2010

IPM of Aphid Pests on Winter Crops

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University of Rajshahi

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A dissertation submitted to the Institute of Environmental
(IES), University of Rajshahi in partial fulfillment of the
requirement for the
Degree of Doctor of Philosophy
in
Environmental Science

By

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Supervisor

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CERTIFICATE

This is to certify that the dissertation entitled "3, , P S D F W R I
Change on Natural Resource-based Food System of Tribal Comm
of North-: H V W H U Q 5 H J L R Q submitted by Mr. Aro
in partial fulfillment of the requirements for the degree of Doc
Philosophy in Environmental Science, University of Rajshahi of B
is an authentic work carried out by him under my supervision.

This interdisciplinary approach, in explaining the above title is a
venture, so far researches are considered in our country. Hopefully,
usher a light in our domain of knowledge and wisdom.

To the best of my knowledge, the matter embodied in the disser
been submitted to any other University or Institute for the award
Degree or Diploma.

I therefore, forwarding this thesis submitted for the degree o
Philosophy to the Institute of Environmental Science (IES), U
Rajshahi, Bangladesh.

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socio-economic and cultural life of the tribal and forest dwellers is c associated with forest to a great extent. The forest has been playing role in the economy of the tribal in Bangladesh. The religious, cu economic activities of them also depend on forest (Khisa, 1998)

In Bangladesh, ethnic or indigenous people like Chakma, Marma Monipuri, Santal and others consume some molluscs specie sources.

A tribal economy should always be characterized by the collectio social, institutional, technological and finally economic arran through which the community seeks to enhance their materials well-being. There is always an interaction between the enviro which the community lives and their practices that led to sus livelihood. Natural environment, surrounding the people, provides s goods, services and amenities to them.

The researcher stated that some extent is conscious environmental and climate changes, decreasing water av deforestation, decrease in open water fish production. So environm change and impact of human activities can be profoundly dam natural resources based food security of the ethnic or indigenous Bangladesh.

There are some report and research on food security, food habit Chittagong Hill Tracts but no authentic literature on food security o on north-western region of Bangladesh.

Although, many study were carried out on the food security issue studies carried out in coastal areas of Mexico, Nicaragua and show that aquatic species, such as clams and oysters, that ar components of the diet of riverine population, may contain relati their forests. The Chittagong Hill Tracts comprising the three hill d Rangamati, Khagrachari and Bandarban, have a population of 1.1 m (Chowdhury, 2007). The region constitutes 10% of the total land a Bangladesh (Raihan et al., 2009) and 76% of the total hilly region of the (Khisa, 1998). Banik (1998) have recorded 12 types of tribal people liv CHTs.

For the centuries, these tribal communities have been living on-s burn agriculture (locally called Jhum), fishing, hunting and harvesting forest products (Mustafa et al., 2002). The Mro or Murung are one o ancient ethnic minorities of the CHTs region (Roy, 1996), and they ex different socio-political organization compared to other tribal groups (Ahm 2002). In exploiting forest products, the Mro apply their own know traditionally transmitted from their precursors (Miah and Choudhary, 2004).

Indigenous knowledge (IK) refers to that knowledge which is g and transmitted by communities over time, in an effort to cope wit own agro-ecological and socio-economic environments (Alam and 2000; Mohiuddin et al., 2002 and Alam, 2002).

According to the government statistics the total number of tribal is 05,978 which is only 1.30 percent of the total population. However doubts remain about this number of Adivasis (BBS, 1991). In the census of Bangladesh government (2011), total tribal/indigen population is 1586,141 which is 1.10 per cent of the total popula

1.1.4 Food Habit of Tribal People in Bangladesh

The tribal are not only distinct as regard to their religious practic and totemic division, but they a different way of living too. The fre molluscs play a vital role in the economy and tradition.

contributing economic livelihoods but already are serious t
environmental and human health because of inadequate att
environment and sustainable development.

1.2.1.4 Wetland Resources in Bangladesh

Bangladesh possess enormous wetland areas out of which th ones are rivers and streams, fresh water lakes and marsh including ha baors and beels, water storage reservoir, fishponds, flooded c fields and estuarine systems with extensive mangrove swamps about 700 rivers in Bangladesh the estimated length of which is (Rahman, 1994). The major wetlands of Bangladesh are vast flo and delta of the Ganges, Meghna and Brahmaputra rivers. The of the wetlands in the country have been variously estimated a eight million hectares, about 50% of the total land surface. But resources have suffered considerably from the impact of b human population. Millions of hectares of wetlands have been l flood control, drainage and irrigation development. The demand enormous considering the density population at over 1222 perso square km (World Bank, 2014). Erosion in the catchment areas is increased situation and having major impacts on the key wetl which are being continuously lost or degraded primarily becau recent development and lack of awareness on wetland functions a (BCAS, 1995).

1.2.1.5 Wetland Environment

Wetlands in Bangladesh have great ecological, economic, comm socio-economic importance. It contains very rich biodiversity of national and regional significance. Among the estimated 5,000 flowering plants and 1,500 of vertebrates in the country up to species and some 400 vertebrate species are judged to be d

1.2.2.4.1 Destruction of Natural System
The requirement of space, food and raw materials for expanding establishment is one the most important cause of such a rapid biological biodiversity.

1.2.2.4.2 The Boreal Coniferous Forest of the North
The northern most belts skirting the arctic sea are probably the only ha in the world where losses of biological diversity are modest. This very thinly populated and possesses little diversity in its composition due to the harsh and severe climatic conditions.

1.2.2.4.3 Temperate in Sub-Tropical Region
These two regions support extensive agriculture and cattle ran tall grass prairies of North America and the hardwood forests o are disappearing or have already disappeared. The temperate are also endangered ecosystems of the original 31 million hectares 18.7 million have already been cleared (Asthana, 2001).

1.2.2.4.4 Tropical Region
The tropical regions are designated as mega diversity countri endowed with richest flora and fauna of the world. The population is r rapidly in this region. To make up food crisis and improve the conditions, these countries are forced to expand agriculture, mo over-exploit natural resources and tastily set up industries.

1.2.2.4.5 Wetlands
Wetland ecosystems are important store houses for biological They are provided suitable habitats for a large number of specie parts of the world, the wetland ecosystems are being drained ar agriculture use of for human settlements or are converted to aqua-cul ponds. Almost 90% of the wetland systems have been lost in ind countries, like Australia, USA etc. (Asthana, 2001).

plants is currently being revised at the Bangladesh National Herba (BNH), and is expected to exceed 500 Species. (Mia and Huq 19 showed that there are 224 species of timber-yielding plants foun Bangladesh. (Khan and Mia, 1984) described 130 species of ind fiber plants.

The IUCN Bangladesh Red Data Book (2000) has recorded 266 sp of inland fishes, 17 marine fishes, 22 amphibians. 109 inland r marine reptiles 388 resident bird, 240 migratory birds, 11 mammals, as well as 3 species of marine mammals in Banglade

1.2.3.3 Biodiversity Extinction

According to the Red List of IUCN (2000), there are 54 species of fishes, 8 amphibians, 58 retiles, 41 resident birds, and 40 mamm are threatened throughout the county. Among the marine and species of animals, 4 fishes, 5 reptiles, 6 birds, and 3 mamma threatened. So far, so far, the Red Data Book on plants whic preparation at BNH (Bangladesh National Herbarium), lists 96 s bearing plant species that are threatened.

1.2.3.4 Depletion of Biodiversity

The depletion of biodiversity is the result of various kinds of development interventions and activities, especially in the agriculture, forestry, fisheries, urbanization, industries, ch minerals, transport, tourism, and energy.

Both flora and fauna are threatened by the loss habitat result increasing human populations, and unwise bio-resource utiliza Increasing demand for timber and fuel-wood, encroachment of c purposes, and Jhum (shifting) cultivation in the hilly district, might be aggravating factors in the annual rate of deforestation and degra

1.3.2.4 Dimensions of Food Security

Food security is the outcome of food system operating efficiently. food system contributes positively to all dimensions of food Following are the dimensions of food security:

1.3.2.4.1 Food Availability

This dimension of food security reports about supply side of the security and expects sufficient quantities of quality food from agriculture production or import. This is simple mathematical ca weather the food available in certain territory/country is enough to total population in that particular territory and calculated from the local agriculture production at that territory, stock levels import/export.

1.3.2.4.2 Food Access

Having sufficient food at national level or at certain territory ca taken as the proof that all the household or individuals in the cou enough food to eat. Food access is another dimension of foo which encompasses income, expenditure and buying capacity households or individuals. Food access addresses whether the or individuals have enough resources to acquire appropriate quality foods.

The indicator of the food access is food price, wage rate, per capi consumption, meal frequency, employment rate etc. and the dimensio be assessed, Food Access Survey, Food Focus Group Discussio household food frequency questionnaire etc.

1.3.2.4.3 Food Utilization

Food utilization is another dimension of food security which address only how much food the people eat but also what and how they covers the food preparation, intra-household food distribution, wat

1.3.4.1 Natural Resources

Natural resources play an important role in the life of the poor. M
1.3 billion people depend on fisheries, forests, and agricultur
employment close to half of all jobs worldwide.

According to the Harriss (2002) described that 90% R I W K H
billion poor those are living on less than $1 per day, depended
for at least some part of their income. In 2002, international develo
agencies estimated that more than 90 percent of the 15 milli
Z R U N L Q J R Q W K H Z R U O G ¶ V -scale fishers, most of them Z
not including the tens of millions of poor who fish inland rivers, la
even rice paddies for protein. While all human societies are
ecological processes and healthy ecosystems that produce the re
for life, rural poor people depend significantly more on natural ca
do other parts of the population. In Africa, more than seven in te
people live in rural regions, with most engaged in resource-depen
activities such as small-scale farming, livestock production, f
hunting, artisanal mining, and logging. Poor people rely on relate
as a primary source of income and fall back on natural resou
other sources of income fail. The development agenda is being d
few key approaches and policies. These include the United Nat
Millennium Development Goals (MDGs) and the World Bank P
Reduction Strategy Papers (PRSPs). Yet these approaches m
account for the links between resource management and poverty
and subsequently fail to realize the full potential of natural r
(goods and services) as wealth-generating assets for the poor. This
characterizes the dependence of the poor on natural resources
NRM-poverty linkages in the policies of leading development ag

1.4 Rational of the study

1.4.1 Literature Review

Kashem et al., (1997) conducted a research on Combating Enviro Degradation in Bangladesh: New Urge for Sustainable Ag Technologies. The findings of the study reveal that a lot of envir changes occurred in Bangladesh during the last ten years; the cultiva of modern rice verities and vegetables has increased along with chemical fertilizers and pesticides. They also stated that some conscious about the environmental and climate changes, decre availability, deforestation, decrease in open water fish production. did not find how the environmental change is impacting on food They also recommended developing appropriate technolog situation and environmental variation.

