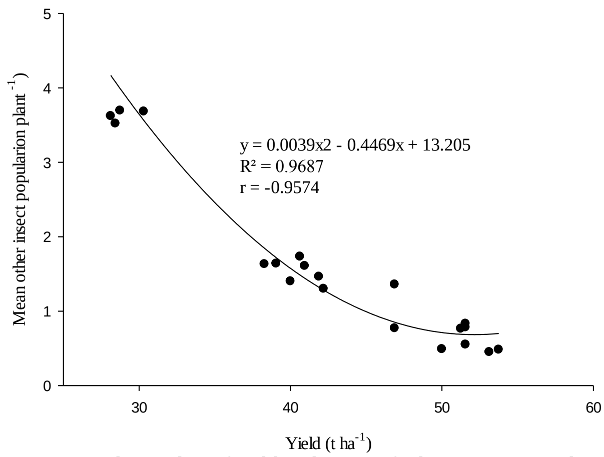

Figure 4: Relationship of yield and mean of other insects population plant-1

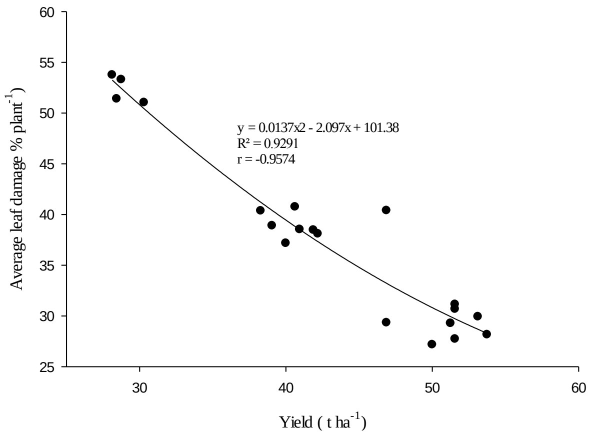

Figure 5: Relationship of yield and average leaf damage % plant-1

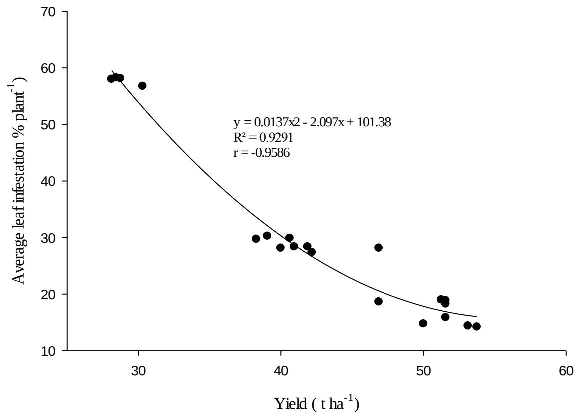

Figure 6: Relationship of yield and average leaf infestation % plant-1

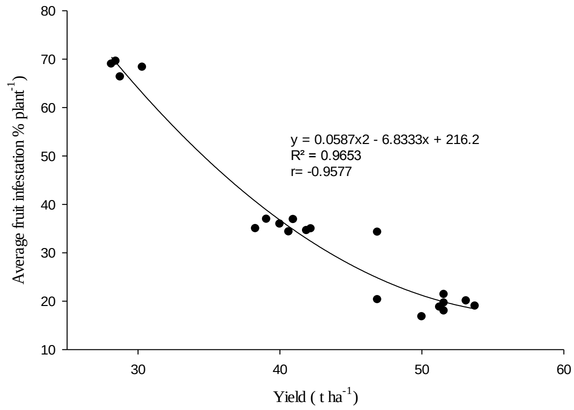

Figure 7: Relationship of yield and average fruit infestation plant-1

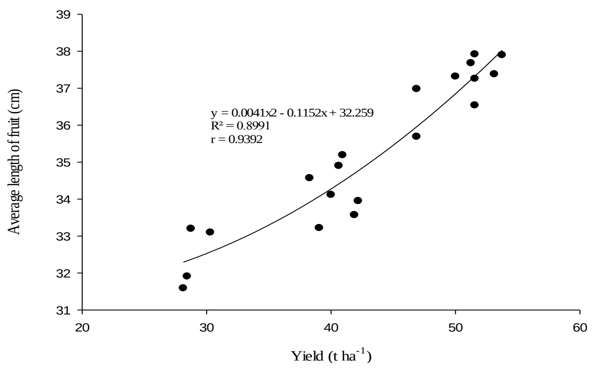

Figure 8: Relationship of yield and the average length of fruit (cm)

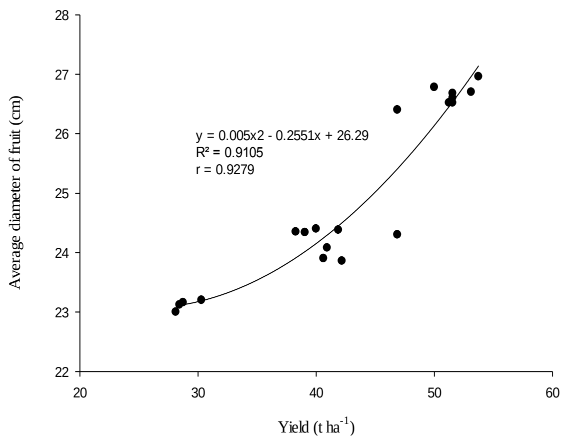

Figure 9: Relationship of yield and average diameter of fruit (cm)

5. Conclusion

All the insecticides evaluated were effective against the major insect pests of summer squash to some extent but Imidachloropid and spinosad were superior in terms of insect pest reduction and crop damage and yield attributes and yield. A higher benefit was obtained with the use of Imidachloropid for controlling the major pests of summer squash. Therefore, Imidachloropid and Spinosad can be recommended for the effective management of major insect pests of summer squash.

References

Abang A, Kouame C, Abang M, Hanna R, Fotso Kuate A. 2013. Vegetable grower's perception of pesticide use practices, cost, and health effects in the tropical region of Cameroon. International Journal of Agronomy and Plant Production, 1.

