Pakistan J. Zool., vol. 44(5), pp. 1317-1324, 2012.

Evaluation of Botanical and Synthetic Insecticides for the Management of Cotton Pest Insects

Muhammad Mamoon-ur-Rashid[1], Masood Khan Khattak,[1,]*and Khalid Abdullah[2]
[1]*Entomology Department, Gomal University, Dera Ismail Khan, Khyber Pakhtun Khwa, Pakistan*
[2]*Ministry of Textile Industry, 2nd Floor, FBC Building, Sector G-5/2, Islamabad, Pakistan*

Abstract.- Field trials were carried out to compare the effect of neem (*Azadirachta indica* A. Juss) oil at 1%, 1.5% and 2% and neem seed water extract at 1%, 2% and 3% concentration with that of synthetic insecticide (Polytrin C® 440 EC) against *Bemisia tabaci*, *Amrasca devastans, Thrips tabaci, Earias insulana, Pectinophora gossypiella* and *Helicoverpa armigera*. The treatments were administered four times during the cotton growing season and observation were recorded before one day and after 24, 72, 144, 216 and 288 days of treatment application. Neem oil at 2% and neem seed water extract at 3% significantly reduced the whitefly, jassids and thrips infestation up to 12 days after spray as compared to that in the control. Similar trend in population reduction of sucking insect pests of cotton was observed in other three treatment applications. Synthetic insecticide proved to be more toxic against the test insects than neem based treatments at any interval. Neem derivatives at all concentrations badly affected the attack of Spotted bollworm where as only at higher concentrations adversely affected the attack of pink bollworms up to 12 days after spray. Plots treated with 1.5% and 2% neem oil and 3% neem seed water extract resulted in to significantly higher yield as compared to that in the control. Polytrin C® 440 EC in all cases was highly toxic to the test insects as compared to any other treatment.

Key Words: Neem, whitefly, jassids, thrips, bollworms, insecticides.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is known as silver fiber due to its worldwide economic importance and this crop is attacked by 145 insect pest species. These pest insects caused 30% reduction in cotton yield in Pakistan (Bo, 1992; Wilson *et al*., 1980; Ahmed, 1980). *Bemisia tabaci, Amrasca devastans, Thrips tabaci*, *Earias insulana, Pectinophora gossypiella* and *Helicoverpa armigera* are the major insect pests of cotton crop. These pests directly reduce the quantity by feeding on cotton crop and indirectly reduce the quality of the product by transmitting different diseases. These pests are mainly controlled by the use of synthetic insecticides such as cyfluthrin, acephate, imidacloprod and lambada. These insecticides significantly reduce the feeding of *Helicoverpa zea*, *Heliothis virescens* and *Lygus lineolaris* on cotton and increase the fruit setting in cotton crop (Ruscoe *et al.,* 1996). Almost 80% of the total agro-chemicals are used every year against the insect pests of the cotton crop which cause different problems such as insecticide resistance, pest resurgence, secondary pest outbreak, killing of non-target fauna and accidental health hazards (Bakhetia *et al.,* 1996).

The use of plant species to control pest insects has been in practice for centuries to a limited extent, the interest has been renewed in the pest management potential of natural products. Plants are natural chemical factories, providing the richest source of organic chemicals on earth. Approximately 42 families of plants carry some medicinal and insecticidal qualities (Feinstein, 1952). Plant products have several uses in insect control (Hashmi, 2001). Neem (*Azadirachta indica* A. Juss) has been served as pest remedial for years in subcontinent and is still a popular practice in remote areas for stored grains in various parts of the world (Lale and Mustapha, 2000; Ahmed *et al*., 2001). Azadirachtin is a major compound of neem (Mordue and Blackwell, 1993) with insecticidal properties and has got the greatest attention in recent years (Parakash and Srivastava, 2008) however, several other compounds like, deacetyl-azadirachtinol, meliantriol, vepol, salannin, sulfur compounds, etc. do have varying degree of insect deterrent, repellant, anti-feedant, anti-ovipositional

* Corresponding author: mamoondik@yahoo.com
0030-9923/2012/0005-1317 $ 8.00/0

and growth regulating properties. (Atawodi and Atawodi, 2009; Diaz *et al.*, 2010)

Market demand of low residues and WTO regulations drive farmers of Pakistan for judicious pesticide use and look for alternatives. Neem being a native plant and with diverse pest management properties could be a good source. Neem oil formulation has been tested for sucking pests of the cotton and other crops and resulted in good control when compared with insecticide. Seed cotton yield was increased with the use of mineral oil, nicotine sulphate and neem oil to control different pest insects of cotton (Reddy and Rao, 1993). The anti-feedant and anti-molting effect of neem crude extract were evaluated against various lepidopterans and comparable results were obtained. This insect order has been reported to be particularly sensitive to neem products (Calvo and Molina, 2003). However, no work has been carried out on neem based products against insect pests of cotton in Khyber Pakhtun Khwa Province of Pakistan. In the present study laboratory based results have been tested in the fields and the efficacy of neem oil and neem based water extract has been compared against different pest insects of cotton.