Sinha and Lakra (2005) conducted a research on wild tribal food plan Orissa and Edible weeds of tribal of Jharkhand, Orissa and We They carried out survey among 10 ethnic communities and identifie numbers of wild plants foods and 43 numbers. of edible weeds species are commonly consumed by the tribal population as per their a in the nature. These are the integral part of tribal died. Man unknown food can be exploited to meet the food and nutrition s the nation. They assumed that these types of indigenous foods pla role for food security and nutritional security of the tribal commu

Butt et al., (2005) conducted a research on the economic and foo implication of climate change in Mali. The findings of the study that may experience moderate economic losses under the magnitude change as projected by HADCM and CGCM models. The losses the range from 70 to $142 million. The risk of hunger in Mali may from 34% of the population 44% due to land degradation and furth

The terrestrial and aquatic areas of the country support a large diverse biological populations, both plant and animal. It is belie development practices have caused a significant depletion of terres aquatic species diversity. Over-exploitation of some very common s in an unwise manner has led to their being reduced to a vulnerable s

1.6 Aim and Objectives

The important linkage between poverty reduction, livelihood promo tribal and natural resources conservation is well recognize development thinkers, researcher.

Keeping these in mind, an investigation was carried out follow bellow objectives:

1. To understand the status of socio-economic condition of tribal of N west region in Bangladesh.
2. To find out the anthropogenic causes for Environmental deg DQG WULEDO SHRSOH¶V SHUFHSWL
3. To identify the Natural resource-based foods of Tribal commun North western region in Bangladesh.
4. To identify the impact of environmental change on natural base food systems and security in term of availability in Northwestern region in Bangladesh.

2.5 Primary Data

Both quantitative and qualitative data have been collected on primary and secondary sources as per requirement of the study the objectives.

The quantitative data have been collected from the field survey appropriate questionnaire was prepared and used for collecting the tribal community of the study area.

For the qualitative data collection three methods i.e. Focus G Discussion (FGD), Case study and Key Informant Interview (K been used.

2.5.1 Focus Group Discussion

A total of 10 Focus Group Discussions (FGD) have been condu different stakeholders such as Tribal, farmer and agriculture d with mixed group of community people, people from NOGs, Fish Agriculture Department, Tribal community leader also been inte for the purpose. An FGD guideline developed on the basis of the of the study was used for collection of data.

2.5.2 Case Studies

Case studies are also considered important tools for colle information from the local community people who provided with information from their long observation and experiences of the aspect of the environmental changes, Natural resources, biodive study area. Case studies were also done in the light of the objectives o research. A total of 10 case studies has been collected with peo different professions and ages who are the user of the natural b

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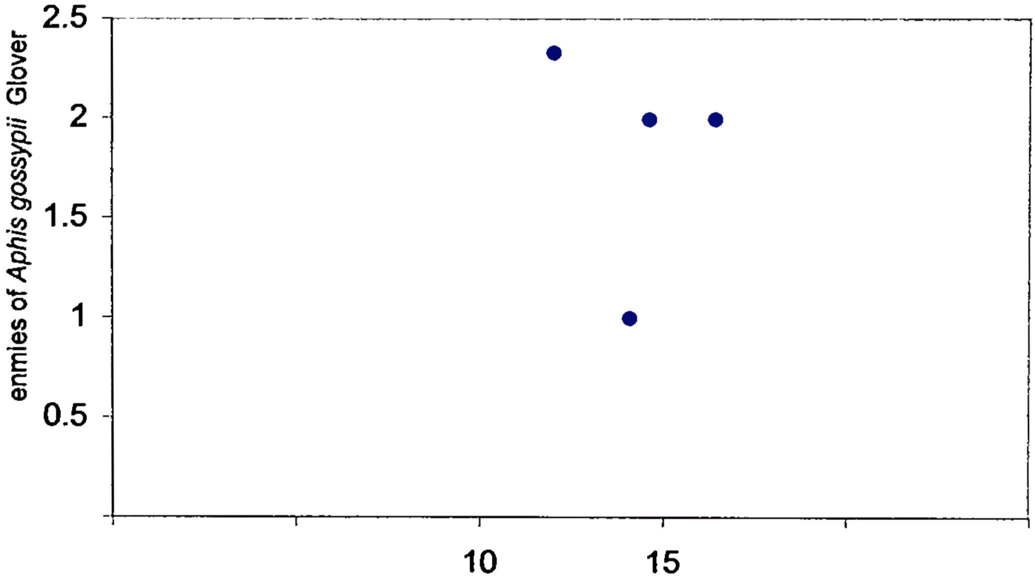

Fig. 4: Relationship of of brinjal aphid, *Aphis gossypii* Glover per plant prevailing dew point.

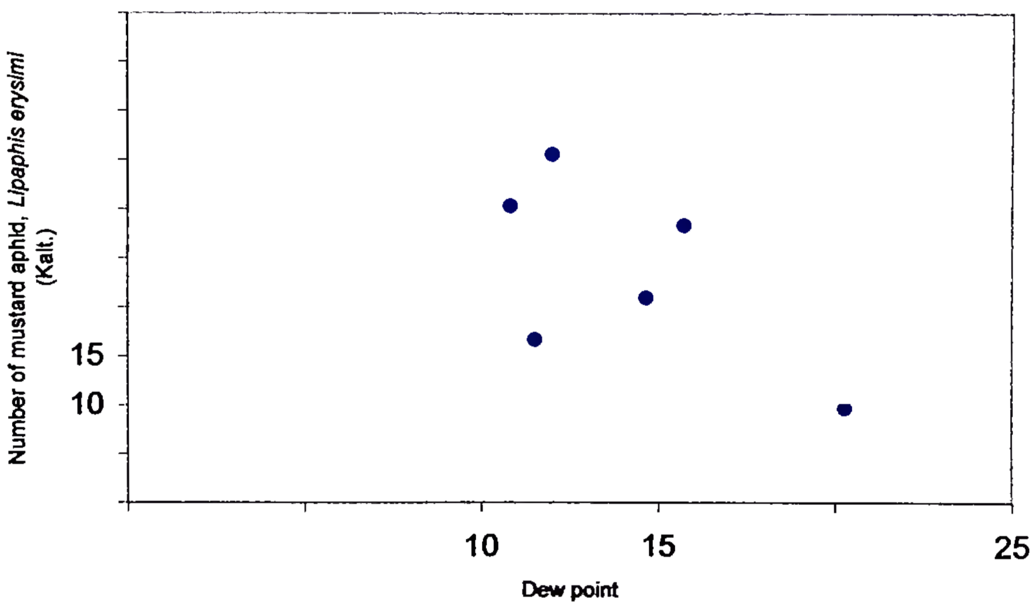

Fig. 5: R ·iation ..ıp number of mustard aphid, *Lipaphis erysimi* (Kalt.) per plant and dew point.

during the experimental period. Of them highest peak of relative humidity (91.21%)was observed during 1st week of January ,2004. A very little amount of rainfall took place in the 3rd week of December 2003; 3rd and 4th week of January 2004. The impacts of above environmental factors *viz.*, temperature, relative humidity, dew point and rainfall on the weekly number of aphids and natural enemies were investigated by calculating the degree of relationships between the said variables. In order to do this analysis of 'r' (Correlation co-efficient) values were calculated separately which are provided in Table 1 and it was observed that dew point influenced the number of natural enemies of brinjal aphid, *A. gossypii* significantly($P<0.001$). Temperature, relative humidity, dew point and rainfall have no significant effect on the population of bean aphid ,*A. craccivora* and its natural enemies. Dew point also have a significant effect ($P<0.01$)on the number of mustard aphid, *L. erysimi*. The regression lines are drawn only in the case of significant relationships (Figs. 4 and 5).

1.4. Discussion

Aphid population on plant is determined by nutrition, natural enemies, plant age, plant species and environment (Kennedy and Booth, 1954). Aphid population fluctuations are also influenced by changes in weather, a major distribution factor (Dixon, 1985). Cool, moist and fall of temperature augment aphid numbers (Nielson and Barnes, 1957; Hajek and Dahlsten, 1988). The prevalence of favorable weather condition for a larger period can cause severe out break of aphids (Singh and Sharma, 2002).

Srikanth and Lakkundi (1990) studied the population fluctuations of cowpea aphid, *A. craccivora* and its Coccinellid predators at Bangalore, India from March to May, 1984 and observed that *A. craccivora* started to attack in the first week of crop growth and peak population was attained (318.4 per cowpea plant) during onset of May. The peak predator populations more or less coincided with the peak aphid population and thus demonstrated a prey dependant predator growth. From the experiment on cowpea, Saharia (1980) also indicated the potential of this aphid to multiply and spread in a short time span with the availability of sufficient space and nutrients in the plant materials. Worked on the seasonal variations of *A. craccivora* on cowpea at Kangbai (500 m above MSL) and Mao (2000 m above MSL) in Manipur ,North Eastern region of India revealed that infestation started right from the seedling stage in April, attained peak in May and then slightly declined during June in both the areas. Once again the aphid number showed an increasing trend in July and subsequently decreased in August (Hizam and Singh, 1989).Decrease in the number of aphids in June might be due to the adverse effect of rainfall which was 40 cm and 17 cm , at Mao and Kangbai respectively. The study also revealed that the minimum temperature within the range of 17-20^{0}C, maximum temperature 29-32^{0}C, R.H. between 77-83% and rainfall less than 4 cm were optimum for build up of *A. craccivora* at Kangbai station. But at Mao the aphid population reached maximum during May with minimum temperature of 10-13^{0}C and maximum of 24-27^{0}C, R.H. between 77-82% and rainfall 5 cm. Because of the difference in agro-climatic conditions, altitudes of the area, and cultivar of the host plant, results of the present study disagreed with the findings of Hizam and Singh (1989). Lal *et al.*,(1989) come to a conclusion from their study, population of *A. craccivora* on chickpea are influenced by cultivar and planting density. The highest and lowest number of aphids was found on the cultivars 2184B (7.62/twig) and 75-35 (3.25/twig) respectively. Fewer aphids were found on plants sown on 30 cm $\times$10 cm apart than on plants sown on 60 cm $\times$20 cm apart which is quite reverse with the results of Lee *et al.*, (2002) who detected population of *A. gossypii* on Chilli was significantly higher ($P<0.05$)in the dense planting than in the sparse Chilli planting density.

