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Eco-friendly management of cucurbit fruit fly, *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae) on cucumber in Kathmandu

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Abstract: An experiment on the efficacy of different compounds-local, commercial and botanical pesticides, along with chemical pesticide were conducted by using RCBD design against cucurbit fruit fly, Bactrocera cucurbitae (Coquillett), on cucumber with three replications and seven treatments under field conditions. Seven different treatments were used- i) Nimbecidine 0.03% @ 4 ml/litre of water; ii) Banana pulp bait (over ripe banana 500 g + 10 ml molasses + 10 g borax and 2.5 ml Malathion, replaced at 4 days interval); iii) Botanical pesticides 'Jholmol'-leaf extract with cow urine, fresh cow urine and spices (materials used-1 kg leaves of each: neem, tomato, titepati, sayapatri, chrysanthemum, gandhe jhar, bakaino and 200 gm of each garlic, chilli, ginger, salt and turmeric); iv) Neem extract (homemade-grinding of neem leaves and seed and extraction diluted with water in the ratio of 1:5); v) cow urine diluted with water in the ratio of 1:5 and sprayed; vi) Malathion @ 2ml/litre of water; and vii) control, only water sprayed. The highest marketable yield (17.35 mt/ha) was recorded in Jholmol treated plots, followed by Malathion and cow urine, respectively. Jholmol treated plots was found superior in terms of size, quality and self life of cucumber. Maximum Gross yield, better benefit cost ratio, the highest number of marketable fruit and the lowest damage yield were recorded in Jholmol treated plots as compared to all other treatments.

Keywords: *Bactrocera cucurbitae*, cucumber, botanical pesticides, Jholmol

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Cucumber (*Cucumis sativus* L.), a cucurbit crop, occupies fourth place in importance in the world, following tomato, cole crops and onion (Tatlioglu 1993) because of its short duration, high productivity, possibility of off-season cultivation and higher returns. In Nepal, total cultivated area under cucumber in FY 2012/2013 is 8,500 ha of total land with 1,24,262 mt production and 14.62 mt/ ha productivity (VDD 2012).

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Kathmandu contributes 212 ha in total cucumber area and 4925 mt in total production with productivity of only 23.23 mt/ha (VDD 2012). Cucumber is basically a summer season crop grown both in the hills and Terai region of Nepal (Shakya et al. 2006). In Nepal, cucumber production is high in summer season and low in winter season. There are number of factors limiting the production of cucurbits. As other crops in the Cucurbitaceae family, cucumber has many field problems, such as insect pests and diseases, deteriorated varieties and reduced fruit quality (FAO 2007).

Cucurbit fruit fly (*Bactrocera cucurbitae* Coquillett) is one of the serious problems that limits the production and productivity of cucumber. The extents of damage

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vary between 30 to 100% depending upon the season and susceptibility of the crops species and varieties (Dhillion et al. 2005). Pradhan (1976) reported that the degree of infestation varied from 19.4-22.1% in cucumber. It prefers to infest young, soft skinned ovaries even before anthesis. When the humidity is high, intensity of cucurbit fruit fly damage becomes severe. Its abundance increases with increase in daily temperatures, however higher than 31°C is not ideal for its growth and reproduction (Dhillion et al. 2005). Farmers of Nepal are also using different chemical insecticides to overcome this notorious insect pest but this method is not able to control the pest population completely because three of its life stages are hidden and the only adult stage is the usual target of the pest control activities. In this situation, alternative control measures such as botanical pesticides and cue-lure, as an integrated pest management (IPM) tool would be possible and viable options for the sustainable management of *B. cucurbitae* in Nepal.

