DISCUSSION
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Plant chemicals repel the approaching insects, deter feeding and oviposition on the plants, disrupt behaviour and physiology of insects in various ways.

In this study, different neem products were tested in laboratory conditions as well as in the field. In field evaluation, different neem products were tested against rice pests in field condition. The results are discussed in this chapter.

Experiment: I - Laboratory Studies:

The results obtained from the laboratory studies revealed that A. indica oil 3% and neem seed kernel extract 5 percent acted as best ovipositional deterrent in which only 65 eggs were laid compared to 140 eggs in control. In other treatments, eggs laid by the females ranged from 93.67 (A. indica seed kernel 5%) to 138.33 (A. cocculus 10 percent). Hatchability of egg was minimum (58.19 percent) in A. indica oil 3 percent compared to control (91.19 percent). Hatchability ranged between 59.22 (A. indica cake 10%) and 82.18 (A. calamus 10%) percent in other treatments. The present finding is in consonance with the findings of Islam (1983), who reported that hexane extract of neem seed reduced the egg deposition by brown planthopper. Contrary to this Saxena et al (1983) found that neem cake application had not adversely affected adult longevity, fecundity, oviposition and hatchability of brown planthopper.

Unhatchability of eggs of brown planthopper may be due to the systemic action of neem products as reported against Schistocerca gregaria F. (Gill and Lewis, 1971) European corn borer Ostrinia nubilalis Hub (Meisner and Ascher, 1986) and leaf miner
Liromyza trifoli (Burgess) (Hiram, 1988). Shelke et al (1987) reported that rat mayoti oil, Neem oil and Karanj oil were the most effective ovicide against Pthorimaea operculella (Zell) eggs.

Investigations made on the effect of plant extracts on development of brown planthopper indicated that there was reduction in development of nymphs to adults in plants-extracts treated plants. Only 20.00 percent nymphs became adults in A. indica oil 3 percent treated plants followed by T. purpurea 10 percent and A.indica seed kernel 5 percent in which 26.67 percent nymphs became adults.

Studies also made on the effects of plant extracts on population build up of brown planthopper also showed that there was a considerable reduction in the population buildup in the plant-extracts treated plants compared to control. A. indica oil 3 percent was found to be superior (106.00) in reducing the population buildup in plants compared to control. The reduction in first generation nymphal emergence and development could be attributed to ovipositional deterrent and growth disrupting effects of botanicals. These findings could be substantiated with interpretation of Saxena et.al. (1984b) who explained that neem oil and neem cake acted primarily against immature stages by interfering with the moulting process and may have been responsible for the comparatively lower build of the brown planthopper population. Saxena et al (1987a and b) also pointed out that the increase in population build of brown planthopper was much lower on the plants sprayed with neem seed bitters than on control plants.

The quantum of excreta produced by the rice leaf folder larvae fed on leaves treated with A. indica oil 3 percent was 57.42 percent, lower than control. In T. purpurea
10 percent and A. indica seed kernel 5 percent 47.52 and 44.55 percent reduction in faecal pellets excretion was noticed respectively compared to control. The leaf area fed was less in A. indica oil 3 percent (69.86 %) and T. purpurea 10 percent (55.46 %), when it was compared to control. Similar results were reported by Saxena et al (1980) that first instar of larvae of C. medinalis were apparently repelled by 12 percent neem oil as they did not settle to fed on treated leaves in large numbers as on control leaves. Reduction in faecal pellets excretion by leaf folder is in accordance with the work of Durairaj (1984) who registered 6.25 mg of faecal pellets production in 4 percent neem seed kernel treatment compared to 13.41 mg in control. The results on antifeeding activity is in line with the findings of Saxena et al (1980) who reported that 12% neem oil effectively inhibited rice leaf folder larval feeding.

In A. indica oil treated leaves, only 13.33 percent of rice leaf folder larvae became adults followed by 16.67 percent in T. purpurea treated leaves. In other treatments adults’ emergence ranged between 23.33 per cent (A. indica seed kernel 5% and O. basilium 10%) and 43.33 percent. The growth disrupting effects of A. indica, T. purpurea could be substantiated with the results of Schmutterer et al (1983) who found that partially purified fraction of neem seed kernel exhibited pronounced developmental abnormalities in rice leaf folder C. medinalis. The feeding, growth and development of rice leaf folder were significantly affected by different plant products( P= 0.05)

From the present in field investigations and laboratory studies, it may be concluded that besides extracts of A. indica plant products (oil, seed kernel and cake); extract of T. purpurea may also be included for further studies as one of the components of integrated pest management programme.
Experiment II —Field evaluation:

5.1. Efficacy of neem products against brown planthopper (*Nilaparvata lugens*), and green leafhopper (*Nephotettix virescens*) population:

The results obtained from the field studies revealed that neem products acted as best organic pesticide against brown planthopper (*N. lugens*), and green leafhopper (*N. virescens*) in rice crop.