A. gossypii was found throughout the year on brinjal plant at Bhubaneswer and their heaviest infestation occurred during September to November (Roy and Behura, 1979).Karim *et al.,* (1994) worked on the population of *A. gossypii* on egg plant, *Solanum melongena* L. interms of weather parameter from October 1992 to March 1993 at Rajshahi, Bangladesh and observed maximum number of aphids during January,1993 when average temperature, R.H., dew point , sun light and rainfall were obtained as 16.55^{0}C, 74.55%, 12.40^{0}C, 6.43 (hour) and 0.00 mm respectively. They also mentioned aphid began to appear during October, 1992 and disappeared during March, 1993. The 'r' values for temperature and rain fall showed significant ($p<0.05$) effect on the population growth of the aphid. But in the present study peak population of *A. gossypii* (17.00±1.16/plant) was obtained in the 4th week of December, 2003 when average temperature, R.H., dew point , and rainfall were noticed as 19.32^{0}C, 75.72%, 12.29^{0}C and 0.00 mm respectively. Slosser *et al.* (1992) observed that the population of *A. gossypii* increased rapidly during August only in June planted cotton, which suggests that time of year interacts with plant age to influence population development. The number of *A. gossypii* on brinjal plant decreased gradually in older leaves and increased in younger leaves towards harvest(Banerjee and Raychauduri ,1987).From a twelve years (1972-1983) study of Raj (1989b), highest population build up (745 aphids/100 leaves) of *A. gossypii* infesting potato Var.Kufri Bahar was observed in Deccan Plateau during 3rd Std. week in January in early rabi crop (planted on first week of November) when average temperature was ranging from 10.7^{0}C- 29.9^{0}C and R.H. between 31-81%. The population development was low in kharif (planted on first week of July) and late rabi crop(planted on middle of December).The kharif crop was subjected to high temperature and intermittent rains. Jamwal and Kandoria (1990) observed the appearance and build up of *A. gossypii* on june planted brinjal Var. Chamkila from July 1986 to December 1986 at Punjab and found that the population varied from 2 to 84 aphids/30 plants from the end of July to end of August. The population reached it's peak by the third week of September and started decreasing drastically from fourth week of September onwards. Maximum activity of the aphid was recorded in September when the average temperature and relative humidity varied from 27.2-29.7^{0}C and 68-73% respectively. Five years (1983-87) mean data on the population of *A. gossypii* in relation to weather factors showed that it appeared on potato at emergence stage during 45th Std. week (November) and attained two peaks, first with low population (13 aphids /100 leaves) in 48th Std. week (December) and second with high incidence (86.8 aphids /100 leaves) during 5th Std. week (January). It's population started declining considerably from 6th Std. week (February) and almost disappearing from 11th Std. week (March).Significant negative correlation with maximum (-0.484) and minimum temperatures (-0.574) and non significant negative correlation with relative humidity (-0.311) and aphid population were also observed (Verma and Parihar,1995). Populations of *A.gossypii* on strawberries grown in green house were monitored twice weekly from January to May during 2002 and 2003 at University of Florida. The average temperature in the green house during this experiment was 22 and 16^{0}C day and night respectively. In both the years, number of aphids on bud were greater than on the leaves (Rondon *et al.*, 2005). In 2002, two peaks were observed on bud on 15th February (24.65±9.87 aphids/plant) and 15th March (56.40±11.35 aphids/plant).But in 2003, one peak was observed on bud on 15th February (33.16±2.89 aphids/plant) .

Observation on the incidence of *L. erysimi* on mustard in two rabi seasons (1986-87 and 1987-88) at Haryana, India indicated that incidence initiated from mid November to early December and peak incidence occurred during second fortnight of February to first fortnight of March when 85 to 200 aphids/10 cm main shoot were recorded (Yadav and Kalra,1990). In India and Bangladesh where more or less similar ecological zones are present, *L. erysimi* appears there in the field during the first week of November and goes its peak during January and is disappeared by February (Das, 2002; Singh and Sharma, 2002 and Bakhetia and Sidhu, 1983). Early sown varieties are less susceptible for aphid infestation in comparison to late sowing varieties (Singh *et al.*, 1984; Singh and Bakhetia, 1987; Bakhetia and Sekhon, 1989; Patel, 2004; Singh and Dhaliwal, 2004).Bakhetia and Sidhu (1983) recorded the high population of *L. erysimi* up to second week of February (122.30 aphids/plant on 11 February, 1978) after which it decreased suddenly(27.17 aphids/plant on 18 February, 1978). They mentioned that this sharp decline was due to 33 mm rainfall received from 12-17 February, 1978. Bakhetia and Sidhu (1983) also reported that the aphid colonies were dislodged and killed by the continuous rainfall for 4-5 days. In their studies (Bakhetia and Sidhu, 1983), the aphid did not build-up higher proportions in the subsequent weeks contrary to the earlier report by Atwal *et al.*, (1971).According to Saharia (1984) population of *L. erysimi* attained it's peak during mid-January to mid-February in Jorhat, Assam, India, and population variation had relationships with that of the reproductive rate of the aphid and the abundance of its predator, *Coccinella repanda*. Pandey *et al.,* (1986) recorded higher population of *L. erysimi* during 3rd week of December and the first week of January in India and mentioned that the most favourable temperature and R.H. for population build up of the said aphid was 15°C to 20°C and 60% to 70% respectively.

It was observed from the study of Biswas and Das (2000), infestation of *L. erysimi* was first noticed in the first week of January in 1997, while in 1998, it was in

Another researcher (Galib et al., 2013) recorded 81 fish species incl
72 indigenous and 9 exotic species in the chalan beel area under 1
orders, 27 families and 59 genera. Availability of maximum 6% 4
species were ranked as low followed by common (23%), abunda
rare (9%) and very rare (5%). This result also supports of this st

3.3.2.2 Prawn, Crabs and Mollusks Resources in the Study Area

Table 18. Prawn, Crabs and Molluscan Diversity in the Study Area

Status of	Total Number	%
CA	5	50.00
MA	2	20.00
RA	1	10.00
CR	0	-
EN	2	20.00
EX	0	-
Total	10	100.00

Source: Field Survey 2012

A= commonly available, MA= moderately available, RA= rarely available, CR= Critically endang
EN= Endangered, VU = Vulnerable, NO= Not threatened, DD=Data deficient, EX= Exotic

The table 18 shows that in the study area a total of 10 Shrimp and Pra
Crabs and Mollusks Resources were found. Among the 50% (5
commonly available, 20% (2) are modernly available, 10 (1) i
available in the study area. (Appendix 10.b)

Deb (1998) indicated that the societal value of the coastal environ
supports life and livelihood of millions of coastal communit
Bangladesh is not recognized, aquaculture industry might give
severe ecological, economic and social problems and conflicts.

fallow land. Plenty types of tubers also the collected from the jung types of leaves of trees (Pikor-A kind of Banyan) the collecte preserved it by drying. In the lean period, they used it for carry.

There were many types of indigenous fish in the Beel and nearby ri Ruhi, Katla, Kalbouse (Carp), Tengra, Bain, Soil, Shati, Cheng, Sing was available in the beel. During the dry season, the trib collected much fishes from the beel and dried it for preservation. fish was not available they used their dried fish. At the same times, t collected snail from the beel and preserved it in mud whole.

When they have no work, much tribal man went out for two or th for hunting. They collected mongoose, hare, tortoise, etc. from the na They conserved the meat of hunted animals applying their t technology.

He said that Mohua fruit was the very popular in the tribal society used the flash of fruits with rice floor for making bread and Handi (beer) in special occasion. They also use the nut for making oil for c

He was asked about environmental changing in the area. He in that climatic parameter has changed. Earlier, in the rainy season rainfall was happening. He informed me that after liberation, government social forestry activities were started. At that time trees were cut down. During the last 30 years many exotic plants place in the government forest land area where no indigenous pl are grown even the birds and wild animals are not seen in tha Therefore, the tribal people lost their sources of natural food.

Now, they have to depend on cultivated vegetable these are non for the tribal people due to low income. Many tribal peoples in vill are taking vegetable once in a week. Some tribal household

3.4 The Impact of Environmental Degradation on ³Tri Traditional Food System´

, Q P \ W K H V L V , K D Y H X V H G W K H W H ... to identify all food within a particular culture available from local n resources and culturally accepted. It also includes the sociocu meanings, acquisition and processing techniques, use, composit nutritional consequences for the people using the food. Depletion of na resources by environmental degradation has a significant effe traditional tribal food systems.

Destruction of wetlands has a negative impact on poor people the tribal people in the study area. The tribal people capture i fisheries items (snail, crab etc.) is the main source of protein for th tribal. Again loss or depletion of animal and plant species lin productive opportunities of U X U D O 7 K H F R X Q W U \ ¶ out with using chemical fertilizers and pesticides extensively. The Health Organization (WHO) estimates that, 37 million peopl developing world suffered acute or chronic poisoning due to ex toxic pesticides (Khan, 1991). Most of the tribal people are involv agriculture daily labor therefore these group are usually at greater sickness due to pesticide poisoning.