MATERIALS AND METHODS

Preparation of neem oil concentrations

Neem fruits were collected from the local plantation during the autumn 2007, cured in shade for 15 days, the neem seeds were dehulled and oil was extracted using experimental oil extractor (150 lbs/inch). The oil was filtered using Whatman 1 filter paper and used for the field tests. To prepare water based field solution, 2g of detergent was dissolved in small quantity of water and later required amount of neem oil was added to get a homogenized water-based concentration. Further water was added to make the desired concentration of field solution *viz.*, 1, 1.5 and 2%.

Preparation of neem seed water extract

Two kg of locally collected neem fruit were dried in shade and grounded to 60 mesh particle size. This powder was tied in a cotton cloth and dipped in ten liters of water at 80°C for 16 h. and the concentration obtained as above was labeled 20%. It was then diluted to 1%, 2% and 3% for spray in the trials.

Field trails

The experiment was conducted at experimental farms of Agriculture Research Institute, Ratta Kulachi, Dera Ismail Khan using cotton variety CIM-506 during 2008. The crop was sown in 5 x 3.5 m^2 plots maintaining 30 cm and 70 cm inter plant and inter row distances. The crop was applied two times NPK and standard agronomic practices were given at a proper time.

Three concentrations of neem oil (1, 1.5 and 2%), neem seed water extract (1, 2 and 3%) and synthetic insecticide chloropyriphos+cypermethrine (Polytrin-C™ from Syngenta Crop Sciences Pak. (Pvt.) Ltd.) @ 220g of a.i./acre were evaluated, against sucking pests (*Bemisia tabaci*, *Empoasca devastance*, *Thrips tabaci*) and bollworms.

Statistics

The experiment was laid out in Randomized Complete Block (RCBD). There were eight treatments (3 neem oil concentrations, 3 neem seed water extract concentrations, synthetic insecticide and untreated check) and replicated three times. Linear model was applied on the averaged data using F test to reject the hypothesis at alpha level 0.05. The means were separated using least significant difference test (LSD).

Data recording

For the assessment of insect pests of cotton a diagonal method was used. To assess population of sucking insects, data were recorded early in the morning by counting number of whiteflies, jassids, and thrips through the use of magnifying lens on six randomly selected plants per treatment. Three leaves of upper, middle and lower portion from these different plants were observed. The crop was sprayed four times at an interval of 20 days. The first spray was carried out when the pest attack reached economic threshold level. The threshold level for sucking insects and bollworms is as follows:

White flies:	4-5 adults/crawlers per leaf
Thrips:	8-10 adults/nymphs per leaf
Jassids:	1-2 adult/nymph per leaf
Spotted bollworm:	5-10% infestation in Aug-Sep.
Pink bollworm:	5-10% infestation in Oct-Nov.
American bollworm:	1 larva per 10 plants/1 egg per 5 plants.
Army worm:	At sight.

Each neem derivative and pesticide used in this experiment was sprayed with knapsack hand operated sprayer. Polyethylene sheet was placed between plots during spray to avoid chemical drift. Pre-treatment data was recorded 24 h before spray and then 24, 72, 144, 216 and 288h after spray to determine the antifeedant, deterrent and residual effect of these chemicals on the cotton insect pests complex.

The mean populations of sucking insect pests from sprayed plots were considered to be an indirect reflection of efficacy of different chemicals, thus a lower mean value of population of insect pests after spray reflected on a higher efficacy of the chemicals applied and vice versa. Percent population change was calculated by using modified Abbot's formula (Fleming and Retnakaran, 1985).

or bollworms percent damage, *i.e.,* combined infestation of *Earias* spp. and *H. armigera* was recorded and the data on the damage from six randomly selected plants in each treatment was taken by counting the sound and damaged fruiting bodies (squares + bolls). The data were recorded 144h and 288h after spray. The damage caused by American bollworm was negligible, therefore, not included in the data. The damage caused by pink boll worm was recorded by examining 15 randomly collected green bolls from each plot. These bolls were dissected, and damage caused by pink bollworm was recorded. The damage was recorded on August 20, September 20, and October 20, 2007. The recorded data in each treatment was then converted into respective percent damage with following formula.