MATERIALS AND METHODS

The experiment was carried out at Manamaiju VDC, Kathmandu, on Bhaktapur Local variety of cucumber. The experimental site lies in Mid-hills having temperate climate with an elevation of 1373 m. The experiment was conducted in randomized complete block design with 3 replications and 7 treatments. The treatments were: i) Nimbecidine 0.03% @ 4 ml/litre of water ii) Banana pulp bait (over ripe banana 500 g + 10 ml molasses + 10 g borax and 2.5 ml Malathion, replaced at 4 days interval); iii) Botanical pesticides 'Jholmol'-leaf extract with cow urine, fresh cow urine and spices (materials used-1 kg leaves of each: neem, tomato, titepati, sayapatri, chrysanthemum, gandhe jhar, bakaino and 200 gm of each garlic, chilli, ginger, salt and turmeric); iv) Neem extract (homemade-grinding of neem leaves and seed and extraction diluted with water in the ratio of 1:5); v) cow urine diluted with water in the ratio of 1:5 and sprayed vi) Malathion @ 2ml/litre of water; vii) control, only water sprayed.

The twenty seven days old seedlings were transplanted on 29 March, 2012 in plot size of 4.4 m × 2.9 m with planting distance of 1.5 m × 1.5 m and fertilizers were applied at the rate of 120:60:50 kg NPK/ha with FYM @ 20 mt/ha (Sharma et al., 2005). Three plants per plot were randomly selected in net area of experimental field for observation. The first pre-treatment observation was made before 24 hours of spraying at 57 days after transplanting (DAT); whereas the post treatment counts were taken after 3, 7 and 10 days of each spray. The 10 days counts formed pre-treatment counts for next spray. Treatments were applied on cucumber field after 58 DAT. The application was repeated at 10 days interval. Related to cucumber yield and yield attributes, plant height, no. of leaves, primary branches, secondary branches, male flower, female flower, no. of fruits (marketable and unmarketable) and weight of fruits (marketable and unmarketable) were taken into consideration.

The raw data obtained from field experiment were tabulated by using EXCEL and analyzed by using MSTATC software package. Duncan's multiple range test (DMRT) was used to compare the mean at 5% level of significance.

RESULTS AND DISCUSSION

Morphological characters of cucumber plants

There was significant effect of different treatments only on total number of female flowers per plant at maximum flowering stage (Table 1). Other parameters like plant height, number of leaves, primary branches, secondary branches, and number of male flowers were not significantly different. The highest number of female flower (14.89 flowers/plant) was recorded in banana pulp bait and the lowest female flowers in control (6.97 flowers/plant). This might be due to luring capacity of over ripe banana pulp, that different kinds of insects such as wasps, bees visited the flowers. Fuchs et al. (1970) reported that nutrients from mineral fertilizers and bio-pesticides enhanced the establishment of crops while those from the mineralization of organic matter promoted yield.

Cucurbit fruit fly damage at different stages

Very young and immature fruit damaged due to cucurbit fruit fly having less than 100 g weight is known as post set damage fruit. The average number of post set fruit weight damaged due to cucurbit fruit fly per plant differed significantly (Table 2). Out of total fruit set, more than one-third (34.45%) fruits were dropped or damaged just after fruit set (<100g). Number of post set damage fruit was significantly lower in homemade neem extract followed by Jholmol, Nimbecidine, cow urine, Malathion, banana pulp bait treated plots than control. The highest number of marketable fruit set of 11.44 (75.44%) was obtained in Jholmol treated plot and the lowest number of post set fruit was found in control 6.37 (47.18%). Significantly higher number of fruits (52.82%) were damaged just after fruit set (<100g) in control than Jholmol (24.56%) and Cow urine (27.96%) treated plots. Similarly, unmarketable fruit set due to fruit fly were significantly higher in control as compared to the other treatments. The cucurbit fruit fly favored the early stage of fruit and the infested fruit failed to develop properly and dropped off from the plants. Thus, from the above analysis the result revealed that the young and just after set fruits (< 100 g) were severely damaged.