The combined effect of fishing, overcapacity, by-catch manageme well as environmental degradation have made 60-70% of the major w fisheries resources are in urgent need of management action to increase in fishing capacity and to rehabilitate damaged resour 1991). The survey reports from the Department of Fisheries, (D showed that 1,24,216 acres of open water area in the greater Ra District including rivers, numerous beels and floodplains, is grad declining because of flood control, drainage and irrigation proje

Table 30. Perception of Tribal People on Environmental Changing

Types Natural Resource	Before 1970	1985	2000	2005	20
Agriculture (%)	31	71.33	78	81.00	94
Forest (%)	2	1.50	0	0	0.
Fallow Land (%)	24	8.33	5	5.00	1.
Jungle (%)	19	9.17	0	0.83	0.
River	4	4	4	4	4*
Canal	-	1	2	2	2
Pond	8	12	0	11	13
Beel	1	1	1	1	1
Government. Pond	13	8.83	0	2.83	3.
Public pond	0	4	8	12	15

Rivers*- Atri, Punorvova, Mahananda and Pa

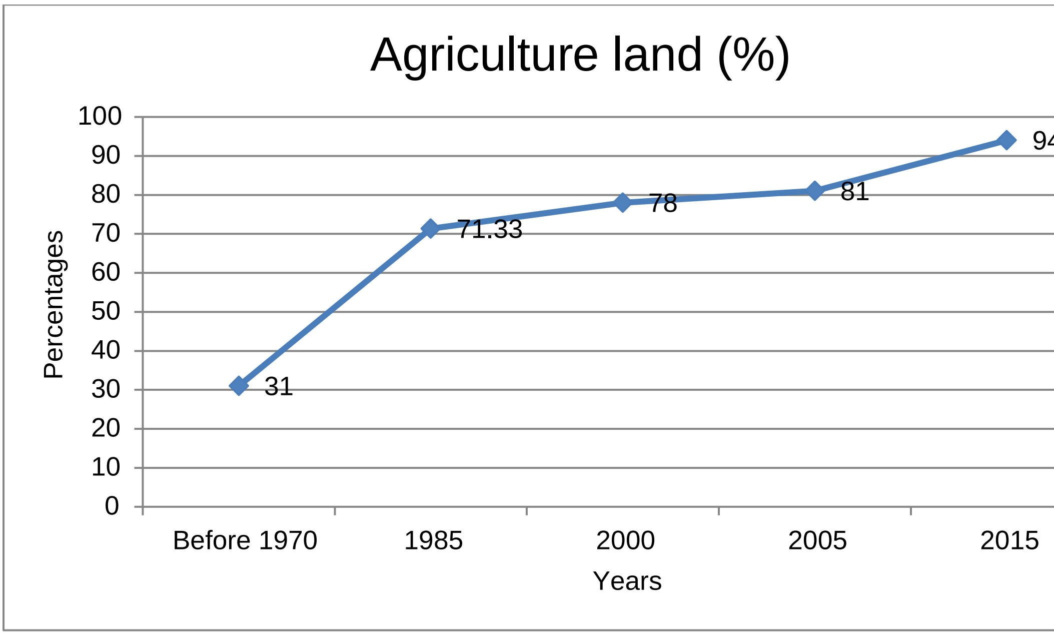

Figure 18. Tribal People's Perception About Changing Agriculture La

The figure 18 shows the trend of changing land pattern in the stu
The respondent said that before dependent near about 31% land use
agriculture that was tripled in 2000. They also reported almost
cultivable land is under any types of agriculture cultivation in 2015.

3.4.2.2 Availability of Wild Tuber Food Consumed by Tribal People o Study Area

Table 32. Present Status of Wild Tuber Food Items Consumed by Tri People.

Period	Status of availability of wild tuber food items				
Before 1070	Commonly Available	Moderately Available	Rarely available	Not available	Tota
1970	11	0	0	0	11
1985	6	5	0	0	11
2000	3	6	2	0	11
2005	1	2	8	0	11
2015	1	2	1	7	11

6RXUFH $XWKR2

3.4.3 Edible Weeds Consumed by Tribal People in the Study A

The non-conventional plant items that are consumed by the trib may have considerable nutritive value as they have been cons longer period of time. At the same time, the tribal knowledge plants, gained over centuries of living amidst natural conditions, in greater documentation of edible plants that have survived in t but may have disappeared from the regions where forests have b due to human habitat.

Recommendations

Based on the findings of the study, the following recommendatio been suggested to improve their livelihood and food securit resources based food systems of tribal people, food consumptio copping strategies of indigenous households in various stress situatio

1. Governments should consider seriously taking steps to co reserve forest and wetland resource by strong monitoring.
2. The indigenous foods especially edible plants, vegetabl should be popularized through a massive education program V W X G \ D U H D V R W K D W W K H P D M R
3. Government should take initiatives to make availability food items snail, Jhinuk (oyster), tortoise and other conventional fisheries through conserving protecting area.
4. This is necessary to create an enabling environment to access to and availability of micronutrient rich tribal foods. long-term strategies that ensure nutritious foods are availab by restoring natural ecosystems.
5. Tribal should be given priority to lease the government po tribal village.

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Appendix 5.6. Edible Weeds, Plants and Tubers Use as Fo Tribal People of North-Western Region in Bangladesh.

Sl. No	Local name	Scientific name	Parts consume	Consum by tribe
1	Lopung	Aerua lanata Juss	Leaf /Seed	Santa
2	Jangli chauria	Amaranthas viridis Linn.	Leaf and young shoot	All tribe
3	Jangli lahsun	Asphodelus tenuifolius Cavan	Leaf	Oraon
4	Koil Khara	Asteracantha longifolia Nees	Leaf	All tribe
5	Ochoic arak	Boerhaavia diffusa Linn.	Leaf	Santa
6	Garudi arak	Alternanthera sessilis Br.	Young plant	Santal a Oraon
7	Janum arak	Amaranthus spinosus Linn	Leaf and tender shoot	All tribe
8	Kokro pump	Celosia cristata Linn.	Leaf	Oraon
9	Beng Sag, Chatum arak	Centella asiatica Linn	Whole plant	Oraon Munda a Santa
10	Bhatua arak	Chenopodium album Linn	Leaf	Santa Oraon
11	Hurhura	Cleome vlscosa Linn	Young plant	Santa Oraon
12	Kenna Sag	Commelina benghalensi Linn	Leaf	All tribe
13	Pat sag	Corchorus olitorius	Leaf	Oraon Santa
14	Tena arkha	Cyanotis axillaris Roem. And Sch.	Leaf	Oraon
15	Kantha arak	Euphorbia granulate Forsk	Young plant	Santa
16	Seta kata arak	Gynandropsis gynandra (Linn.) Briq.	Young plant	Santa
17	Pitta sag	Leucas cephalotes Spreng	Leaf	All tribe
18	Muchari	Limnophila conferta Benth	Leaf	All tribe
19	Chottor arkha	Limnophila gratioloides R. Br.	Tender plant	Oraon
20	Sunsunia/ Chatong arak	Marsilea minuta Linn.	Leaf	All tribe
21	Netho sag	Oxalis corniculata Linn	Leaf	Santal a Oraon
22	Gima arak/ Gima sag	Polycarpon loeflingiae Benth.	Leaf	Santa
23	Sauri arak	Polygonum glabrum Willd	Tender young plant	Santa
24	Kawoa sag	Rungia parviflora Nees	Young Plant	Oraon

To be contin

41.2 ±1.8 and 65.3 ±8.3 aphids of *A. craccivora* per day respectively. Egg, larval, prepupal and pupal stages lasted for 2.0±0.22, 8.23±0.66, 0.61±0.13 and 2.48 ±0.21 days on same food at a mean temperature of 28.3±1.1^{0}C and R. H. 57.9±10 % respectively.

The fourth instar larva of *C. transversalis* consumed fifty aphids of *L. erysimi* and the total larval period were recorded as 21 to 22 days on same food and this duration was higher than the present findings (Roy ,1976).

Ngammuang (1987) found that the feeding capacity of four larval and adult stages of *M. discolor* were 21.80±3.29, 41.90±7.78, 66.25±20.13, 125.15±25.20 and 1295.7±605.69 aphids of *A. craccivora*. On an average, the egg, larval, pre-pupal and pupal stages took 2, 3.43, 1.2 and 3 days respectively to complete their development. In 1991, Rahman reported that the feeding rate of *M. discolor* larvae at the 1st day after hatching ranged between 4 to 7 on cotton aphid, *A. gossypii* (average 5.2±0.58). From the 2nd day, the consumption gradually increased and reached an average of 26.8±2.59 aphids on the 8th day after which feeding rates sharply dropped. Each larva of this beetle consumed an average of 131.6±13.25 aphids in total larval period. The adult consumed 21.0 ±2.21 aphids during 1st day and the rates gradually increased up to 9th day which was 86.4±4.84 aphids. Rahman (1987) studied the larval and adult voracity of *C. trasversalis* (=*C. repanda* Thunb) on *A. gossypii* and noted that average feeding rate of the newly hatched grub(first day after hatching) was 7-2 aphids. From the second day the rate increased up to an average of 70.8 aphids on the 9th day. There after, the feeding rate of the grub declined suddenly and on the 10th day on an average it was 33.7 aphids. Incase of adults feeding rate was 24.4 aphids first day after emergence and gradually increased from the second day onwards and averaged 96.2 aphids on the 9th day and then come down to 88.7 aphids on the 10th day. Singh and Singh (1994a) investigated the predatory potential of *C. septempuncata* L. and found that 1st, 2nd, 3rd and 4th instar larvae of *C. septempunctata* consumed averages of 22.78, 66.00, 172.50 and 333.11 aphids of *L. erysimi* in the laboratory at 28°C. Rahman (1984) recorded the larval durations of *C. transversalis* as 89.38±3.25, 64.76±1.52, 73.18±2.24 and 245.02±3.19 hours for 1st, 2nd, 3rd and 4th instars respectively at 20°C and the feeding rate of both larvae and adults increased with the increase of their age. But Rahman (1984) did not mention the name of the prey aphid used during his experiment. According to Khursheed *et al.*, (2006) the first, second, third and fourth instar larvae of *C. septempuncata* L. consumed 10.0±1.73, 29.0±2.89, 39.0±1.16, 52.3±7.23 aphids of *L. erysimi* respectively in first generation while the corresponding figures in second generation were 11.5±2.02, 27.0±2.89, 51.0±5.78, 60.3±9.54 aphids. Singh *et al.*, (2002) observed the larval consumption of *C. transversalis* as 413.8±58.7 aphids of *L. erysimi* whereas in the present investigation number of consumed *L. erysimi* were recorded as 249.8±10.60 aphids by the grub of same predator. Omkar and James (2004) examined the prey consumption of *C. transversalis* on six aphid species of which *A. gossypii*, *A. craccivora*, and *L. erysimi* are also included. Total consumption of aphids during the whole larval period of *C. transversalis* were recorded as 665.30 ± 5.75, 626.40 ± 3.53, 572.70 ± 2.99 aphids of *A. gossypii*, *A. craccivora*, and *L. erysimi* respectively. Total number of aphids consumed by male *C. transversalis* during their whole adult life were recorded as 4831.10 ± 123.54, 3883.70 ± 81.95, 3068.70 ± 130.50, aphids of *A. gossypii*, *A. craccivora*, and *L. erysimi* respectively but the corresponding figures for female adults were 5412.30 ± 94.51, 4494.00 ± 140.14, 3587.80 ± 61.49 aphids. Regarding larval and adult voracity of *C. transversalis,* results of Omkar and James (2004) is almost higher and relative prey suitability also varied from the present study.