$$\% \text{ damage of fruiting bodies} = \frac{\text{damaged fruiting bodies}}{\text{total fruiting bodies}} \times 100$$

To know the effect of neem derivatives and Polytrin-C on the yield of cotton seed, the raw cotton was picked from the bolls during November 10, 2007 to the last boll ready for picking. Seed cotton yield of each treatment was converted to yield per hectare. The final data were analyzed with analysis of variance (ANOVA) and means separated using least significant difference (LSD) test.

RESULTS

Effect of insecticides on the infestation

Whiteflies

Neem oil at 1% and neem seed water extract at 1% and 2% were the least effective and gave lowest percent reduction of whiteflies after 24h of spray. Neem oil at 2% and neem seed water extract at 3% gave 37.27% and 26.52% whiteflies reduction except Polytrin-C which gave 87.23% whiteflies reduction (Table I). The maximum reduction in whiteflies population was observed after 144h of spray, which may be due to the anti-feedant and deterrent effects of neem derivatives at higher concentrations, besides their toxic effect to the test insect. Neem oil at 2% and neem seed water extract at 3% resulted in to 57.46% and 48.29% whiteflies population reduction, respectively. Neem derivatives remained effective against the test insects up to 288 h after spray, though there was a promising decline in their efficacy.

The effect of the neem derivatives and Polytrin-C against whiteflies on cotton in 2nd, 3rd, and 4th sprays were identical to the results in 1st spray. Polytrin-C showed highly significant reduction in the test insect pest infestation compared to that in the control even 288h after spray. Neem oil at 1.5%, 2% and neem seed water extract at 3%, although, reduced insect infestation statistically more than that in the control even 288h after spray, these would have lost their efficacy soon against the test insect (Table I).

Jassids

Polytrin-C ranked 1st in its efficacy by giving 87.73% population reduction of jassids on cotton when observed 24h after spray followed by neem oil at 2% and neem seed water extract at 3% with 37.17% and 31.33% jassid reduction, respectively . Neem oil at 2% and neem seed water extract at 3% resulted in to 59.85% and 52.52% population reduction of jassids infestation 144h after spray (Table II). The 87.73% reduction of the test insect population 24h after spray and 32.63% reduction in jassid infestation 288h after Polytrin-C spray were significantly more than any other treatment after the mentioned time period. There was noticeable decrease in the efficacy of neem oil at 2% and neem

Table I.- Effect of neem derivatives and insecticide on the percent mortality of whitefly at different intervals.

Treatment (Hours)	Neem oil			Neem seed water extract			Insecticide	Check
	1%	1.5%	2%	1%	2%	3%		
1st application								
24 h	4.50 e	7.52 d	37.27 b	4.12 e	7.34 d	26.52 c	87.23 a	4.36 e
72 h	4.12 f	11.89 d	40.93 b	4.11 f	8.04 e	30.19 c	85.60 a	3.28 f
144 h	3.35 e	27.84 d	57.46 b	2.77 e	3.94 e	48.29 c	69.34 a	2.83 e
216 h	1.76 f	6.32 d	28.87 b	1.59 f	4.09 e	20.71 c	52.74 a	1.35 f
288 h	0.16 e	2.18 d	4.32 b	0.22 e	2.73 cd	3.88 bc	34.70 a	0.19 e
2nd application								
24 h	0.75 e	6.03 d	32.26 b	0.44 e	6.66 d	23.51 c	85.13 a	2.20 e
72 h	1.53 f	9.17 d	32.92 b	1.22 f	6.30 e	25.89 c	83.75 a	1.21 f
144 h	0.80 f	26.45 d	54.20 b	0.92 f	2.67 e	45.50 c	66.84 a	0.52 f
216 h	0.69 c	3.69 c	24.60 b	0.40 c	3.37 c	18.11 b	61.43 a	0.17 c
288 h	-0.80 d	2.83 c	4.25 b	-0.53 d	2.94 c	4.16 b	32.41 a	-0.70 d
3rd application								
24 h	0.93 e	5.47 d	36.65 b	0.85 e	5.48 d	26.97 c	87.11 a	0.78 e
72 h	0.55 f	8.20 d	39.12 b	0.26 f	5.48 e	29.68 c	85.97 a	0.31 f
144 h	0.46 f	24.17 d	56.40 b	0.54 f	8.55 e	44.73 c	73.15 a	0.47 f
216 h	-0.53 f	5.48 d	23.59 b	-0.64 f	2.15 e	17.57 c	52.32 a	-0.48 f
288 h	-0.91 e	1.94 c	2.75 b	-1.25 e	0.69 d	1.61 c	30.45 a	-1.11 e
4th application								
24 h	2.96 f	1.64 e	38.75 b	2.69 f	5.27 d	25.62 c	85.37 a	3.17 f
72 h	1.67 f	7.603 d	37.36 b	1.69 f	4.94 e	27.80 c	84.71 a	1.40 f
144 h	0.27 f	23.50 d	60.98 b	0.84 f	8.30 e	44.24 c	72.44 a	0.47 f
216 h	0.65 f	7.643 d	29.58 b	0.65 f	3.26 e	18.07 c	53.44 a	0.63 f
288 h	-0.57 f	2.677 c	4.92 b	-0.78 f	1.73 d	2.55 c	32.41 a	-0.64 f

