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Comparing the efficacy of bio-pesticides versus chemical pesticide against leafhoppers (*Empoasca kraemeri*) in Cowpea (*Vigna unguiculata*) under field condition in Summer Season in Chitwan, Nepal

Roshan Dhakal[1*], Suman Bhattarai[1], Sushma Paneru[1], Sushmita Sharma[1], Dija Bhandari[1], Pooja Dhakal[1] and Rajendra Regmi[2]

[1]Faculty of Agriculture, Agriculture and Forestry University, Chitwan, Nepal
[2]Department of Entomology, Agriculture and Forestry University, Chitwan, Nepal
wrotsan@gmail.com

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Abstract

Leafhopper (Empoasca kraemeri) is one of the key pests of cowpea. Along with the growing use of chemical pesticide, several research works had been done to examine their efficacy to reduce the key pests of cowpea. Not only emphasizing the chemical pesticide, this paper has checked and compared the efficacy of chemical pesticides with bio-pesticides against leafhopper. For the experiment, treatment namely Jholmol (125ml/L), Neem (Azadiracta indica) extract (2ml/L) and Cannabis extract (100g/L) as bio-pesticides, Chloropyrifos 50% EC and Cypermethrin 5% EC (2 ml/L) as chemical pesticide along with control was assigned and the research was conducted in the horticulture research field of Agriculture and Forestry University, Chitwan, Nepal in 2018. The experiment was laid out in Randomized Block Design (RBD) with five treatments i.e. four insecticidal treatments and one untreated control in four replications. The results showed that all the insecticidal treatment was found significantly efficient over the control. From the three insecticidal application, it was found that chemical pesticide showed highest control on leafhopper which is at par with Neem extract, followed by Cannabis extract and Jholmol. But yield of cowpea was found significantly highest in Neemix application (100.7qt/hac) at par with chemical pesticide (93.75qt/ha) amongst the insecticidal treatment, while lowest in control (68.6qt/hac). Similarly, the highest net profit and lowest incremental cost/benefit ratio was obtained in Neem extract treatment followed by chemical pesticide, Jholmol and Cannabis extract. It showed that the use of bio-pesticide like Neem extract can replace the chemical pesticides providing better yield and efficiency.

Keywords: Leafhopper (Empoasca kraemeri), neem extract (Azadiracta indica), efficacy, bio-pesticides, chemical pesticide.

Introduction

Cowpea (*Vigna unguiculata*) popularly known as black-eye pea, is grown both as summer and in rainy season crop in Nepal. It belongs to the family leguminosae, sub family fabaceae and genus Vigna. It is grown mainly for green pods, dry seeds and fodder. Dry seeds are rich in protein (23%-28%). Therefore, it is called as vegetable meat.

Insect damage is regarded as the major constraint for the production of cowpea grains[1]. The key pests of cowpea include Aphids, leafhoppers, Sucking bugs and Pod borers which affect 90% plants of total according to the field study[2]. Besides the reduction in the quantity produced degradation in quality as well as spread of diseases is high in cowpea due to these insect pests. Jassids or leafhoppers (*Amarasca kerri*, *Empoasca kraemeri*) belonging to Hemiptera order cause injury to the cowpea due to loss of sap and probably also due to the injection of toxins. Both the nymphs and adults pierce the plant issues and suck the cell sap. Initial damage is yellowing of leaf margins followed by curling up. At later stage, the margin of the leaf broken and crumble into pieces when crushed i.e. the leaves dried up as well as shed and finally the growth of the crop is retarded[3].

For controlling these sucking insects farmers mostly rely on the chemical insecticides due to their prompt action[4]. The resultant of the extensive use of insecticides include various health hazard problems, resistance development in insects, resurgence of secondary pest, environmental pollution and interruption of natural balance[5]. Therefore, for controlling these sucking insect pests various alternative methods are to be used[6]. As an alternative, plant derivatives and bio-pesticides are highly suggested over synthetic insecticides to control insect pests since they contain huge proportion of bio-active compounds[7]. Plant derivatives and bio-pesticides are those forms of pesticides which are based on plant and natural products respectively. These are also considered as eco-friendly since their biodegradability is high, persistence level is low and least toxic to non-target organisms, as well as these are highly economic and are easily available. At present, insecticidal activities are known on about 200 plants[8].