Marketable and damage yield of cucumber

The total number of harvested fruits per plant differed significantly among the treatments. The total number of marketable fruits harvested per plant was significantly higher in Malathion (12.25 fruits/plant) followed by Jholmol (11.44 fruits/plant) treated plots which was almost double than that of control (6.86 fruits/plant). However, the result indicated that the lowest fruit damaged percentage was recorded in Jholmol (22.34%) treated

Table 1. Effect of different treatments on morphological character of cucumber

Treatments	**Plant height (cm)**	**Number of leaves per plant**	**Number of primary branches per plant**	**Number of secondary branch per plant**	**Number of male Flowers per plant**	**Number of female flowers per plant**	**Female Flower (%)**
Nimbecidine @4ml/L of water	145.20±14.28	64.58±7.33	54.39±5.03	35.01±6.44	24.10±5.031	7.983^{bc}±1.25	25.40^{b}±2.14
Banana pulp bait @350gm/2.5ml of malathion	167.39±24.91	87.39±15.52	61.39±6.26	48.78±4.95	24.44±7.02	14.89^{a}±3.56	39.11^{a}±3.12
Jholmol @ 1:5 ratio	145.11±24.96	75.33±9.18	54.00±5.50	35.56±7.69	19.89±3.23	8.79^{bc}±1.01	30.92^{b}±1.31
Neem Extract @ 1:5 ratio	154.78±20.19	79.89±12.20	53.44±10.58	42.78±7.89	28.64±4.70	11.91^{ab}±1.05	30.05^{b}±3.65
Cow Urine @ 1:5 ratio	183.56±30.08	100.89±25.13	70.44±10.51	42.51±7.78	28.24±3.76	13.78^{a}±2.98	32.16^{ab}±1.97
Malathion @ 2ml/L of water	148.33±7.00	74.22±7.80	52.22±6.68	31.44±2.02	24.10±6.35	11.14^{abc}±2.18	32.34^{ab}±1.65
Control	145.78±17.57	76.33±4.60	53.78±9.28	35.00±1.86	18.77±3.50	6.97^{c}±0.92	27.50^{b}±1.26
Grand mean	155.735	79.805	57.096	38.726	24.027	10.779	31.069
LSD at 0.05	NS	NS	NS	NS	NS	4.167**	7.081*
CV%	19.16%	25.70%	20.47%	18.69%	18.63%	21.73%	12.81%

CV: Coefficient of variation; LSD: Least Significant Difference; * indicates significant, ** indicates highly significant, NS indicates non significant at 0.05 level of significance, means followed by the same letter are not significant by DMRT at 5% level, values after ± indicate standard error

Table 2. Effect of different treatments in post set damage fruit of cucumber by fruit fly, Manamaiju-5, Kathmandu, 2012

Treatments	**Maketable fruit set (No.)**	**Fruit fly damaged fruit set (No.)**	**Total fruit set (No.)**	**Marketable fruit set (%)**	**Fruit fly damaged fruit set (%)**
Nimbecidine @4ml/L of water	7.62^{bc}±1.34	4.11^{b}±1.14	11.73±2.46	66.23^{e}±3.62	33.77^{bcd}±3.62
Banana pulp bait @350gm/2.5ml of malathion	9.86^{ab}±0.84	5.33^{b}±0.64	15.20±1.49	65.05^{abc}±0.82	34.95^{bc}±0.82
Jholmol @ 1:5 ratio	11.44^{a}±1.31	3.88^{b}±0.96	15.31±2.25	75.44^{ab}±2.60	24.56e±2.60
Neem Extract @ 1:5 ratio	6.37^{c}±1.13	3.87^{b}±0.98	10.23±2.03	62.90^{d}±2.85	37.10^{b}±2.85
Cow Urine @ 1:5 ratio	10.83^{a}±1.01	4.37^{b}±1.03	15.20±2.00	72.04^{a}±3.40	27.96^{de}±3.40
Malathion @ 2ml/L of water	10.25^{a}±0.91	4.47^{b}±0.70	14.72±1.59	69.98^{cd}±1.87	30.02^{cde}±1.87
Control	6.86^{c}±1.04	7.99^{a}±2.02	14.84±3.06	47.18^{bcd}±2.43	52. 82^{a}±2.40
Grand mean	9.032	4.859	13.891	65.546	34.454
LSD at 0.05	2.473**	2.595 *	NS	6.140**	6.140**
CV%	15.39%	30.02%	19.49%	5.27%	10.02%