seed water extract at 3%, however, 30.78% and 20.98% population reduction, respectively was statistically better than that in the control. Neem oil at 1% and neem seed water extract at 1% did not show any significant decrease in the infestation of jassid on cotton.

Neem derivatives and Polytrin-C showed identical results in 2nd, 3rd, and 4th sprays. Polytrin-C showed highly significant reduction in the test insect pest infestation compared to that in the control even 288h after spray. Neem derivatives at higher concentrations, although, reduced statistically more insect infestation than that in the control even 288h after spray, these would have lost their efficacy soon against the test insect (Table II).

Thrips

Polytrin-C with 79.99% reduction in pest infestation 24h after spray ranked 1st followed by 32.69% and 25.04% reduction in pest infestation by 2% neem oil and 3% neem seed water extract, respectively (Table III). However, their efficacy decreased up to great extent 288h after spray. Polytrin-C, although, significantly reduced the pest infestation 288h after spray, it showed gradual decrease in its effectiveness.

All the tested neem derivatives and the insecticide behaved in a similar fashion in the 2nd and 3rd spray as they did in the 1st spray. The insecticide (polytrin-C) was the most toxic treatment against the test insect and showed its highest toxicity up to 288h after spray, while neem derivatives at higher concentrations significantly reduced insect pest infestation, but very rapidly decreased in their effects against the test insect (Table III).

Spotted bollworm

All the tested concentrations of neem derivatives and Polytrin-C when observed 144h after spray significantly reduced the percent damage of the fruiting bodies of cotton by spotted boll

Table II.- Effect of neem derivatives and insecticide on the percent mortality of jassids at different intervals.

Treatment (Hours)	Neem oil			Neem seed water extract			Insecticide	Check
	1%	1.5%	2%	1%	2%	3%		
1st application								
24 h	-1.51 e	2.77 d	37.17 b	-2.31 e	1.63 d	31.33 c	87.73 a	0.75 e
72 h	-0.22 e	5.62 d	38.47 b	-1.56 e	4.07 d	31.29 c	85.35 a	0.72 e
144 h	-1.64 d	13.14 c	59.85 b	-1.31 d	6.01 cd	52.52 b	70.59 a	-1.45 d
216 h	-2.65 f	4.11 d	30.70 b	-2.49 f	0.15 e	20.98 c	52.43 a	-2.87 f
288 h	-3.31 d	-0.83 c	0.93 b	-3.82 d	-0.79 c	1.22 b	32.63 a	-2.79 d
2nd application								
24 h	-0.22 e	3.033 d	37.49 b	-1.90 e	2.58 d	29.14 c	89.12 a	0.80 e
72 h	-1.073 f	7.867 d	38.68 b	-1.33 f	2.52 e	31.32 c	84.47 a	1.20 f
144 h	-0.88 f	24.11 d	56.43 b	-2.02 f	7.91 e	47.80 c	69.64 a	-1.22 f
216 h	-1.28 f	5.663 d	29.25 b	-2.83 f	2.01 e	19.54 c	37.03 a	-2.82 f
288 h	-3.27 d	-1.08 c	1.03 b	-4.05 d	-1.12 c	0.78 b	27.79 a	-3.13 d
3rd application								
24 h	-0.46 f	3.58 d	34.87 b	-0.69 f	2.32 e	27.16 c	89.39 a	0.84 f
72 h	-1.35 f	7.85 d	38.25 b	-0.42 f	2.41 e	28.72 c	84.17 a	0.42 f
144 h	-1.89 f	24.91 d	57.05 b	-2.50 f	8.08 e	48.47 c	69.99 a	-1.70 f
216 h	-2.61 f	5.25 d	28.85 b	-2.23 f	2.44 e	18.02 c	49.60 a	-1.25 f
288 h	-3.59 c	-0.32 b	0.74 b	-3.94 c	-0.29 b	0.62 b	30.43 a	-2.06 c
4th application								
24 h	-0.63 e	2.92 d	35.24 b	-0.64 e	3.30 d	28.42 c	89.54 a	1.38 e
72 h	-1.35 f	8.14 d	37.65 b	-1.39 e	4.01 e	27.51 c	84.08 a	0.46 f
144 h	-0.76 f	27.33 d	59.57 b	-1.45 e	7.92 e	49.62 c	69.25 a	0.46 f
216 h	-1.18 d	20.36 bc	28.52 b	-1.46 d	3.30 cd	19.37 bc	48.35 a	-0.94 d
288 h	-1.56 c	1.41 b	1.65 b	-2.49 c	0.75 b	2.19 b	30.24 a	-1.40 c