Various literatures were taken into consideration for analyzing the effectiveness of various insecticides against major pests of Cowpea[9-15]. Almost all the literature had discussed about the effectiveness of either chemical insecticides or the bio-pesticides on the insect control and plant production. Still there are few literatures comparing the effectiveness of chemical and bio-pesticides under the field condition which could help and suggest the farmers in the today's scenario of pesticide overuse causing deterioration of health and environment. So, with the objective to check and compare the relative effectiveness of plant derivatives and bio-pesticides versus the chemical insecticide research has been conducted on cowpea against leaf hoppers. Under chemical method, combination of both systemic and contact insecticide was used i.e. Chloropyrifos 50% EC and Cypermethrin 5% EC whereas under bio-pesticides, extract of different plants (*Azadiracta indica* and *Cannabis sativum*) and Jholmol were used separately.

Methodology

Experiment site and design: The present experiment on comparing the efficacy of bio-pesticides versus chemical pesticide against leafhoppers was carried out at horticultural research field of Agriculture and Forestry University on cowpea of karma stick-less variety. The experimental field was at the geographical location of 27^0 37' N latitude, 84^0 25' E longitude at an altitude of 256 meter above sea level and has a sub tropical climate [16]. The experiment was carried out under field condition during summer season. The seed was sown on 30th March and crop growing period was about 3 months.

The experiment was laid out in simple Randomized Block Design (RBD) with five treatments including untreated control, each replicated four times. 50 cm wide border was left around the experimental field and 1m in between the blocks. Plot size is of 9 sq. m. area maintaining row to row and plant to plant distance of 60 cm and 60 cm, respectively.

Agronomic practices: For the prevention of weed infestation and for the moisture conservation in the field, mulching was practiced[17]. Different intercultural practices like gap filling, thinning, weeding, irrigation practices were done in the field in the required time according to the need of the crop.

The plant derived insecticides such as Cannabis extract, Neem (*Azadiracta indica*) extract, bio-pesticide like Jholmol and chemical insecticide like chloropyrifus 50% EC and cypermethrin 5% were used as different treatments in the experiment (Table-1).

For the use of cannabis extract as insecticides, at first it's leaves were dried and then grinded on the floor, mixed with water at 100g/l and applied in the respective treatment plot assigned as T_1 through knapsack sprayer. *Cannabis* has been used as a pest repellent and pesticide in various formulations [18]. Similarly, for Jholmol preparation, animal urine, animal dung and water was mixed in 1:1:1 ratio and fermented for 2-3 weeks to form a slurry liquid and for the application, obtained slurry was mixed with water at 1:8 concentration (125ml/litre) and applied in the respective treatment plot assigned as T_3 through knapsack sprayer Neem extract with trade name "Neemix" and Chloropyrifos 50% EC and Cypermethrin 5% EC were commercially obtained agitating with water to make the required concentration (Table-1) and applied in the treatment plot assigned as T_2 and T_4 respectively through knapsack sprayer. The treatments with biological origin were jholmol, neem extract, cannabis extract) and chemical origin was Chloropyrifos 50 % EC and Cypermethrin 5 % EC. Treatment of chemical origin was applied at fortnight interval and of biological origin were applied at weekly interval.

Table-1: Name of treatments used in experiment and their concentrations.

Treatment no.	Treatment name	Concentration	Origin or Derivates
T_1	Cannabis extract	100gm/l	Plant
T_2	Neem extract (Trade name: Neemix)	2ml/l	Plant
T_3	Jholmol	125ml/l	Animal
T_4	Chloropyrifos 50% EC and Cypermethrin 5% EC	3ml/l	Chemical
T_5	Control(water)	--------	------

Data collection: Out of total 25 plants planted in each plot, 5 were selected as sample plant and tagged for the data collection. The insect population was counted by visual counting method on 3rd, 5th and 7th days after the insecticide application. The sucking pest leafhoppers were counted randomly from top, center and base side of the plant from the tagged plants[19]. The crop was harvested at the maturity stage and pod yield of the tagged plant in the plot was recorded and the pod yield was converted into quintal per hectare and the recorded data was analyzed. The data of leafhopper count could not fit the assumptions of analysis of variance so it was transformed by square root transformation according to Gomez and Gomez[20].