CV: Coefficient of variation; LSD: Least Significant Difference; * indicates significant, ** indicates highly significant, NS indicates non significant at 0.05 level of significance, means followed by the same letter are not significant by DMRT at 5% level, values after ± indicate standard error plots and the highest in Neem extract (34.29%) treated plots. This can be illustrated that though the harvested number of fruits were higher in Malathion they were smaller in size and of low quality but in Jhomol treated plots fruits were larger and of better quality (long self-life) (Table 3).

The scrutiny of data revealed that weight of marketable fruit differed significantly (Table 4). The total marketable fruit weight (17.35 mt/ha) was higher in Jholmol treated plots as compared to control (4.64 mt/ha) that was more than four times higher in Jholmol treated plots. Similarly, out of total fruit weight (21.85 mt/ha), only (4.50 mt/ha) of fruit was damaged due to fruit fly in Jholmol treated plot that was slightly higher damaged fruits than in Malathion treated plots (4.47 mt/ha). Lower damage fruit weight (3.62 mt/ha) was found in Nimbecidine treated plot that was nearly two times lower (5.21 mt/ha) than in control plots. The result indicated that out of total fruit harvested 70.07% fruits were marketable and rest fruits damaged due to fruit fly. Some studies reported that fruit borer populations were consistently lower with the application of eco gold, garlic extract and neem extract (Titiloye 1982). Similar results from other studies in Asia and parts of Africa support these findings (FAO 2003). Malathion treated plot produced highest marketable fruits (79.50%) which was slightly higher than in jholmol treated plots (79.40%) but very low in control (47.12%) plots. Thus, more than 50% (52.88%) fruit was damaged by fruit fly in control plots. It was also noted that the grower preference and consumer accessibility played an important role in selecting fruit size. In general, 300-1200 g weight fruits were harvested as marketable fruits depending upon the environment, management factors and grower's preference. The productivity of cucumber was lower in different treatments. This might be due to less number of marketable fruit per plant and its weight, short duration of crop, lesser number of harvests and lesser number of female flowers

There was higher productivity in Jholmol treated plot. This might be due to less number of fruit fly damage and large size fruits might be due to the

Table 3. Effect of different treatments on total number of harvested and marketable fruits of cucumber, Manamaiju-5, Kathmandu, 2012

Treatments	Total number of fruits/plant			Marketable fruits (%)	Unmarketable fruits (%)
	Harvested	Marketable	Unmarketable		
Nimbecidine @4ml/L of water	145.20±14.28	64.58±7.33	54.39±5.03	35.01±6.44	24.10±5.031
Banana pulp bait @350gm/2.5ml of malathion	167.39±24.91	87.39±15.52	61.39±6.26	48.78±4.95	24.44±7.02
Jholmol @ 1:5 ratio	145.11±24.96	75.33±9.18	54.00±5.50	35.56±7.69	19.89±3.23
Neem Extract @ 1:5 ratio	154.78±20.19	79.89±12.20	53.44±10.58	42.78±7.89	28.64±4.70
Cow Urine @ 1:5 ratio	183.56±30.08	100.89±25.13	70.44±10.51	42.51±7.78	28.24±3.76
Malathion @ 2ml/L of water	148.33±7.00	74.22±7.80	52.22±6.68	31.44±2.02	24.10±6.35
Control	145.78±17.57	76.33±4.60	53.78±9.28	35.00±1.86	18.77±3.50
Grand mean	155.735	79.805	57.096	38.726	24.027
LSD at 0.05	NS	NS	NS	NS	NS
CV%	19.16%	25.70%	20.47%	18.69%	18.63%