Debaraj and Singh (1989) recorded the first, second third and fourth instar larval consumption of *C. transversalis* as 35.50, 68.40, 131.60 and 288.50 aphids of *A. craccivora*. The total number of aphids consumed by the larvae during its development ranged from 401 to 736 aphids with an average of 516.3 aphids. Among the larval instars the fourth instar larva was most voracious. Side by side the rate of consumption and developmental periods of first, second third and fourth instar larvae were also recorded as 8.0.20.1,26.7 and 40.9 aphids /day and 4.7, 3.9, 5.0 and 7.7 days respectively. During the experimental period, temperature and R. H. were ranging from 14°C-21°C and 43%-75% respectively. Results of the present study more or less in conformity with the findings of Debraj and Singh (1989) regarding gradual increase of prey consumption with the progression of developmental stages of the predator. Reddy *et al.*, (2001) recorded the larval stage of *Dideopsis aegrota* (Diptera:Syrphidae) consumed 505.80±13.81 aphids of *Macrosiphum rosae* (rose aphid) during its development and the rate of consumption was 48.10±1.99 aphids/day and the larval period was recorded as 10.47±13.81 days (Reddy *et al.*, 2001).In terms of different aphid species as prey significant variation was observed in developmental stages of *M. discolor* (Hannan *et al.*, 1998).The incubation period, larval and pupal period of *M. discolor* were found to be 2.63,10.10 and 2.48 days respectively which were lower than the present results except the incubation period when bean aphid, *Aphis mediciginis* was used as prey(Hannan *et al.*, 1998). Prodhan *et al.*, (1995) stated that the egg, larva, prepupa and pupa of *M. discolor* took 2.9±0.23, 8.0±0.33, 1.2±0.13 and 3.0±0.21 days respectively on bean aphid,*A. craccivora*. However some variations of results revealed by different researchers might be due to the variations of nutritive quality of food and environmental differences.

CHAPTER 4 Integrated management of bean aphid, *Aphis craccivora* Koch

4.1. Introduction

4.1.1. Importance and cultivation of bean

Country bean, *Lablab purpureus* L. a crop of Indian origin (Chaudhury *et al.*, 1989) is an important annual as well as a perennial leguminous vegetable having twining, creeping or bushy habit. In Bangladesh it is popularly known as "Seem" and grown intensively all over the country in rabi season, although some varieties *viz.*, IPSA Seem-1 and IPSA Seem-2 developed by Bangabandhu Seikh Mujibur Rahman Agricultural University, Bangladesh can be grown year round including kharif season. Its green pods are used as vegetables and dry seeds as pulse. The dry seeds are also used for various vegetable preparations. The foliage of the crop provides hay, silage and green manure. Medicinal uses are also recorded. Its cultivation and use is so widespread here that it would be impossible to find a homestead in rural areas of Bangladesh which is lacking a bush of country bean in the winter. It is rich in nutritive value and per 100 gm edible portion of a green pod contains 86.1 g moisture, 6.7 g carbohydrate, 3.8 g protein, 0.7 g fat, 1.8 g fiber, 0.9 g mineral, 34.0 mg magnesium, 210.0 mg calcium, 68.0 mg phosphorus, 55.4 mg sodium, 1.7 mg iron, 74.0 mg potassium, 40.0 mg sulphur, 312I.U. vitamin A, 0.06 mg riboflavin, 0.1 mg thiamine, 0.7 mg nicotinic acid and 9.0 mg vitamin C respectively (Aykroid, 1963). During 2000-2001 crop season in our country it covered about 27130 acres of land and the production was about 49795 metric tons and its production is increasing gradually (B.B.S., 2004). It is sown in June-August and marketable green pods are harvested from November and continued up to March. Because of its photo/ and or thermo sensitive behavior the beans remain available only in the winter months when a lot of other vegetables are also available in the market.

4.1.2. Pest complex of country bean

High incidences of the insect pests result in low yield and poor quality of the country bean. Although no accurate statistical records are available, conservative estimate of the yield loss in country been due to insect pests is reported to be about 12-30% (Hossain, 1990). Country bean is attacked by different pests at different stages of its growth and the method of infestation is also varied. According to Alam (1969), nine different insect species and one species of mite attack country bean. Among them attack by one aphid species, *A. craccivora* is frequently severe and it is the most destructive pest of bean and other vegetables in oriental countries (Sing, 1978; Thakur *et al.,* 1984; Shrivastava and Sing, 1986). According to Ahamed *et al.*,(2003),country bean (*Dolichos lablab*) is attacked by seven insect pests of which aphid (*A. craccivora*) and pod borer (*Maruca testulalis* Geyer) were the most serious while others were of minor importance. The incidence of aphid was the highest, followed by pod borer.

4.1.3. Ecology of bean, *Lablab purpureus* L.

Lablab purpureus L.is grown as a dry land crop. The field crop is drought resistant and can be grown in areas with a low rainfall. It can tolerate poor soils, provided they are well drained. In India and Burma it is often grown on sandy river banks exposed when the monsoon subside.The crop can be grown from sea level to 7.00 feet in Asia. It is photo periodic and both long and short day varieties are said to occur. Short-day varieties in India take 6-17 weeks to flower according to the sowing date.

4.1.4. Black aphid, *Aphis craccivora* Koch

The aphids are soft bodied pear-shaped shiny black or dark brown insects each measuring1.0-1.5mm with two appendages at the abdomen. Initially they are found on the lower surface of the leaves but move to the upper surface, stem and flower when they increase in enormous number. They multiply by parthenogenesis instead of reproducing through eggs. The immature insects develop into adult aphid within a weak and start producing next generation.

4.1.5. Morphology of *Aphis craccivora* Koch

Morphological characters of *A. craccivora* are highly variable and associated with the species of host with microclimate condition(Ruiz-Montoya *et al.*,2005).This aphid generally occurs as in both wingless (apterous viviparous female) and winged(alate viviparous female) morphs. Nymphs are wingless, dark or dusty brown and fairly rounded in body shape.

4.1.6. Nature of damage by *Aphis craccivora* Koch

Both nymphs and adults of aphid, *A. craccivora* damage bean crop from vegetative to fruiting stages and may cause up to 100% yield loss of different species of legumes (Attia *et al.,* 1986). *A. craccivora* is most dangerous for new plantings where excessive sap removal is more likely to affect general plant vigor. In vegetative stage, it sucks the sap from tender leaves and shoots. Flowers and flower buds fell of. *A. craccivora* draws sap from the phloem tissue of host plants using piercing-sucking type of mouth parts. Phloem sap is rich in sugars but poor in amino acid which are essential for growth. They inject toxic salivary secretions into plants during feeding. In fruiting stage mature and immature pods were infested severely and yield was adversely affected.York (1992) observed that the aphid fed on the underside of young leaves of country bean. When plants are heavily infested, leaf distortion and stunting are common resulting in poor fruit setting. In Asian countries, 20 to 40% yield loss is caused by this aphid (Sing and Allen, 1980). *A. craccivora* transmits about 20 viruses non-persistently including broad bean mossaic virus, Iranian strain virus etc., in many places of the world (Kaiser and Danesh, 1971; Kaiser, 1979; Thottappilly and Rossel, 1985).

4.1.7. Distribution and host plants of *Aphis craccivora* Koch

A. craccivora is widespread in warm temperate, subtropical and tropical regions. But some authorities believe that they are present worldwide and particularly well distributed in the tropics (Sing, 1978; Raychaudhuri, 1980; Blackman and Eastop, 1984). A large number of fruits, vegetables, agronomic and ornamental plants as well as many weeds are infested by *A. craccivora.* Raychaudhuri (1980, 1983) mentioned about 100 plant species under 13 families as the hosts of *A. craccivora.* Of these *A. craccivora* lives mainly on leguminosae but especially under drought conditions will colonize irrigated crops or succulent members of other families. In subtropical and tropical regions weeds are favored as summer hosts but in places where winter is more severe, the shrubs serve as primary host plants. In our country *A. craccivora* has been reported from 14 different plant species by Das (2002), out of which 10 species *viz., Arachis hypogea* L., *Cucurbita maxima* Duch., *Glycine max* L., *Lablab purpureus* L., *Lanegera leucantha* (Duch), *Lens esculenta* Moench, *Momordica* *charantea* (B.) Rob, *Moringa olcifera* Lamk, *Phascolus mungo* L. and *Vigna sinensis* Endl. are vegetables and crops, one species *viz., Ricinus communies* L. is an oil producing plant and the remaining three are weeds *viz., Amaranthus spinosus* L. *Amaranthus* sp. and *Chenopodium album* L.

4.1.8. Natural enemies of *Aphis craccivora* Koch

A number of authors reported predators, parasitoids and fungi of *A. craccivora* from time to time. Some of them are as as follows:

A. Predators:

i. Coccinellidae:Coleoptera

Adonia variegata Goeza: Saxena *et al.*, 1970; Hamid *et al.*,1977;Patro and Behura,1993.

Cheilomenes lunata (Fabr.):Booker, 1963; Don and Pedro,1980;Ofuya,1997.

ii. Staphylinidae:Coleoptera

Paederus sp.:Sathpathi and Mondol,2006.

iii. Syrphididae:Diptera

Allograpta nasuta (Macquart):Booker, 1963.

Episyrphus balteatus (de Geer):Saxena *et al.*,1970; Hamid *et al.*,1977; Patro and Behura,1993.

Ischiodon scutellaris (Fabr.): Saxena *et al.*, 1970; Hamid *et al.*,1977;Patro and Behura,1993.

Melangyna viridiceps(Macquart):Waterhouse and Sands,2001.

Paragus borbonicus(Macquart): Booker ,1963; Don and Pedro,1980.

Paragus logiventris Loew: Booker, 1963; Don and Pedro,1980.

Paragus serratus(Fabr.): Booker ,1963; Saxena *et al.*,1970; Tao and Chiu,1971; Hamid *et al.*,1977; Don and Pedro,1980.

Paragus tibialis(Fllen.): Saxena *et al.*,1970; Hamid *et al.*,1977;Patro and Behura, 1993.