Economic analysis: For the economic analysis, cost of insecticides were recorded i.e. Neem extract (Neemix): $1.39 for 100 ml, Cannabis extract: $ 0.3/kg, Jholmol: $ 0.43/L and Chemical (Chlorophyriphos 50% EC and Cypermethrin 5% EC)=$ 1.74 for 100ml., Labor charge: $ 8.71 /ha , Market price of cowpea: $ 0.21/kg pod. Similarly, net profit was calculated separately by subtracting the cost of treatment from additional income of respective treatment. The incremental cost/benefit was calculated separately for each treatment according to the following formula:
According to Chejara[21], Incremental Cost-Benefit ratio (ICBR) = Cost of treatment / Net profit,

Statistical analysis: The transformed data of leafhopper count, yield, net profit and ICBR was statistical analyzed with the help of Microsoft Excel and R stat package.

Results and discussion

To compare the efficacy of different insecticides against leafhopper, evaluation was carried out under the basis of leafhopper count, yield and economic efficiency.

Leafhopper count per plant in cowpea: Leafhopper count was done on 3rd, 5th and 7th day after each insecticidal application. There was three insecticidal application which is represented below.

1st insecticidal application: After the 1st insecticidal application, the leafhopper count from each insecticidal treatment was found significantly lower than the untreated control (Table-2). At the 3rd day after the 1st insecticidal application, the leafhopper count was found significantly lowest in Chloropyrifos 50% EC and Cypermethrin 5% EC with the value of 1.41 which was at par with Neem extract. Similarly, the leafhopper count had been found significantly higher in Jholmol and Cannabis extract.

At the 5th day after the 1st insecticidal application, all the insecticidal treatment was found significantly similar on the basis of leafhopper count.

Similarly at the 7th day after the 1st insecticidal treatment, Chloropyrifos 50% EC and Cypermethrin 5% EC and Neem extract had the significantly lower values for leafhopper count whereas Cannabis extract and Jholmol had the significantly higher values amongst the insecticidal treatment.

While overall checking the efficiency of all insecticidal treatments after the 1st spray, Chloropyrifos 50% EC and Cypermethrin 5 % EC was found significantly superior amongst all the insecticidal treatments which was at par with Neem extract and followed by Cannabis extract and Jholmol.

2nd insecticidal application: After the 2nd insecticidal application, the leafhopper count from each insecticidal treatment was found significantly lower than the untreated control (Table-3). At the 3rd day of 2nd insecticidal application, the leafhopper count (1.017) was found significantly lowest in Chloropyrifos 50% EC and Cypermethrin 5% EC which was followed by Neem extract, Cannabis extract and Jholmol among the insecticidal treatments.

At the 5th day of 2nd spray, similar result was obtained; Chloropyrifos 50% EC and Cypermethrin 5% EC had significantly least leafhopper count (4.38) which was at par with Neemix and Cannabis extract and followed by Jholmol.

Similarly at the 7th day of spray also, number of leafhopper was found significantly lowest in Chloropyrifos 50% EC and Cypermethrin 5% EC and Neem extract which was followed by Cannabis extract and Jholmol. While overall checking the efficiency of all insecticidal treatments after the 2nd spray, Chloropyrifos 50% EC and Cypermethrin 5% EC was found significantly superior amongst the insecticidal treatments and followed by Neem extract, Jholmol and Cannabis extract.

Table-2: Leafhopper count per plant in Cowpea after 1st spray of insecticide.