Table III.- Effect of neem derivatives and insecticide on the percent mortality of thrips at different intervals.

Treatment (Hours)	Neem oil			Neem seed water extract			Insecticide	Check
	1%	1.5%	2%	1%	2%	3%		
1st application								
24 h	0.32 f	3.167 d	32.69 b	0.51 f	2.67 e	25.04 c	79.99 a	0.48 f
72 h	0.45 f	11.64 d	38.86 b	0.22 f	4.81 e	28.11 c	77.56 a	1.09 f
144 h	0.32 f	27.35 d	57.07 b	0.30 f	5.89 e	46.27 c	67.99 a	0.49 f
216 h	0.18 f	4.55 d	26.49 b	0.06 f	2.79 e	18.88 c	55.12 a	0.12 f
288 h	-0.40 e	1.83 d	4.95 b	-0.46 e	1.77 d	2.92 c	34.12 a	-0.37 e
2nd application								
24 h	0.22 f	2.24 e	31.77 b	0.31 f	2.52 d	21.76 c	81.01 a	0.37 f
72 h	0.49 f	6.79 d	36.97 b	0.07 f	4.34 e	24.08 c	78.26 a	0.28 f
144 h	0.41 f	19.23 d	52.61 b	0.85 f	5.19 e	39.07 c	65.53 a	0.94 f
216 h	-1.77 f	1.22 d	25.11 b	-1.42 f	1.33 d	13.58 c	62.64 a	-1.52 f
288 h	-1.84 f	0.20 d	5.23 b	-1.87 f	-0.07 e	1.41 c	28.12 a	-1.78 f
3rd application								
24 h	0.18 e	3.02 d	34.16 b	-0.12 e	2.69 d	23.13 c	83.09 a	0.25 e
72 h	0.28 f	12.13 d	34.97 b	0.22 f	6.910 e	24.62 c	78.35 a	0.42 f
144 h	0.31 f	22.28 d	54.66 b	0.19 f	11.11 e	40.67 c	67.60 a	0.17 f
216 h	0.10 f	2.27 e	22.37 b	-0.09 f	2.84 d	14.17 c	53.05 a	-0.08 f
288 h	1.42 f	3.52 d	6.98 b	1.37 f	3.56 d	3.98 c	37.36 a	1.28 f

worm; as 19.71% 17.57% and 9.5% infestation of fruiting bodies of cotton crop with neem oil at 1%, 1.5% and 2%, respectively and 21.12%, 19.48% and 14.64% with neem seed water extract at 1%, 2% and 3%, respectively were significantly less than the 29.84% damage in the control. Regarding its efficacy against the test insect, neem derivatives remained effective up to 288h after spray (Fig. 1).

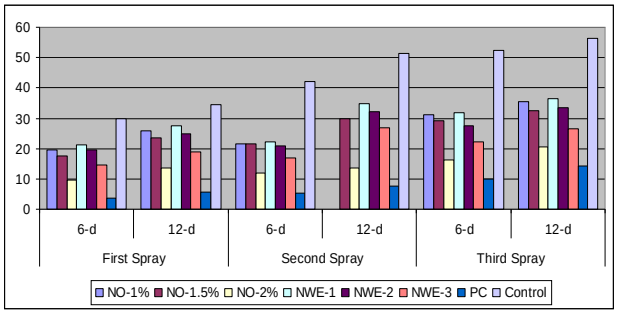

Fig. 1. Effect of neem derivatives and insecticide on the infestation of spotted bollworms at different intervals.