Simosyrphus grandicornis (Macquart): Waterhouse and Sands, 2001.

iv.Chamaemyiidae:Diptera

Leucopis formosana Hennig: Waterhouse and Sands, 2001.

v. Chrysopidae:Neuroptera

Chrysoperla carnea(Stephens): Saxena *et al.*,1970; Hamid *et al.*,1977;Patro and Behura,1993

B. Parasitoids

i. Braconidae:Hymenoptera

Adialytus salicaphis (Fitch): Hamid *et al.*, 1977; Selim *et al.*, 1987.

Aphidius colemani Viereck: Waterhouse and Sands, 2001.

Aphidius absinthii Marshall: Hamid *et al.*, 1977; Selim *et al.*,1987.

Aphidius ervi Haliday:Stary, 1979.

Aphidius funebris Mackauer: Stary, 1979.

Aphidius ribis Haliday: Stary, 1979.

Aphidius salicis Haliday: Stary, 1979.

Bindodoxys acalephae(Marshall):Rakhshani *et al.*, 2005

Bindodoxys angelicae Haliday: Rakhshani *et al.*, 2005

Bindodoxys indcus Subba Rao and Sharma:Agarwala *et al.*, 1981; Das, 2002.

Ephedrus nacheri Quilis:Takada,1968.

Ephedrus persicae Froggatt: Stary, 1979; Agarwala *et al.*,1981.

Ephedrus plagiator(Nees): Takada,1968.

Lipolexis gracialis Foerster: Tao and Chiu, 1971.

Lipolexis scuellaris Mackauer: Tao and Chiu,1971; Agarwala *et al.*,1981.

Lysiphlebia japonica (Ashmead): Takada, 1968; Tao and Chiu, 1971.

Lysiphlebus confusus Tremblayand Eady: Rakhshani *et al.*, 2005

Lysiphlebus delhiensis Subba Rao and Sharma:Paik, 1975.

Lysiphlebus fabarum(Marshall): Waterhouse and Sands,2001;Rakhshani *et al.*,2005.

Lysiphlebus testaceipes(Cresson): Waterhouse and Sands,2001;Rakhshani *et al.*,2005.

Trioxys acalephae (Marshall): Stary, 1979.

Trioxys angelicae Haliday: Stary, 1979.

Trioxys asiaticus Haliday: Stary, 1979.

Trioxys auctus Haliday: Stary, 1979.

Trioxys centaureae Haliday: Stary, 1979.

Trioxys cirsii(Curtis): Stary,1979.*Trioxy scomplanatus* Quilis: Stary,1979.

ii. Aphelinidae:Hymenoptera

Aphelinus gossypii Timberlake: Waterhouse and Sands, 2001.

Aphelinus abdominalis (Dalman): Hamid *et al.*, 1977.

C. Fungi

i. Neozygitaceae:Entomopathorales

Neozygites fresenii (Nowak): Ofuya, 1997.

Predation and parasitism by natural enemies are most important in pest management but to control pests sufficiently biological control needs to be combined with other control methods which are not harmful to them (Soerjani and Morallo-Rjesus, 1980).

4.1.9. Significance of integrated management of *Aphis craccivora* Koch

The need of control of the said pest is immense from the context of socio-economic development of Bangladesh. During implementation of any IPM programme, it requires many diverse information through research works both from laboratories and fields. But it is true that significant research work on IPM of aphids has not yet been undertaken in our country. So to control aphids, our farmers have to rely only on the insecticide spray in spite of its hazardous effect on the environment. In fact successful cultivation of crops must include efficient management of pests including aphids (Chhabra and Kaur, 1994) and successful pest control depends on the application of appropriate strategies and tactics (Youdeowei and Service, 1983). Thus in order to develop such strategies or tactics especially in the case of mysterious group of insects like aphids (Behura, 1994), field trials on various parameters of IPM are of great importance. Accordingly, effect of some components of IPM not all *viz.*, variety, sowing time, insecticides, botanicals, natural enemies, various indigenous materials like kerosinized ash were evaluated separately or in combination with one another on the population of *A. craccivora* and ultimately on yield of bean. The findings of this type of research may be helpful to develop such strategies and tactics. These are the objectives of the present work.

4.2. Materials and Methods

In order to evaluate the impact of some parameters of IPM independently or in combination with one another on bean aphid population and finally on the yield of bean, an experiment was conducted at Rajshahi University Campus, Rajshahi from the month of July 2003 to February 2004. Certified seeds of two bean varieties (BARI Seem-1 and BARI Seem-2) were collected from BARI, Joydebpur, Gazipur . Seeds of two collected varieties were sown in experimental earthen tubs of 120 cm diameter and 40 cm deep on three different dates *viz.*, 31.07.2003, 15.08.2003 and 31.08.2003. On the basis of sowing date altogether one hundred and eighty tubs of both varieties were divided into six fields *viz.*, Field A (Var.BARI Seem-1) and B (Var.BARI Seem-2), (early sowing); Field C (Var.BARI Seem-1)and D(Var.BARI Seem-2), (mid sowing) and Field E (Var.BARI Seem-1) and F (Var.BARI Seem-2), (late sowing). Each experimental field was divided into six blocks (T_1 to T_6), i.e. five tubs comprised as a block. After germination excess plants were uprooted from the tubs. Finally one bean plant per tub was allowed to grow. Bamboo sticks were inserted in tubs to support the plants. Required moisture level was maintained by regular irrigation in the soil of the tubs. Block to block distance was 2.0 meters and between the tubs 1.5 meters. Each of the blocks of experimental fields was used for specific type of treatment and assigned as:

Treatment block T_1 = Two times insecticide spray (first round and second round).

Treatment block T_2 = One time spray of insecticide (first round) and one time spray of botanical (second round).

Treatment block T_3 = Two times release of natural enemies (first round and second round)

Treatment block T_4 = One time release of natural enemies (first round) and one time spray of botanical (second round).

Treatment block T_5 = One time dusting of kerosinized ash (first round) and one time botanical spray (second round).

Treatment block T_6 = Two times spray of water only (first round and second round) **(Controlled).**

The bean plants of each of the blocks were checked regularly to detect the infestation of *A. craccivora* on them. With the beginning of heavy infestation in the first week of December 2003, application of aforementioned treatment parameters were started at 20 days intervals.

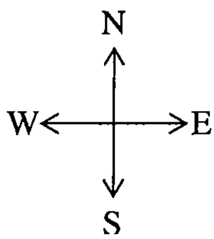
For the application of insecticide, botanical and water (for controlled blocks) a plastic bodied South Korean made Knaps-ack type lever operated hand sprayer of 18 liters capacity brand name (Manseok) was used. The sprayer was thoroughly washed and dried before use. Procedure of application including calibration of insecticide was followed mainly as per Mathews (1988). Calibration was made to ensure application of right dose of insecticide on experimental plants. The sprayer was operated with full stroke to raise optimum air pressure. Spraying was done on the experimental blocks with sufficient time to ensure optimum deposit. The walking speed was maintained @20 m/minute through the block to ensure optimum coverage. A hollow cone type of nozzle was used. The output was checked by collecting and measuring the spray liquid sprayed for 1 minute. A pressure gauge was fitted as close to the nozzle, the lever was operated evenly with a full stoke and uniform pressure as possible was maintained. This was practiced before the actual spray on the experimental crop. To ensure optimum deposit of spray volume on the plant surface the spray was checked by spraying on water sensitive paper. The desired droplet diameter (Vmd) was 100μm and the number of droplets that spread uniformly on the paper per square centimeter was around 20. Having determined the output from the nozzle in liters per minute, the rate per unit area was treated and calculated for knowing the swath width and walking speed.

Following Mathew's (1988), with a swath of 1 meter and walking at 20m/ min and flow rate of 0.45 liters/min., volume of spray per square meter was:

$$\frac{0.45 \text{ lit/min}}{1\text{m x } 20\text{m/min}} = 0.02225 \text{ liters/m}^2 = 225\text{lit/hectare}$$

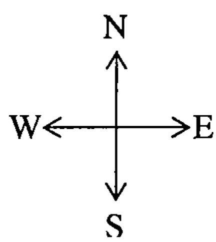
LAYOUT OF THE FIELD EXPERIMENT

ET_1	ET_2	ET_3	ET_4	ET_5	ET_6
ET_1	ET_2	ET_3	ET_4	ET_5	ET_6
ET_1	ET_2	ET_3	ET_4	ET_5	ET_6
ET_1	ET_2	ET_3	ET_4	ET_5	ET_6
ET_1	ET_2	ET_3	ET_4	ET_5	ET_6



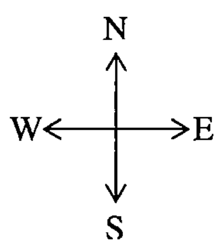
Field A (early sowing) – 31st July 2003(Var.BARI-Seem -1)

ET_1	ET_2	ET_3	ET_4	ET_5	ET_6
ET_1	ET_2	ET_3	ET_4	ET_5	ET_6
ET_1	ET_2	ET_3	ET_4	ET_5	ET_6
ET_1	ET_2	ET_3	ET_4	ET_5	ET_6
ET_1	ET_2	ET_3	ET_4	ET_5	ET_6

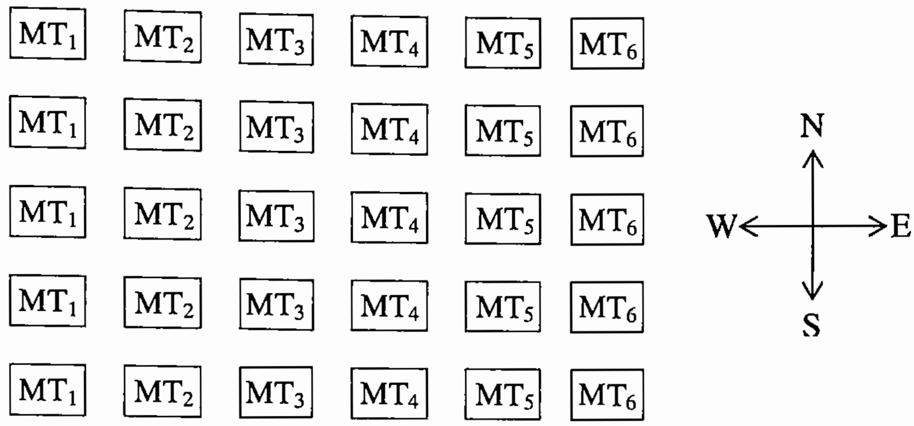


Field B (early sowing) – 31st July 2003(Var.BARI-Seem -2)