Insecticides	Leafhopper count per plant			
	3rd day after 1st spray	5th day after 1st spray	7th day after 1st spray	Mean
Cannabis extract	2.45 ^{b} (1.72)	1.57 ^{b} (1.44)	3.46 ^{ab} (1.99)	2.45 ^{b} (1.72)
Neem extract (Trade name: Neemix)	2.09 ^{bc} (1.61)	1.43 ^{b} (1.39)	3.03 ^{b} (1.88)	2.15 ^{bc} (1.63)
Jholmol	2.74^{b} (1.80)	2.09 ^{ab} (1.61)	3.74 ^{ab} (2.06)	2.81 ^{b} (1.82)
Chloropyrifos 50% EC and Cypermethrin 5% EC	1.41^{c} (1.384)	0.96 ^{b} (1.21)	2.49 ^{b} (1.73)	1.57 ^{c} (1.44)
Control(water)	3.8^{a} (2.09)	3.78 ^{a} (2.07)	4.88 ^{a} (2.32)	4.16 ^{a} (2.16)
Grand mean	1.72	1.55	2.0	1.75
SEM	0.06	0.1	0.07	0.06
CV(%)	10.1	20.2	12.8	9.6
$LSD_{0.5}$	0.27	0.483	0.394	0.261

Means with the same letter do not differ significantly at p= 0.05 by DMRT. CV = Coefficient of variation. LSD= least significant difference, SEM= Standard error of mean. The figures in the parentheses are the square root transformed values.

3rd insecticidal application: After the 3rd insecticidal application, the leafhopper count from each insecticidal treatment was found significantly lower than the untreated control (Table-4). At the 3rd day of 3rd insecticidal application, the leafhopper count was found significantly lowest in Chloropyrifos 50% EC and Cypermethrin 5% EC which was followed by Neem extract, Cannabis extract and Jholmol among the insecticidal treatments.

At the 5th day of 2nd spray, similar result was obtained ; Chloropyrifos 50% EC and Cypermethrin 5% EC had significantly lower leafhopper count (1.24) which was at par with Neemix and Cannabis extract and followed by Jholmol amongst all the insecticidal applications.

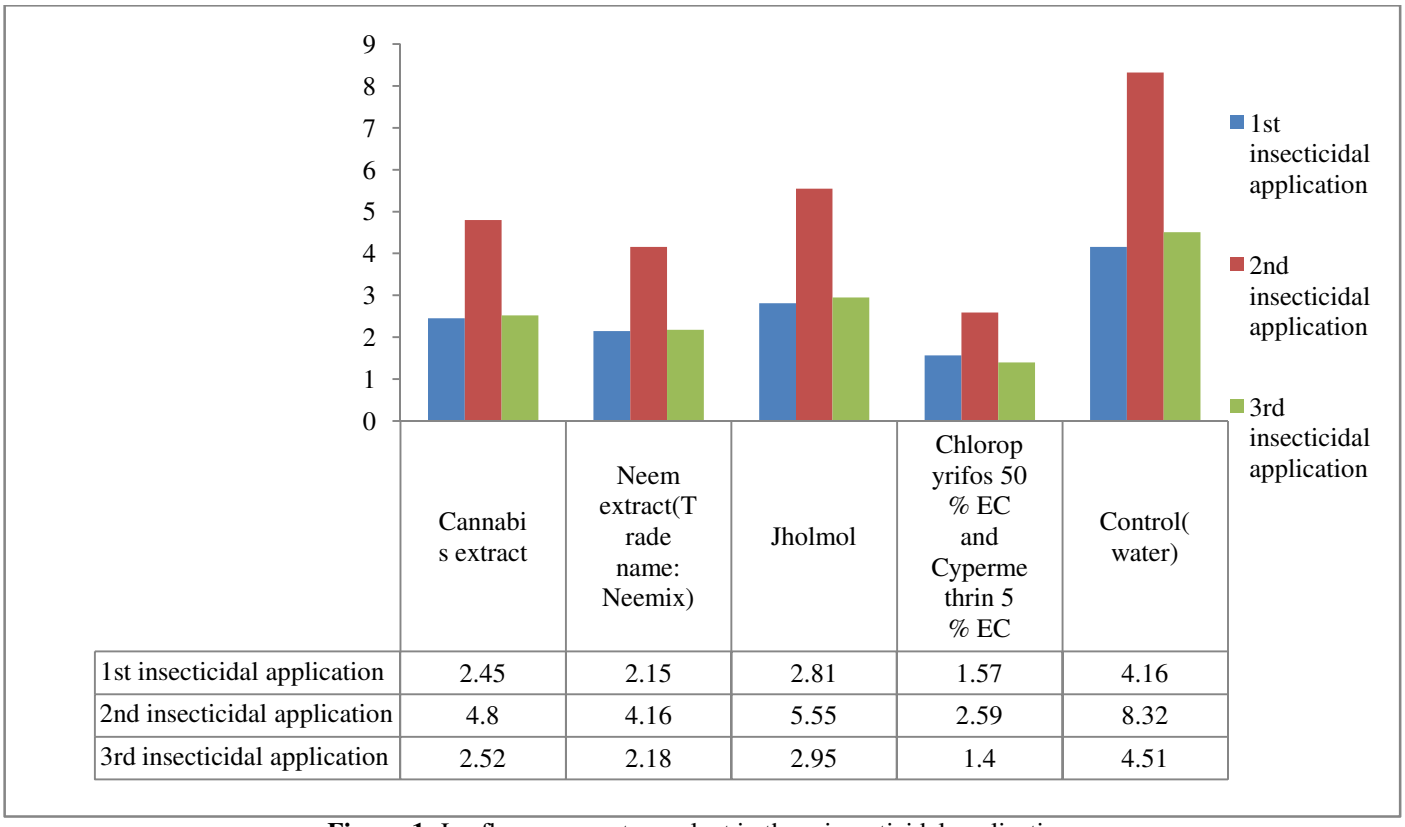
Similarly at the 7th day of spray also, number of leafhopper was found significantly lowest in Chloropyrifos 50% EC and Cypermethrin 5% EC and Neem extract which is followed by Cannabis extract and Jholmol. While overall checking the efficiency of all insecticidal treatments after the 3rd spray , Chloropyrifos 50% EC and Cypermethrin 5% EC was found significantly superior amongst the insecticidal treatments which was at par with Neem extract and followed by Cannabis extract and Jholmol.