CV: Coefficient of variation; LSD: Least Significant Difference; * indicates significant, ** indicates highly significant, NS indicates non significant at 0.05 level of significance, means followed by the same letter are not significant by DMRT at 5% level, values after ± indicate standard error

Table 4. Effect of different treatments on total weight of cucumber fruit, Manamaiju-5, Kathmandu, 2012

Treatments	Unmarketable fruit weight (mt/ha)	Marketable fruit weight (mt/ha)	Total fruit weight (mt/ha)	Marketable fruit weight (%)	Unmarketable fruit weight (%)
Nimbecidine @4ml/L of water	3.62±0.46	8.61^{cd}±2.24	12.23^{b}±2.70	70.41	29.59
Banana pulp bait @350gm/2.5ml of malathion	4.57±0.70	10.87^{bc}±1.02	15.45^{ab}±1.72	70.40	29.60
Jholmol @ 1:5 ratio	4.50±0.58	17.35^{c}±1.35	21.85^{a}±1.92	79.40	20.60
Neem Extract @ 1:5 ratio	3.70±0.32	7.76^{cd}±1.44	11.46^{b}±1.76	67.69	32.31
Cow Urine @ 1:5 ratio	4.89±0.58	15.50^{ab}±2.20	20.40^{a}±2.78	76.00	24.00
Malathion @ 2ml/L of water	4.47±0.52	17.34^{a}±1.55	21.81^{a}±2.04	79.50	20.50
Control	5.21±0.51	4.64^{d}±0.41	9.86^{b}±0.89	47.12	52.88
Grand mean	4.42	11.73	16.15	69.88	30.12
LSD at 0.05	NS	1.05**	1.40**	8.48**	8.48**
CV%	21.44%	22.34%	21.50%	3.51%	8.15%

CV: Coefficient of variation; LSD: Least Significant Difference; * indicates significant, ** indicates highly significant, NS indicates non significant at 0.05 level of significance, means followed by the same letter are not significant by DMRT at 5% level, values after ± indicate standard error nutrient enriched leaf extract 'Jholmol' sprays. The plant materials used in Jholmol were rich source of nutrients, such as titepati (Artimisia vulgaris Mugwort) contains 2.4:0.42:4.1 (%) $N:P_2O_5:K_2O$, neem (Azadirachta indica A. Juss.) contains 2.83:0.28:0.35 (%)$N:P_2O_5:K_2O$ and cow urine contains 0.8:0.12:0.7 (%)$N:P_2O_5:K_2O$ (Palaniappan and Annadurai, 2006). Furthermore, the result is also supported by Sapkota et al. (2010) findings. She reported that 'Jholmal' contains nutrient enriched supplements for fruit growth and development, and the decomposed plant materials might have repelled or destroyed the successful life cycle of cucurbit fruit fly resulting in reduced fruit damage by this pest. Earlier studies have also reported that the application of 'Jholmal' increased the quality and yield of vegetables (Khatiwada and Pokhrel, 2004).

In Malathion treated plots also, marketable fruit weight (17.34 mt/ha) was very similar with Jholmol (17.35 mt/ha) treated plots and percent of marketable fruit weight was higher in Malation (79.50%) than jholmol (79.40%). This might be due to less infestation of fruit fly as Malathion smell is irritating, fruit fly might be distracted. From the above data, we can say that although Malathion is good for the management of fruit fly, it harms the health of human, wildlife, pollute soil, water as well as whole environment. Thus, Jholmol can be the better option for its management.

Conclusions

The finding of the experiment revealed that the cost effective botanical pesticides 'Jholmol' treated plots gave superior yield. There was less damaged fruit yield due to cucurbit fruit fly in Jholmol treated plots than all other treatments. Thus, Jholmol; biorational compound which can be alternative options to chemical pesticides in eco-friendly management of fruit fly.

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