Polytrin-C ranked 1st in its efficacy against spotted bollworm; as 5.58% damage of fruiting bodies were, significantly lower than any other treatment in the experiment. Results showed that the reduction in the damage of fruiting bodies of cotton by bollworm in the plots treated with neem derivatives were dose dependent. Neem derivatives at higher concentrations were more effective against spotted bollworm as compared to the low concentrations.

Reduction in the damage of cotton fruiting bodies by spotted bollworm remained identical in all three sprays **(**Fig. 1**).** From the result, it could be recommended that almost 3-4 sprays of neem derivatives or synthetic insecticide are best for checking the spotted bollworms.

Pink bollworm

Neem oil at 1.5% and 2% and neem seed water extract at 2% and 3% resulted into 13.33%, 8.88%, 15.55%, and 11.11% damage, respectively of the cotton fruiting bodies, which were significantly lower than the 22.22% damage of the fruiting bodies in the control (Fig. 2). The 17.78% and 20.00% damage of fruiting bodies in the plots treated with 1% neem oil and 1% neem seed water extract, respectively were statistically similar to the 22.22% fruiting bodies damage in the control. Reduction in percent damage of the fruiting bodies by neem derivatives were dose dependent. The higher the neem oil and neem seed water extract concentration, the lower the damage of the fruiting bodies. Polytrin-C was very much toxic to the test insect; however, it was statistically similar to 2% neem oil and 3% neem seed water extract in 1st and 2nd spray, but was slightly better in the 3rd spray which may be because of the change in the environmental conditions.

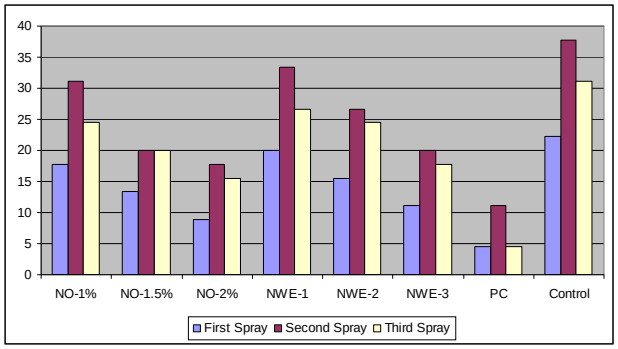

Fig. 2. Effect of neem derivatives and insecticide on the infestation of pink bollworms at different intervals. PC, Polytrin-C; NO, neem oil; NEW, neem seed water extract.

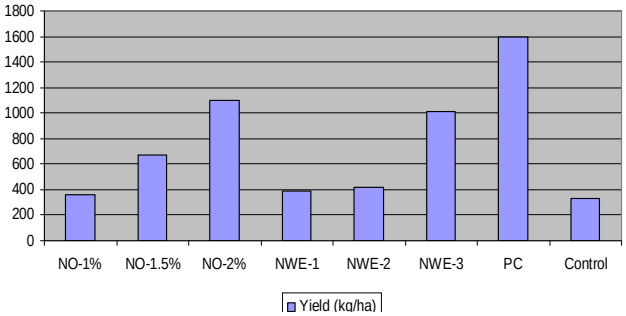

Fig. 3. Effect of neem derivatives and insecticide on the cotton seed yield. For abbreviations see Fig. 2.

Effect of insecticide on per hectare yield

Results indicated that neem oil at 1.5% and 2% and neem seed water extract at 3% had positive impact on per hectare yield of seed cotton; as 676.2 kg, 1095 kg and 1010 kg yield/hectare, respectively was significantly more than 333.3 kg/hectare in the

control (Fig. 3). The 361.9 kg/hectare, 390 kg/hectare and 419 kg/hectare yield in the plots treated with 1% neem oil, 1% and 2% neem seed water extract were statistically similar to 333.3 kg yield/hectare in the control. Plot treated with Polytrin-C yielded 1600 kg/hectare which was significantly more than the yield of any other treatment in the experiment.