Table-3: Leafhopper count per plant in Cowpea after 2nd spray of insecticide.

Insecticides	Leafhopper count per plant			
	3rd day after 2nd spray	5th day after 2nd spray	7th day after 2nd spray	Mean
Cannabis extract	2.63 [b] (1.77)	6.10 [bc] (2.57)	6.15 [ab] (2.58)	4.8 [b] (2.31)
Neem extract (Trade name: Neemix)	2.12[b] (1.62)	5.50 [bc] (2.45)	5.30 [b] (2.41)	4.16 [b] (2.16)
Jholmol (Bio pesticide)	3.26[b] (1.94)	7.11[b] (2.76)	6.79 [ab] (2.7)	5.55 [b] (2.46)
Chloropyrifos 50 % EC and Cypermethrin 5 % EC	0.53 [c] (1.017)	4.38[c] (2.21)	3.78 [b] (2.07)	2.59 [c] (1.76)
Control(water)	5.55[a] (2.46)	10.39[a] (3.30)	9.29 [a] (3.13)	8.32[a] (2.97)
Grand mean	1.76	1.77	2.58	2.34
SEM	0.12	0.105	0.09	0.105
CV	14.5	10.2	10.1	9.57
$LSD_{0.5}$	0.394	0.419	0.40	0.345

Table-4: Leafhopper count per plant in Cowpea after 3rd spray of insecticide.

Insecticides	Leafhopper count per plant			
	3rd day after 3rd spray	5th day after 3rd spray	7th day after 3rd spray	Mean
Cannabis extract	3.03 [b] (1.88)	2.15 [b] (1.63)	2.45 [b] (1.72)	2.52 [b] (1.74)
Neem extract(Trade name: Neemix)	2.59[b] (1.76)	1.87 [bc] (1.54)	2.12 [bc] (1.62)	2.18[bc] (1.64)
Jholmol (Bio pesticide)	3.62[b] (2.03)	2.52[b] (1.74)	2.81[b] (1.82)	2.95 [b] (1.86)
Chloropyrifos 50 % EC and Cypermethrin 5 % EC	1.43 [c] (1.39)	1.24[c] (1.32)	1.54 [c] (1.43)	1.40 [c] (1.38)
Control(water)	5.75[a] (2.50)	3.86[a] (2.09)	4.07 [a] (2.14)	4.51[a] (2.24)
Grand mean	1.76	1.66	1.75	1.77
SEM	0.12	0.07	0.06	0.07
CV	14.5	9.86	9.53	9.82
$LSD_{0.5}$	0.394	0.253	0.257	0.269