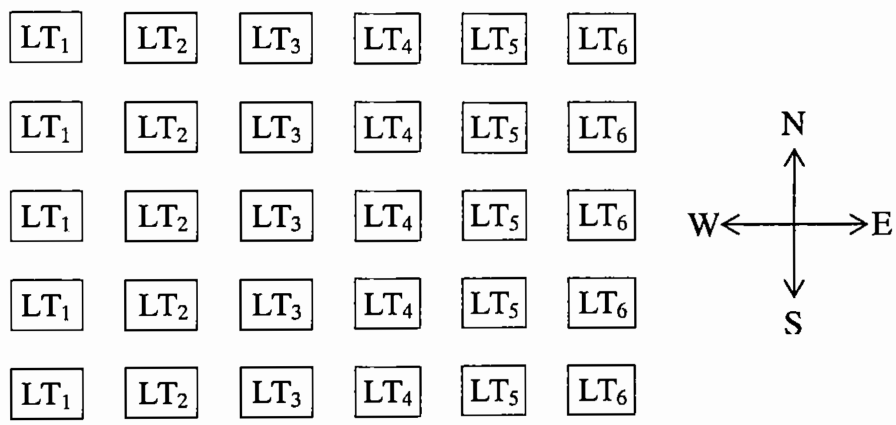
MT_1	MT_2	MT_3	MT_4	MT_5	MT_6
MT_1	MT_2	MT_3	MT_4	MT_5	MT_6
MT_1	MT_2	MT_3	MT_4	MT_5	MT_6
MT_1	MT_2	MT_3	MT_4	MT_5	MT_6
MT_1	MT_2	MT_3	MT_4	MT_5	MT_6



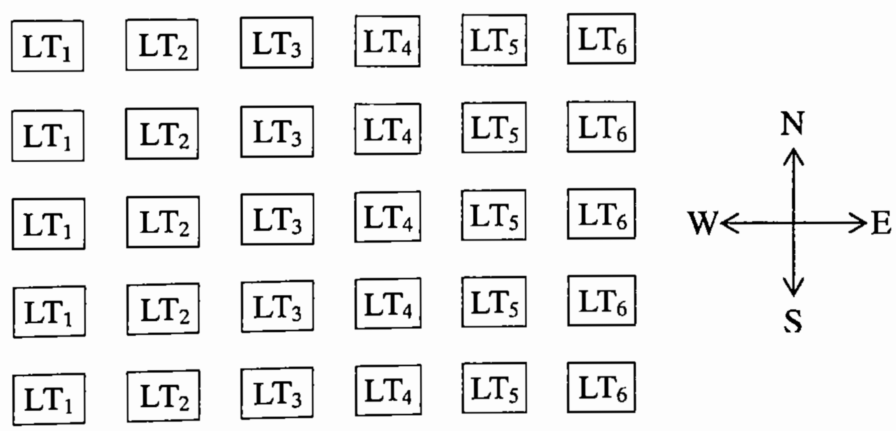
Field C (mid sowing) – 15th August 2003(Var.BARI-Seem -1)



Field D (mid sowing) – 15th August 2003(Var.BARI-Seem -2)



Field E (late sowing) – 31st August 2003(Var.BARI-Seem -1)

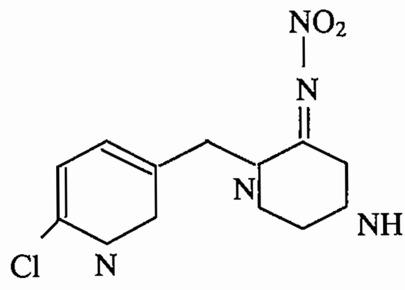


Field F (late sowing) – 31st August 2003(Var.BARI-Seem -2)

Because of the different sowing date, treatment schedule varied from field to field. For the convenience of counting of aphid population Field A and B were treated on 08.12.2003 (first round) and 29.12.2003 (second round). Similarly Field C and D were treated on 13.12.2003 (first round) and 03.01.2004 (second round). But in case of late sowing Field E and F, first and second round application were done on 18.01.2004 and 08.02.2004 respectively.

Insecticide:

A very common systemic insecticide, Imidacloprid ($C_9H_{10}ClN_5O_2$) of Bayer Crop Science, commercially marketed as Admire 200 SL frequently used to control aphids including other sucking insect pests in Bangladesh was selected for this purpose. The prescribed dose rate of Admire 200SL is 1 ml / L water against bean aphid and thus 50 ml/ha. Insecticide was sprayed in blocks T_1 (first and second round) and T_2 (first round only) of each field.



Chemical structure of Imidacloprid.

Tobacco leaf extract (botanical):

Nicotine is an effective pesticide and highest concentration of nicotine is present in stalks and leaf ribs of Tobacco (*Nicotina tabacum* L.) plant (Ghosh, 2000). Collected mature green leaves of Tobacco were chopped with a sharp knife to very small chips. The chips were soaked in normal water at room temperature for 10 days. The proportion of plant material and water was 1:10 (w/v). After soaking for the stipulated time, the plant materials were squeezed manually to extract the active ingredient as much as possible. The solution was then screened through fine mesh nylon cloth to obtain the extract free from plant residue or darts. The tobacco leaf extracted water was poured into the sprayer and sprayed in block T_2, T_4 and T_5 (second round) of each experimental field.

Natural enemies:

Both the larval and adult stages of many coccinellid species are promising biological control agents of many crop pests including aphids (Haque and Islam, 2008). Of these, *C. transversalis* (Fabr.) is an important one in preventing bean aphid, *A. craccivora* population (Patro and Sontakke, 1994). Hence, third instar larvae of *C. transversalis* were obtained from the stock culture in plastic container (6 cm height × 6.5 cm diameter). The mouth of the containers were covered with thin cloths, secured with rubber bands to permit aeration. The larvae were released at the rate of five larvae per plant with a soft brush (0 size) on scheduled date around the infested twigs of bean plant in block T_3 (first round and second round) and T_4 (first round only) . Small quantity of Vaseline was placed around the base of the predator treated bean plants to avoid escaping of predator larvae.

Kerosinized ash:

This method is recommended as a preventive measure and quite effective against sucking type of insects like aphids (Stoll, 1998). Six teaspoon of kerosene were mixed with 1 kg of wood ash and applied manually by throwing in block T_5 (first round) of each field.

The control blocks T_6 of each field were also sprayed with water only at the time of treatment made on other blocks of respective field.

Aphid population counts were taken using hand lens on randomly selected leaves (old, mature and young), twigs of 5 cm in length, pods (if infested) from each of the five tubs of six blocks of an individual field. In case of thick colonies aphids were dislodged carefully from the above mentioned plant parts by means of a camel hair brush (0 size) on white plastic plate, counted and thereafter they were placed back to same place of the plant. No distinction was made between the nymphs and adults since both the stages cause similar injury to the plants. The leaves and twigs observed once were not considered for further observation. Pretreatment data were taken 1 day prior to and post treatment data were obtained on 1, 3, 7 and 20 days after treatment. To compare yield with the controlled block, pods produced by per block were collected separately and recorded. Usually the very immature pods were not considered.

Statistical analysis:

For all the experiment, analysis of variance (ANOVA) was done to test the significance in difference among the treatments. Comparison of means was done by Duncan's Multiple Range Test (DMRT) at 0.05 level of significance. Statistical Software SPSS (Ver. 11.5) was used to carry out the analysis.

4.3. Results

Color of bean pod of both BARI Seem-1 and BARI Seem-2 is although green but their size and weight is different. Size of each matured bean pod of BARI Seem-1 is 10-11cm long and 2.0-2.5cm wide while it is 10-13cm long and 1.5-2.0cm wide for BARI Seem-2.Weight of each matured bean pod of BARI Seem-1 is 10-11gm whereas the weight of each matured bean pod of BARI Seem-2 is 7-8 gm. Life span of the variety BARI Seem-1 is 200-220 days but the life span of BARI Seem-2 is 190-210 days. Under various control parameters, field and block wise pretreatment and post treatment data on aphid population of *A. craccivora* Koch along with yield of bean are presented in Table 9-14 and it is observed that aphid population before the application of the first round treatment was much higher in all the treatment blocks. It is also evident from the experiment two times insecticidal treatment proved more effective in all the fields as compared to the remaining treatments in terms of aphid population reduction and finally increase in yield. After the initiation of first round treatment, aphid numbers started to decrease sharply up to 7^{th} days but on the 20^{th} day aphid incidence increased slightly in some treatment blocks. Just after the second round treatment aphid population again decreased whereas the population of controlled blocks (water sprayed) remained more or less same from the beginning to the end of different counting date. In the Table 9, the highest yield was obtained from the treatment block T_1 that was treated with two times by an insecticide Admire 200SL @ 1 ml per liter water and it was statistically higher from other treatments. Minimum yield 1.14 kg/plant was recorded from the untreated control block (T_6) of field A which had the highest number of aphids during different counting date. More or less similar trend was also observed in Table 10-14. The increase in yield over control in various treatments ranged from 28.07 to 193.36%, 47.22 to 469.44%, 22.00 to 210.00%, 25.00 to 250.00%, 29.55 to 256.82% and 35.29 to 358.82% in field

Table 9. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of bean aphid, *A. craccivora* Koch and yield of bean in field A (Var.BARI Seem-1).

Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									Yield (kg/ plant) Mean ±S.E.
			Pre-treatment	First round treatment (08.12.2003)				Second round treatment (29.12.2003)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
A 31.7.03 (Early sowing)	ET_1	Admire 200 SL@ 1 ml/L water (first round and second round)	53±4.63	25±2.23	3.6±1.80	1.4±0.51	5.4±1.71**cd**	0.2±0.20	1.6±0.09	3.6±1.77	10±2.94**b**	3.35±0.19 **a**
	ET_2	Admire 200 SL@ 1 ml/L water (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	53±7.18	22±6.03	5.6±5.86	0.4±0.09	1.4±0.51**d**	0.2±0.20	5±0.20	18±2.56	19.8±1.65**b**	2.74±.18 **b**
	ET_3	Larvae of *C. transversalis* (first round and second round)	48.6±6.39	22±4.05	41±3.31	40±3.53	21.2±2.43**bc**	16±1.87	24±1.41	19±2.93	17.8±2.24**b**	1.78±.15 **c**
	ET_4	Larvae of *C. transversalis* (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	57.6±5.63	18.8±1.84	27.6±2.87	32±6.62	25±3.53**b**	28.6±8.12	19±5.56	22±2.55	16±3.67**b**	1.60±.09 **c**
	ET_5	Kerosinized ash (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	52±4.63	15±1.97	24±5.33	23.2±4.33	22±5.82**bc**	10.6±1.96	15±2.23	30±6.11	14±4.29**b**	1.46±.22 **cd**
	ET_6	Control, spray water only (first round and second round)	51±8.70	44±10.28	59±6.39	65±4.99	56±12.06**a**	23±5.36	27±6.62	37±8.87	56±9.26**a**	1.14±0.06 **d**
							P=.000 F=10.795				P=.000 F=12.614	P=.000 F=45.973

- All figures are mean of five replications
- DAT – Days after treatment
- Means having the same letter(s) in a column are not significantly different at 0.05 probability level by DMRT.
- Average canopy size 0.87 square meter/plant.