DISCUSSION

Neem oil at 1.5% and 2% and neem seed water extract at 2% and 3% significantly reduced the mean percent infestation of whiteflies, thrips and jassids up to 288h after spray but synthetic insecticide was more toxic to the test insect pests Nimbalkar *et al.* (1993) found that endosulfan was more effective against bollworms as compared to indiara, *Pongamia glabra* and neem extracts. endosulfan, chlorpyrifos and fenpropathrin were highly toxic to *Earias* spp. and *P. gossypiella* on cotton in Pakistan (Mahar *et al.,* 1993). Kumawat and Jheeba (1999) recommended azadirachtin, endosulfan and monocrotophos for the control of gram pod borer. Sexana *at el.* (1981) found that neem oil was good antifeedant for the control of rice brown hopper. Hoppers generally avoided the rice plants treated with 3, 6, and 12% crude emulsifiable neem oil. Gupta and Sharma (1997) noted that in spray schedule where neem was used alternately with *Bacillus thuringiensis* and synthetic pyrethroid successfully managed the bollworms and *Bemicia tabaci*. Neem seed water extract and neem oil at different concentrations significantly reduced the nymphal and adult population of *B. tabaci.* Khattak *et al*. (2001) demonstrated that the detrimental effect of the 1000 ppm neem oil treatment was lost by 30 days after treatment, but the 10,000 ppm retained its effect up to 60 days against *Sitophillus zeamais* Matsch. Devi and Mohandas (1982) found that against *Rhizopertha dominica*, neem seed extract at 0.5 % and 1% gave good protection to stored rice for up to six months.

Neem derivatives kill small bodied insects and immature stages of several insect species. Neem oil extract at 0.04% caused 100% kill of the 1st and last larval instar of mosquitoes in 24 h (Attri and Prasad, 1980). Hellpap (1984) found that 5ppm and 10ppm of methanol extract of neem seed kernel when mixed with rearing diet caused complete mortality of 4-10 days old fall armyworm larvae. Feeding on diet containing 250ppm and 500ppm of the extract caused death of armyworm larvae in 24 h. A 25% mortality of *Plutella xylostella* were found when these insects were fed on leaves treated with neem leaf extract or neem oil.

Cotton treated with 1.5% and 2% neem oil and 3% neem seed water extract significantly produced more yield. Deling *et al*. (2000) observed that the effect of azadirachtin on bollworm was shown in a high yield of seed cotton obtained from Azadirachtin treated cotton. The application of neem seed extracts with other cultural means (late or early sowing), deep ploughing etc. controlled foliage and tuber pests of potatoes in Sudan and increased yield by 0.5 tons/hec. (Siddiq, 1987).

ACKNOWLEDGEMENT

This project was financially supported by the Higher Education Commission of Pakistan.

REFERENCES

AHMAD, Z., 1980. *Incidence of major cotton pests and diseases in Pakistan with special reference to pest management*. Proc. of 1st International Consultation on Cotton Production. Manila, Philippines, pp. 156 –179.

AHMED, K.S., YASUI, Y. AND ICHIKAWA, T., 2001. Effect of neem oil on mating and oviposition behavior of azuki bean weevil, *Callosobruchus chinensis* L. (Coleoptera: Bruchidae). *Pak. J. biol. Sci*. **4**: 1371-1373.

ATAWODI, S.E. AND ATAWODI. J.C., 2009. *Azadirachta indica* (neem): a plant of multiple biological and pharmacological activities. *Phytochem. Rev.*, **8**: 601-620.

ATTRI, B.S. AND PRASAD, R.G.**,** 1980. Studies on the pesticidal value of neem oil by-products. *Pestology*, **4**: 16-20.

BAKHETIA, D.R.C., SINGH, J., SOHI, A.S. AND SINGH, J., 1996. Integrated pest management in sustainable agric: Punjab Scenario. *Pest Manage. Ecol. Zool*., **4**: 1-13.

BO, D.Y., 1992. IPM on cotton in Asia and Pacific regions. *Pak. Cottons*, **36**: 87-100.

CALVO, D. AND MOLINA, J.M., 2003. Effects of a commercial Neem (*Azadirachta indica*) extract on streblote panda larvae. *Phytoparas*., **31**: 365-370.

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.

DEVI, D.A. AND MOHANDAS, N., 1982. Relative efficacy of some antifeedant and deterrents against insect pests of stored paddy (rice). *Entomon*, **7**: 261-264.

DIAZ, G.E., COLLADO, J.L., JIMENEZ, A.V., ACOSTA, F.O., COLINA G.O. AND DIAZ E.C., 2010. *Azadirachtin* concentration, insecticide efficacy and phytotoxicity of four neem extracts. *Agrocienc*., **44**: 821-833.

FEINSTEIN, L., 1952. *Insecticides from plants. Insects* (The Year book of Agriculture). United States Department of Agriculture, Washington D.C., pp. 222-229.