	Cannabis extract	Neem extract(Trade name: Neemix)	Jholmol	Chloropyrifos 50 % EC and Cypermethrin 5 % EC	Control(water)
1st insecticidal application	2.45	2.15	2.81	1.57	4.16
2nd insecticidal application	4.8	4.16	5.55	2.59	8.32
3rd insecticidal application	2.52	2.18	2.95	1.4	4.51

Figure-1: Leafhopper count per plant in three insecticidal application.

Chloropyrifos 50% EC and Cypermethrin 5% EC and Neem extract was found to be the most efficient than other insecticides on controlling leafhopper (Figure-1). Chloropyrifos 50% EC and Cypermethrin 5% EC is a special combination insecticide contains organophosphorus compound as chloropyrifos and pyrethroid compound as cypermethrin having a special efficiency to control a wide range of insects of different habitats. Similarly neem (*Azadiracta indica*) contains special complex called Azadirachtin which act as repellent, deterrent, anti-ovipositional and growth inhibitors against insect pests[9,10].

Similar type of results were obtained by Rashid et al.[22] ,who revealed that neem seed water extract at 3% and neem oil at 2 and 3% concentration was very effective against the tested pest like leafhopper amongst the different insecticidal treatment. Similarly, Mansoor et al.[23] observed that significant control of aphids, thrips and leafhopper was achieved by the application of neem samples and also prolonged their nymphal period. Application of Jholmol and Cannabis extract was found less efficient than other insecticidal treatments, but significantly efficient over the control.

Yield of cowpea: The pod yield of cowpea was found significantly higher in all insecticidal treatment over the control. Neem extract produced the highest pod yield of 100.7 qt/hac which was significantly higher than the other all treatments. The chemical treatment and Jholmol was significantly similar to Neem extract with the yield of 93.75 qt/hac and 83.3 qt/hac respectively (Table-5). Among the insecticidal treatment, Cannabis extract produced lowest yield but was significantly superior over the control. The similar type of trend is obtained from the effectiveness of the insecticide's treatments on the basis of leafhopper count.

Botanical insecticides offers safer and much better approach for insect pest management programs compared to synthetic insecticides[24]. Similar result were obtained by Khattak et al.[9] who reported that cotton treated with neem extracts and insecticidal combinations gave significantly more yield controlling major insect pests like leafhopper and whitefly as compared to untreated control. Similarly, Deling et al.[11] obtained more yield from the cotton treated with azadirachtin than other insecticides. Baidoo and Agbonu[12] reported that neem products were effective in controlling sucking pests on cowpea.

Economics of insecticidal application: Amongst all the insecticidal treatments, the highest net profit of $536.35 was obtained in Neem extract was followed by chemical treatment ($401.59), Jholmol ($311.48) and cannabis extract ($145.20). Among the insecticide's treatment, lowest incremental Cost/Benefit ratio (1/3.14) was obtained in Neem extract and followed by chemical treatment (1/2.85), jholmol (1/1.12) and cannabis extract (1/0.85) which shows that Neem extract was the most economically efficient than other insecticidal treatments (Table-6).

Table-5: Effects of different insecticides on the pod yield of Cowpea.

Treatments	Dose	Yield (qt/hac)
Cannabis extract	125ml/ltr	83.3^{b}
Neem extract(Neemix)	2ml/ltr	100.7^{a}
Jholmol	100gm/ltr	95.83^{ab}
Chloropyrifus 50 %EC and Cypermethrin 5 %EC	2ml/ltr	93.75^{ab}
Control (water)		68.8^{c}
CV %		10%
$LSD_{0.5}$		13.69

(Means with the same letter donot differ significantly at p= 0.05 by DMRT . CV = Coefficient of variation , LSD= least significant difference).