Ali H, Ahmad S, Hassan G, Amin A, Naeem M. 2011. Efficacy of Different Botanicals Against Red Pumpkin Beetle (*aulacophora foveicollis*) in Bitter Gourd (*momordica charantia l.*). Pak. J. Weed Sci. Res., 17(1), 65-71.

Aljedani DM. 2018. Assessment of Effectiveness of the Imidacloprid and Azadirachtin on Black Watermelon Bug. International Journal of Zoological Research, 14(2), 61-70. DOI: 10.3923/ijzr.2018.61.70

Asif M, Muhammad R, Akbar W, Tofique M. 2016. Relative Efficacy of Some Insecticides Against the Sucking Insect Pest Complex of Cotton. Nuclear Institute of Agriculture, Tandojam, Pakistan, 140-146.

Asim I, Amjad U, Maqsood S, Syed Sartaj A. 2017. Assessment of Indigenous Plant Extracts in Combination with Synthetic Insecticide and Wood Ash for The Management of Red pumpkin Beetle *aulacophora foveicollis* (*lucas*) (*chrysomelidae: coleoptera*) On Snake Melon (Cucumis Melo Var. Long Melon). Pak. J. Weed Sci. Res, 23(4), 379-386.

Bannayan M, Rezaei EE, Alizadeh A. 2011. Climatic Suitability of Growing Summer Squash (*cucurbita pepo L.*) as a Medicinal Plant in Iran. Notulae Scientia Biologicae, 3. Doi: https://doi.org/10.15835/nsb325846

Bardner R, Maskwell F, Ross G. 1970. Measurements of infestations of wheat bulb fly, *leptohylemyia coarctata* (Fall.), and their relationship with yield. PI. Path., 19, 82-87.