Basal application of neem coated urea followed by neem oil 3 % registered lower population of brown planthopper (*N. lugens*), 0.274 in 1st year and 0.236 in 2nd year. In green leafhopper basal application of neem coated urea followed by spraying of neem oil 3% registered lower population 1.268 in 1st year and 1.508 in 2nd year. It was comparable with basal application of neem coated urea followed by spraying of NSKE (neem seed kernel extract) 5% and monocrotophos 0.04% treatments. This was due to the fact that basal application of neem coated urea followed by spraying of neem products at economic threshold levels was effective against brown planthopper (*N. lugens*), and green leafhopper (*N. virescens*) population in rice crop. As an antifeedant, neem products are quite strong because when the insect feed the neem treated material, they lose their appetite. Hence the insect will prefer to die of starvation rather than feeding on the treated surface and these neem products, which also have a repellant action, they will not eat the treated crops and lay eggs on the leaf surface. Therefore the subsequent population of insect is reduced.

High brown planthopper and green leafhopper populations were noticed in control. During 1st and 2nd year the brown planthopper populations in control plots were
1.67 and 1.69 per hill respectively whereas in green leafhopper the insect populations in control during 1st and 2nd year were 19.49 and 17.41 per hill respectively.

5.2. Efficacy of neem products against rice leaf folder incidence

Neem products were found to be effective against leaf folder in the experiments conducted in 2004 and 2005.

The basal application of neem cake at the rate of 150 kg/ha with urea followed by neem oil 3% sprayed treatment recorded lowest incidence of leaf folder than that of other treatments. The neem products were superior to monocrotophos. The basal application of neem coated urea followed by the neem oil 3% sprayed plot registered 2.64% and 3.17% of leaf damage in 1st and 2nd year respectively, which was followed by basal application of neem coated urea followed by neem seed kernel extract 5% in both the years with values of 2.71% and 3.28% respectively. The higher leaf damage was recorded in control with values of 17.02% and 18.56%. This is due to neem oil and NSKE (neem seed kernel extract) that acted as repellent, inhibitor of growth and development, feeding deterrent and also ovipositional deterrent in leaf folder. Saxena et al (1987a) reported that neem products were effective against leaf folder incidence and they also emphasized that neem seed kernel extracts could be used effectively against rice insect pest and are superior to monocrotophos.

5.3. Efficacy of neem products against yellow stem borer:

Studies made on the effect of plant extracts on population build up of yellow stem borers showed that there was a marked reduction in the population build up in monocrotophos and neem products treated plots compared to control. Monocrotophos
sprayed treatment was found to be superior in reducing the incidence of yellow stem borer compared to control (13.28%) in 1st year and (13.35%) in 2nd year. The basal application of neem coated urea followed by neem oil sprayed plot registered lowest number of yellow stem borer incidence next to monocrotophos (0.04%) with the values of 4.43% and 3.68% during 1st and 2nd year respectively. In the other treatments, stem borer incidence ranged from 4.43 to 9.23% in 1st year and 3.68 to 9.78% in 2nd year. This might probably due to low doses of neem compounds through systemic action or due to delayed application and slow action of the neem products, which were present in lesser quantities in neem cake. However, the pest populations decreased to a minimum level in all the neem treatments and were comparable to the efficacy of insecticides, because the egg laying was significantly reduced. When neem cake was added to soil, it resulted in reduction in oviposition. It is probable that as the neem cake decomposes, the odor emanating from the plots may have a repellent effect on the moth's oviposition. The oviposition of the moth has reduced further after the foliar application of neem products. The interactive effect of soil application of neem cake followed by foliar spray with neem products showed reduction in egg mass numbers and stem borer population in rice plants. Similar results were obtained by Krishmaiah and kalode (1985). They stated that neem oil and other neem products were moderately effective against rice stem borer compared with inorganic pesticides such as monocrotophos.

5.4. Efficacy of Neem products against Ear head bug population:

The results obtained from the field studies revealed that basal application of Neem coated urea followed by spraying of neem oil 3% acted as best treatment in 1st and 2nd year with the ear head bug (L. oratorius) population of 2.24 bugs/m² and 1.79 bugs/m²
during 1st and 2nd years respectively compared to control with the value of 16.76 bugs/m² during 1st year and 15.18 bugs/m² during 2nd year. In other treatments the ear head bug (L. oratorius) populations ranged from 2.24 bugs /m² to 2.86 bugs/m² in 1st year and 1.79 bugs/m² to 4.1 bugs/m² in 2nd year. This might be due to reduction in nymphal emergence, ovipositional deterrent and growth disruption of these neem botanicals. The present finding is in consodance with the findings of Islam (1993) who reported that the neem oil acted as repellent, inhibitor of growth and development, feeding deterrent against earheadbug, Leptocorisa oratorius.