FLEMING, R. AND RETNAKARAN, A., 1985. Evaluation single treatment data using Abbot,s formula with reference to insecticides. *J. econ. Ent.*, **78**: 1179-1881.

GUPTA, G.P AND SHARMA, K., 1997. Neem based pest management strategy in cotton system. *Pestic. Res. J*., **9**: 190-197.

HASHMI, A.A., 2001. *Integrated pest management in the 21st century*, PARC publication, Islamabad, pp. 27.

HELLPAP, C., 1984. Effects of neem kernel extracts on the fall armyworm, *Spodoptera fruqiperda*. In: *Natural pesticides from the neem tree (*Azadirachta indica A. Juss*) and other tropical plants* (eds. H. Schmutterer and K.R.S. Ascher). Proc. Third International Neem Conference, German Agency for Technological Co-operation, Berlin, Germany. pp. 353-364.

KHATTAK, M.K., BROCE, A.B. AND DOVER, B., 2001. Comparative effects of neem or mineral oil on maize weevil, *Sitophilus zeamais* Motsch. and its parasitoid, *Anisopteromalus calandarae* (Howard). *Online J. biol. Sci*., **1**: 378-381.

KUMAWAT, K.C., AND JHEEBA, S.S., 1999. Eco-friendly management of gram pod borer. *Ann. Pl. Prot. Sci.*, **7**: 212-214.

LALE, N.E.S. AND MUSTAPHA, A., 2000. Potential of combining neem (*Azadirachta indica* A. Juss) seed oil with varietal resistance for the management of the cowpea bruchid, Callosobruchus maculatus (F.). J. Stored Prod. Res., 36: 215–22MORDUE, A. J. AND BLACKWELL, A. ,1993. Azadirachtin, an update. *J. Insect Physiol*., **39**: 903-924.

MAHAR, A.M., LOHAR, M.K. AND ABRO, G.H., 1993. Field evaluation on the efficacy of endosulfan, chlorpyrifos and fenpropathrin against cotton bollworm. *Proc. Pakistan Congr. Zool.*, **7**: 113-118.

NIMBALKAR, S.A.,. KHODKE, S.M., TALEY, Y.M. AND PATEL, K.J., 1993. Bio-efficacy of some new insecticides including neem seed extract and neem oil for the control of white fly, *Bemisia tabaci* Genn. on cotton. *Proc. Symp. Botanical Pesticides in IPM.* Rajamunclary, Andrapradsh, pp. 256-260.

PARAKASH, G. AND SRIVASTAVA, A.K., 2008. Statistical elicitor optimization studies for the enhancement of azadirachtin production in bioreactor *Azadirachta indica* cell cultivation. *J. Biochem. Eng*., **40**: 218–226.

REDDY, A.S. AND RAO, N.V., 1993. Efficacy and selectivity of insecticides of natural origin on insect pests of cotton, *Gossypium hirsutum.* In: *Botanical Pesticides in Integrated Pest Management* (eds. M.S. Chari and G. Ramprasad). Indian Society of Tobacco Science, pp. 170-174.

RUSCOE, J.T., ANDREWS, G.L. AND PHLEPHS, L.B., 1996. *Efficacy and duration of early season insecticide applications*. National Cotton Council, pp. 955-956.

SAXENA, R.C., LIQUIDO, N.J. AND JUSTO, H.D., 1981. Neem oil, a potential antifeedant for the control of the rice brown hopper, *Nilaparvata lugens*. I In: *Natural pesticides from the neem tree (*Azadirachta indica A. Juss*) and other tropical plants* (eds. H. Schumterer and K.R.S. Ascher), Proceeding, Third International Neem Conference, German Agency for Technological Cooperation, Berlin, Germany. pp. 171-188

SIDDIQ, S., 1987. A proposed pest management program including neem treatment for combating potato pests in the Sudan, In: *Natural pesticides from the neem tree (*Azadirachta indica A. Juss*) and other tropical plants* (eds. H. Schumterer and K.R.S. Ascher), Proceeding, Third International Neem Conference, German Agency for Technological Cooperation, Berlin, Germany. pp. 449-459.

WILSON, M.C., TRUPIN, F.T. AND PROVOSHA, A.V., 1980. *Practical insect pest management: Insects of livestock and agronomic crops*, 2nd Ed., Waveland Press Inc., Prospect heights, llinois, USA, vol. 2, pp. 163-176.

(Received 4 July 2011, revised 20 July 2011)