Bhowmik P, Mandal D, Chatterjee M. 2014. Chemical management of Melon fruit fly, Bactrocera cucurbitae Conquillett (Dipptera: Tephritidae) on Bitter Gourd (*momordica charantia linn.*). Pesticide Research Journal, 26(1), 68-73.

Caili F, Huan S, Li Q. 2006. A Review on Pharmacological Activities and Utilization Technologies of Pumpkin. Plant foods for human nutrition (Dordrecht, Netherlands), 61, 73-80. doi:10.1007/s11130-006-0016-6

Dangi N. 2006. Investigations on population dynamics of red pumpkin beetle. *A. Foveicollis (Lucas)* and its ecosafe management. Ph.D. Thesis submitted to Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan.

Dhillon M, Singh E, Naresh J, Sharma H. 2005. The melon fruit fly, *Bactrocera cucurbitae*: A review of its biology and management. Journal of insect science.

Elbert A, Nauen R, Leicht W. 1998. Imidacloprid, a Novel Chloronicotinyl Insecticide: Biological Activity and Agricultural Importance. In: Ishaaya I, Degheele D. (eds) Insecticides with Novel Modes of Action. Applied Agriculture. Springer, Berlin, Heidelberg. Doi: https://doi.org/10.1007/978-3-662-03565-8_4

Fayyaz U, Kausar A, Saeed K, Akhtar N. 2016. Diversity and relative abundance of insects (Arthropoda) in pumpkin plantations in District Haripur, Khyber Pakhtunkhwa, Pakistan. The Journal of Zoology Studies, 3(3).

Gould H, Graham C. 1969. The control of Aphis fabae Scop, on spring-sown field beans (*Vicia faba L.*). Ann. appl. Biol., 64, 1-10.

Gupta D, Verma A. 1995. Host-specific demographic studies of the melon fruit fly, *Dacus cucurbitae Coquillett (Diptera: Tephritidae)*. Journal of Insect Science, 8, 87-89.

Harry S. 2008. Summer squash. In Vegetables. Paris: Agricultural Research Organization, Department of Vegetable Crops, 351-379.

Hassan K, Uddin M, Haque M. 2012. Host Suitability of Red Pumpkin Beetle, *Aulacophora Foveicollis (Lucas)* Among Different Cucurbitaceous Hosts. Irjals, 1(4).

Iftikhar A, Sher A, Abdul H, Kamran J, Muhammad IJ, Abdul L, Shahzad AS. 2018. Efficacy of different botanical and synthetic insecticides on red pumpkin synthetic insecticides on red pumpkin beetle. Pure and Applied Biology, 8(1), 530-536.

Jasmine D, Prasai T, Pant S, Jayana B. 2008. Study on major pesticides and fertilizers used in Nepal. Scientific World, 6(6), 76-80.

Kaiser C, Ernst M. 2018. summer squash. University of Kentucky College of Agriculture, Food and Environment., Center for Crop Diversification.

Lakshmi M, Ramchandra Rao G, Arjuna Rao P. 2005. Efficacy of different insecticides against red pumpkin beetle, *Raphidopalpa foveicollis Lucas* on pumpkin, *cucurbita maxima duchesne.* J. Appl. Zool. Res., 16(1), 73-74.

Mahato S. 2017. Evaluation of Newer Insecticides on Pest Complex of Cucumber. Indian Agricultural Research Institute.

Miah Rubel M. 2019. The Thesis Submitted by Mr. Mohammad Rubel Miah to Department of Entomology Sher-E-Bangla Agricultural University.