Table-6: Economics of different insecticides applications against leafhopper on cowpea.

Treatments	Cost of treatments	Yield	Average yield of produce	Gross return over control	Net profit over control	ICBR
	($/ha)	(qt/ha)	($/hac)	($/ha)	($/hac)	
Cannabis extract (Ganja)	170.06436	83.3	1811.18	315.27	145.20	01:00.8
Neem extract (Neemix)	157.24474	100.7	2189.51	693.59	536.35	01:03.4
Jholmol	276.22195	95.83	2083.62	587.71	311.48	01:01.1
Chloropyrifus 50 EC and Cypermethrin EC	140.89407	93.75	2038.39	542.48	401.59	01:02.9
Control (water)	-	68.8	1495.91	-		

Similar findings were concluded by Jackai[25] and Singh et al.[26] who explained that the use of neem extract has been intensified and beneficial as it is relatively cheap, available and effective whereas the conventional insecticides like using chemical insecticides require high cost and not easily available in all places.

Conclusion

Neem extract and chemical control method was found more effective insecticide against cowpea leafhopper. Neem extract treated plot produced higher yield and more economic returns than the other insecticidal treatments. Also, the other plant extracts like Cannabis extract and bio-pesticide like Jholmol were also found relatively efficient insecticides, so their commercialization is necessary for pest control. Chemical method being costly ,risky for health and environment and timely not available in most of rural areas, use of these plant extracts and bio-pesticides can be emphasized as they can be locally made by the farmers and sustainable in nature since they reduce the pest population without harming the predators.

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References

1. Ehlers J.D. and Hall A.E. (1997). Cowpea (Vigna unguiculata L. Walp.). *Field crops research*, 53(1-3), 187-204.

2. Karungi J., Adipala E., Kyamanywa S., Ogenga-Latigo M.W., Oyobo N. and Jackai L.E.N. (2000). Integrating planting time, plant density and insecticide application for management of cowpea field insect pests in eastern Uganda. *Crop Protect*, 19, 237-245.

3. Abro G.H., Syed T.S., Tunio G.M. and Khuhro M.A. (2004). Performance of transgenic Bt cotton against insect pest infestation. *Biotechnology*, 3(1), 75-81.

4. Razaq M., Suhail A., Aslam M., Arif M., Saleem M. and Khan H. (2013). Patterns of insecticides used on cotton before introduction of genetically modified cotton in southern punjab, Pakistan. *Pakistan Journal of Zoology*, 45(2), 574-577.

5. Palumbo J.C., Horowitz A.R. and Prabhaker N. (2001). Insecticidal control and resistance management for Bemisia tabaci. *Crop protection*, 20(9), 739-765.

6. Soomro A.R., Soomro A.W., Soomro K. and Mallah G.H. (2000). Jassid Resistant Variety CRIS-7A. *Pakistan Journal of Biological Sciences*, 3(2), 332-334.

7. Daoubi M., Deligeorgopoulou A., Macías-Sánchez A.J., Hernández-Galán R., Hitchcock P.B., Hanson J.R. and Collado I.G. (2005). Antifungal activity and biotransformation of diisophorone by Botrytis cinerea. *Journal of Agriculture and Food Chemistry*, 53(15), 6035-6039.

8. Singh R., Singh B. and Verma R. (2001). Efficiency of different indigenous plant products as grain protection against Callosobrunchus chinensis Linn. on Pea. *Indian Journal of Entomology*, 63, 179-181.

9. Ktattack M., Khan L., Awan M. and Husain A. (2001). Evaluation of some insecticidal combination and neem (Azadirachta indica A. Juss.) Extracts Against Jassids and Whitefly on Cotton and Their Effect on the Yield. *Pakistan Journal of Bioscience*, 4(4), 419-421.

10. Mamoon-ur-Rashid M., Khattak M.K. and Abdullah K. (2012). Residual Toxicity and biological effects of neem (Azadirachta indica) oil against cotton mealybug, Phenacoccus solenopsis Tinsley (Sternorrhyncha: Pseudococcidae). *Pakistan J. Zool.*, 44(3), 837-843.