5.5. Effect of Neem products on predatory spider population:

Neem product was found to have a positive effect on predator population. Higher predator population of 11.11/20 hills was recorded in basal application of neem coated urea followed by spraying of neem oil 3% treated plot during 1st year. It was comparable with basal application of neem coated urea followed by neem seed kernel extract 5% and neem cake extract 10% sprayed treatments. Monocrotophos applied plots registered lower population of predators compared to other treatments. During the 2nd year basal application of neem coated urea followed by neem oil 3% has higher predator population of 12.27/20 hills. It was comparable with basal application of neem coated urea followed by neem seed kernel extract 5% and neem cake extract 10% sprayed treatments. Monocrotophos applied plots registered lower predators population compared to other treatments. During the 1st year, in the other treatments, spider population ranged from 6.40/20hills to 11.11/20hills. In control the predators’ population was 17.40/20hills. During 2nd year, spider population ranged from 8.18 /20hills to 12.27/20hills. In control the predators’ population was 15.61/20hills. This might be due to the soil application of
neem cake worked primarily by increasing the humus content of the soil. It acted as organic soil conditions and its taste, odor, organic composition retards, repells (or) inhibits the growth and development of plant insects and parasitic nematodes. Basal application of neem cake followed by spraying of neem products acted on good repellent, inhibitor of growth and development, feeding deterrent and also ovipositional deterrent against rice insect pests and induced the predators. Earlier report by Saxena et al. (1984a), showed that the neem products induced the natural predator population with the soil application of neem cake at the rate of 100 kg/ha.

5.6. Efficacy of neem products on crop yield

Higher yields were obtained in 2004 and 2005 when the incidences of pests were reduced due to the application of neem products and it was comparable with monocrotophos applied plot.

Among the yield parameters basal application of neem coated urea followed by spraying of neem oil 3 percent recorded high yield compared to other treatments and it was closely followed by basal application of neem cake with neem seed kernel extract 5 percent sprayed plots during both the years. Lowest yield was recorded in control with the value of 3525 kg/ha during 1st year and where as during 2nd year the value was 3515 kg/ha. This was due to the fact that the basal application of neem cake protected the young seedling from pest and disease incidence and it improved the soil organic matter content significantly and the neem cake improved abundantly soil micro flora, greatly improved soil health and thus yield was increased significantly.
The foliage application of neem products such as neem oil, neem seed kernel extract and neem cake extract significantly reduced the insects' population in crop growth stages. These organic products acted as repellent, inhibitor of growth, development, feeding deterrent and also used as ovipositional deterrent against rice insect pest. It reduced the damage caused by the pest and increased the crop grain yield. Hence the soil applications of neem cake followed by neem product treatments were superior to others. But it was at par with monocrotophos 0.04 percent treatment.

5.7. Effects of neem products on cost-benefit ratio (B: C ratio)

In the year 2004 and 2005, the higher B: C ratio was recorded in neem products applied plots compared to chemical pesticide (monocrotophos) and other treatments.

Basal application of neem coated urea followed by neem oil 3% registered higher benefit cost ratio of 2.06 during 1st year and 2.18 during 2nd year. It was comparable with monocrotophos 0.04% (T10) applied plots and basal application of neem coated urea followed by neem seed kernel extract 5% (T5) treated plots. Lower benefit cost ratio was recorded in control (T11) plot with the B: C value of 1.48 and 1.64 during 2004 and 2005 respectively. The neem products treated plots registered higher benefit cost ratio compared to chemical pesticides sprayed plots and control. This was mainly due to the neem products having less cost compared to commercial insecticides. The reduced and less quantity of neem products were required to treat one hectare of rice crop. Hence, the neem products have significant cost-benefit advantage over the most advanced commercial insecticides, such as synthetic pyrethroids.

Various combinations of integrated pest management practices altered the economics. It is well known that farmers are generally not in a position to apply the
recommended dose of pesticides, in view of their high cost, harmful effect to eco system and risks involved in crop protection. Integrated use of organic products and fertilizer is considered to be an alternative (economically). It has the potential to increase and sustain the rice productivity. It also makes a good environmental ecosystem for beneficial insects and predators.

Higher grain yields of rice and lesser cost involved in basal application of neem coated urea followed by neem oil 3% resulted higher net return and benefit cost ratio compared with other treatments. Basal application of neem coated urea followed by neem oil 3% recorded higher net return of Rs.17,775 and 21,202 per hectare respectively in first and second year with a B: C ratio of 2.06 and 2.26 respectively. It was comparable with basal application of neem coated urea followed by neem seed kernel extract 5% and monocrotophos 0.04% treatments.

Lower net return and B: C ratio was recorded in monocrotophos 0.02% followed by neem seed kernel extract 3% and monocrotophos 0.02% followed by neem cake extract 5% treatments.

Control registered a least value of net return and B: C ratio during first and second years.

The gross return was increased to Rs. 34,475 and 38,037 per hectare with a B.C ratio 2.06 and 2.26 with basal application of neem coated urea followed by neem oil 3% applied treatment in 2004 and 2005 respectively. Higher grain productivity and lesser cost of cultivation due to the application of organic products resulted in increased net return and B: C ratio with environmentally safe ecosystem suggested the integrated pest
management is necessary to raise the productivity in a sustained manner which also reduces the insect populations considerably in forthcoming years.