MoAD. 2018/19. Statitistical Information on Nepalese Agriculture. Agri-business Promotion and Statistics Division, Ministry of Agriculture and Cooperatives, Kathmandu, Nepal. Retrieved from http://namis.gov.np/uploads/files/library/2018-04-24/015_Statistical%20Information%20on%20Nepalese%20Agriculture-2009.2010_Searchable.pdf

Nasiruddin M, Alam S, Khorsheduzzaman A, Rahman A, Karim A, Jasmine H, Rajotte E. 2004. Integrated management of cucurbit fruit fly. IPM

CRSP Bangladesh Site Technical Bulletin, 1, 16

Osman S, Uddin MM, Adnan SM. 2013. Assessment of the performance of different botanicals and chemical insecticides in controlling Red pumpkin beetle *Aulacophora foveicollis (Lucas)*. International Journal of Agricultural Science, 2(8).

Pareek B, Kavadia V. 1988. Economic insecticidal control of two major pests of musk melon, *Cucumis melo*, in the pumpkin beetle, *Raphidopalpa spp.* and the fruit fly, *Dacus cucurbitae* in Rajasthan, India. Tropical Pest Management, 34(1), 15-18.

Paris, H. 1996. Summer Squash: History, Diversity, and Distribution. Hort Technology, 6. Doi: 10.21273/HORTTECH.6.1.

Pessarakli M. 2016. Handbook of Cucurbits. USA: Boca Raton: CRC Press. Doi: https://doi.org/10.1201/b19233

Purohit BK. 2010. Assessment of novel insecticides against the insect pests against major insect pests of cucumber. The thesis submitted by Mr. Bharat Kumar purohit to the Maharana pratap university of Agriculture and Technology, Udaipur. MPUAT, Udaipur. Retrieved from http://krishikosh.egranth.ac.in/handle/1/5810027483

Rahman M, Uddin M. 2016. Comparative study on host preference damage potentiality of Red pumpkin beetle, *Aulacophora foveicollis* and *Epilachna beetles*, *Epilachna dodecastigma*. Research in Agriculture Livestock and Fisheries, 3(3), 411-416.

Rashid M, Khan M, Arif M, Javed N. 2014. Red Pumpkin Beetle, *Aulacophora foveicollis Lucas*; A Review of Host Susceptibility and Management Practices. Academic Journal of Entomology, 7, 38-54.

Ratnakar V, Vijayaraghavendra, Srinivasa R, Reddy, Padmasri A. 2016. Efficacy of Certain Insecticides to Red Pumpkin Beetle, *Aulacophora Foveicollis* on Cucumber, *Cucumis Sativus*. Progressive Research – An International Journal, 11(1), 478-480.

Sarwar M. 2014. Some Insect Pests (*Artropoda: Insecta*) of summer vegetables, their Identification, occurrence, damage and adoption of management practices. International Journal of Sustainable Agricultural Research., 1(4), 108-117.

Sharma DR. 2015. Status of Chemical pesticides use and their regulation in use in Nepal. Government of Nepal. Retrieved from http://www.npponepal.gov.np/uploads/files/Status%20of%20Chemical%20Pesticides%20and%20their%20use-%20Dr%20Dilli%20Ram%20Sharma.pdf

Sharma A, Rana C, Shiwani K. 2016. Important Insect Pests of Cucurbits and Their Management. CHAP, 327-360.

Srivastava K, Butani D. 1998. Pest Management in Vegetables Part- 1. Houston, Texas: Research Periodicals and Book Publishing House

Taylor W, Bardner R. 1968. Effects of feeding by larvae of *Phaedon cochleariae (F.)* and *Plutella maculipennis (Curt.)* on the yield of radish and turnip plants. Ann. appl. Biol, 62, 249-254.

Thapa R, Bista K, Bhatta M, Bhandari S, Sapkota B. 2019. Comparative Performance and Economic Efficiency of Different Pesticides Against Okra Jassids (*Amrasca Biguttula Biguttula*): Their Impact on Okra Yield and Growth Attributes. Journal of Entomology and Zoology Studies, 7, 525-531.

Waseem M, Nagangoud A, Patil B, Prabhuraj A, Hussain A. 2009. Efficacy of some insecticides against melon fly, *Bactrocera cucurbitae Coquillett* on cucumber. Karnataka J Agri Sci, 22, 701-702

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