11. Deling M.A., Gordh G. and Zalucki P.M. (2000). Toxicity of bio-rational pesticides and chemicals to Helicoverpa spp. and predators in cotton field. *Int. J. Pest. Manage*, 46, 237-240.

12. Baidoo P.K., Baidoo-Ansah D. and Agbonu I. (2012). Effects of Neem (Azadirachta indica A. Juss) Products on Aphis craccivora and its Predator Harmonia axyridis on Cowpea. *American Journal of Experimental Agriculture*, 2(2), 198-206.

13. Prasannath K. and Mahendran S. (2013). Efficacy of botanicals on the control of cowpea pests. Proceedings of the International Conference of Eastern University. Retrieved from https://www.researchgate.net/publication/260267725_Efficacy_of_botanicals_on_the_control_of_ cowpea pests.

14. El Shafie H.A.F. and Basedow T. (2003). The efficacy of different neem preparations for the control of insects damaging potatoes and eggplants in the Sudan. *Crop protection*, 22(8), 1015-1021.

15. Ogah E.O. and Ogbodo E.N. (2012). Comparative efficacy of neem seed extract with carbofuran in the management of African rice gall midge, Orseolia oryzivora Harris and Gagné (Diptera: Cecidomyiidae). *J. Biol. Agric. Healthcare*, 2, 147-153.

16. Thapa R.B. and Dangol D.R. (1988). A preliminary survey of weed flora at IAAS and its vicinity. In: F. P. Neupane (ed.) *IAAS Research Report* (1985-1991). Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal, 59-65.

17. SchonbecK D. (2015). Mulching for Weed Management in Organic Vegetable Production. *Extension issues, innovations, impacts*.

18. Mc Partland John M. (1997). Cannabis as repellent and pesticide. *Journal of the International Hemp Association,* 4(2), 89-94.

19. Sahito H., Shah Z.H., kousar T., Mangrio W.M., Mallah N.A. and Kubar W.A. (2016). Comparative Efficacy of Novel Pesticides Against Jassid, Amrasca biguttula biguttula (Ishida) on Cotton Crop under Field Conditions at Khairpur, Sindh, Pakistan. *science alert*.

20. Gomez A.A. and Gomez K.A. (1984). Statistical procedures for agricultural research. *John Wiley & Sons*., 6, 680.

21. Chejara B.K. (2013). Studies on Gram Pod Borer, Helicoverpa armigera (Hub.) on Chickpea and its control with insecticides and biopesticides. M.Sc. Thesis. Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, M.P., India.

22. Rashid Mamoon-Ur Muhammad, Jilani Muhammad Salim, Khan Qudratullah, Hashim Malik Muhammad, Sayal Obaid Ullah, Khan Muhammad Pervaiz, Latif Asif, Waseem Kashif and Nawaz Shahid (2016). Evaluation of neem (Azadirachta indica) derivatives against jassids (Emrasca devastans) and cotton mealy bug (Phenacoccus solenopsis) and side effects on the feeding potential of green lacewing (Chrysoperla carnea) on cotton aphid (Aphis gossypii). *Pakistan Journal of Zoology*, 48(6), 1763-1768.

23. Ahmad F., Ali A. and Ahmad M. (1996). Some studies on the effect of synthetic growth regulators and neem plant materials against sucking insect pests of cotton. *Pakistan Entomologist*, 18(1), 24-27.

24. Copping L.G. and Menn J.J. (2000). Biopesticides: a review of their action, applications and efficacy. *Pest Management Science*, 56(8), 651-676.

25. Jackai L.E.N. (1993). The use of neem in controlling cowpea pests. *UTA Research*, 7, 5-11.

26. Singh B.B., Mohan Raj D.R., Dashiell K.E. and Jackai L.E.N. (1997). Advances in cowpea research. Copublication of International Institute of Tropical Agriculture (UTA) and Japan International Research Center for Agricultural Sciences (JIRCAS). UTA, Ibadan, Nigeria., 375. https://doi.org/10.1007/s13398-014-01737.2.