Table 10. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of bean aphid, *A. craccivora* Koch and yield of bean in field B (Var.BARI Seem-2).

Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									Yield (kg/plant) Mean±S.E.
			Pre-treatment	First round treatment (08.12.2003)				Second round treatment (29.12.2003)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
B 31.7.03 (Early sowing)	ET_1	Admire 200 SL@ 1 ml/L water (first round and second round)	60.20± 5.16	32.00± 6.04	17.00± 4.36	1.60± 0.93	3.80± 0.66**c**	0.00± 0.00	0.20± 0.20	0.40± 0.24	0.80± 0.37**c**	2.05±0.12 **a**
	ET_2	Admire 200 SL@ 1 ml/L water (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	64.00± 9.67	39.00± 10.50	10.80± 2.42	4.00± 0.71	5.60± 0.75**c**	9.20± 1.02	10.60± 1.17	12.60± 1.25	24.00± 1.87**b**	1.45±0.12 **b**
	ET_3	Larvae of *C. transversalis* (first round and second round)	64.00± 8.12	61.00± 6.78	52.00± 4.90	44.60± 3.70	43.00± 4.36**b**	35.60± 2.80	29.60± 3.27	19.00± 3.32	24.00± 2.92**b**	0.95±0.28 **c**
	ET_4	Larvae of *C. transversalis* (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	80.00± 6.52	74.60± 3.76	53.60± 3.44	61.00± 5.10	41.00± 8.12**b**	37.60± 3.71	24.00± 5.79	22.60± 2.69	16.60b± 2.93**b**	0.55±0.05 **cd**
	ET_5	Kerosinized ash (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	90.60± 6.66	78.60± 3.31	63.00± 6.63	52.20± 3.93	38.60± 6.00**b**	32.60± 3.91	37.00± 6.25	27.60±3 .36	22.80± 4.05**b**	0.53±0.06 **cd**
	ET_6	Control, spray water only (first round and second round)	86.00± 4.30	81.00± 3.32	76.00± 1.87	61.00± 4.00	70.00± 4.47**a**	64.60± 2.48	74.00± 5.79	72.00±3 .74	100.00± 7.58**a**	0.36±0.04 **d**
							P=.000 F=26.755				P=.000 F=76.565	P=.000 F=22.266

- All figures are mean of five replications
- DAT – Days after treatment
- Means having the same letter(s) in a column are not significantly different at 0.05 probability level by DMRT.
- Average canopy size 0.87 square meter/plant.

Table 11. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of bean aphid, *A. craccivora* Koch and yield of bean in field C (Var.BARI Seem-1).

Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									Yield (kg/plant) Mean±S.E.
			Pre-treatment	First round treatment (13.12.2003)				Second round treatment (03.01.2004)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
C 15.8.03 (Mid sowing)	MT_1	Admire 200 SL@ 1 ml/L water (first round and second round)	57±5.14	17± 3.74	2.80±0.66	.80±0.58	5.40±1.50**d**	0.00± 0.00	3±1.09	1.20±0.58	5.60± 1.50**c**	3.10±0.09 **a**
	MT_2	Admire 200 SL@ 1 ml/L water (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	59±6.19	24± 3.99	2.20±0.58	1.80± 0.19	6.60± 1.82**d**	0.40± 0.24	1.80± 0.37	13±1.99	21± 2.24**b**	2.72±0.44 **b**
	MT_3	Larvae of *C. transversalis* (first round and second round)	54±6.58	30± 0.00	31±2.45	29±4.29	19.60±2.76**bc**	16±2.91	23±4.35	20.80± 0.80	19.20± 2.03**b**	1.48±0.14 **c**
	MT_4	Larvae of *C. transversalis* (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	62±5.36	31.20 ± 5.18	24±2.91	33±6.62	26± 4.29**b**	19±3.67	20±1.58	24±2.45	20± 3.86**b**	1.46±0.05 **c**
	MT_5	Kerosinized ash (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	58±3.74	30± 7.06	21±2.45	13± 1.10	13.60± 2.10**cd**	15± 2.23	22± 2.55	20±5.23	21± 10.48**b**	1.22±0.06 **cd**
	MT_6	Control, spray water only (first round and second round)	5±9.12	45± 11.16	52±6.03	37± 3.74	47± 2.99**a**	41± 7.47	57± 4.89	47±7.98	36± 6.58**a**	1.0±0.03 **d**
							P=.000 F=32.285				P=.001 F=6.417	P=.000 F=89.769

- All figures are mean of five replications
- DAT – Days after treatment
- Means having the same letter(s) in a column are not significantly different at 0.05 probability level by DMRT.
- Average canopy size 0.87 square meter/plant.

Table 12. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of bean aphid, *A. craccivora* Koch and yield of bean in field D (Var.BARI Seem-2).

Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									Yield (kg/plant) Mean±S.E.
			Pre-treatment	First round treatment (13.12.2003)				Second round treatment (03.01.2004)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
D 15.8.03 (Mid sowing)	MT_1	Admire 200 SL@ 1 ml/L water (first round and second round)	71.60±6.68	45.60± 4.17	17.00± 3.39	7.60± 1.94	8.60± 2.25**c**	6.60± 1.89	1.20± 0.58	10.00± 2.83	19.20± 2.06**c**	1.40±0.10 **a**
	MT_2	Admire 200 SL@ 1 ml/L water (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	83.00±5.39	48.00± 6.04	30.00± 1.58	10.00± 0.71	4.60± 1.36**c**	4.40± 0.51	9.80± 2.15	21.40± 5.52	12.40± 3.75**c**	1.25±0.08 **a**
	MT_3	Larvae of *C. transversalis* (first round and second round)	92.00±2.25	81.00± 3.32	77.00± 3.39	62.00± 8.60	73.00± 2.55**a**	65.10± 2.24	57.00 ±5.39	57.00± 3.39	56.60± 3.94**b**	0.80±0.05 **b**
	MT_4	Larvae of *C. transversalis* (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	79.00±4.30	72.60± 3.57	61.00± 2.92	51.00± 4.30	48.00± 4.64**b**	36.00± 3.67	23.00 ±3.39	15.60± 3.92	24.00± 6.78**c**	0.52±0.02 **c**
	MT_5	Kerosinized ash (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	101.00±6.40	84.00± 4.30	75.00± 2.74	58.00± 6.04	50.00± 5.70**b**	30.00± 5.70	47.00 ±4.90	23.00± 4.36	19.00± 4.92**c**	0.50±0.03 **c**
	MT_6	Control, spray water only (first round and second round)	109.00±23.60	74.00± 19.40	69.00± 23.90	65.00± 10.00	61.60± 12.10**ab**	53.00± 10.90	52.00 ±9.03	63.00± 7.68	74.00± 5.10**a**	0.40±0.06 **c**
							P=.000 F=22.169				P=.000 F=32.540	P=.000 F=44.690

- All figures are mean of five replications
- DAT – Days after treatment
- Means having the same letter(s) in a column are not significantly different at 0.05 probability level by DMRT.
- Average canopy size 0.87 square meter/plant.

Table 13. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of bean aphid, *A. craccivora* Koch and yield of bean in field E (Var.BARI Seem-1).

Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									Yield (kg/plant) Mean±S.E.
			Pre-treatment	First round treatment (18.01.2004)				Second round treatment (08.02.2004)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
E 31.8.03 (Late sowing)	LT_1	Admire 200 SL@ 1 ml/L water (first round and second round)	62±4.89	18±2.54	5.20±1.06	2±0.70	2.40±0.50**b**	00±00	.20±.20	1.80±0.37	4.60±1.32**c**	3.14±0.17 **a**
	LT_2	Admire 200 SL@ 1 ml/L water (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	61±4.57	19±3.99	5±1.41	1.40±.60	2.80±1.31**b**	1.60±.51	9.40±1.77	4.80±1.49	6.60±2.56**c**	2.62±o.10 **b**
	LT_3	Larvae of *C. transversalis* (first round and second round)	58±5.82	35±2.23	31.60±2.46	20.60±3.98	28±2.55**a**	19±3.31	24.80±3.67	32±2.55	24±2.91**b**	1.28±0.19 **c**
	LT_4	Larvae of *C. transversalis* (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	70±3.52	35.40±3.87	30.80±2.62	22±5.13	26±1.86**a**	14±1.86	16±1.86	13.6±2.11	23±2.55**b**	1.18±0.07 **cd**
	LT_5	Kerosinized ash (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	63±3.73	33±9.93	39±3.31	15±2.23	16±3.99**a**	11.6±2.65	24±4.86	41±6.39	15.80±5.20**bc**	1.14±0.05 **cd**
	LT_6	Control, spray water only (first round and second round)	54±8.98	52±5.82	67±3.74	31±10.03	25±8.41**a**	23±5.37	36±3.9	20±6.51	51±5.56**a**	0.88±0.05 **d**
							P=.000 F=7.614				P=.000 F=20.862	P=.000 F=63.271

- All figures are mean of five replications
- DAT – Days after treatment
- Means having the same letter(s) in a column are not significantly different at 0.05 probability level by DMRT.
- Average canopy size 0.87 square meter/plant.

Table 14. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of bean aphid, *A. craccivora* Koch and yield of bean in field F (Var.BARI Seem-2).

Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									Yield (kg/plant) Mean±S.E.
			Pre-treatment	First round treatment (18.01.2004)				Second round treatment (08.02.2004)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
F 31.8.08 (Late sowing)	LT1	Admire 200 SL@ 1 ml/L water (first round and second round)	96.00±4.30	34.00± 5.10	5.80± 1.28	0.40± 0.24	5.80± 1.43**c**	0.40± 0.24	2.60± 0.93	6.40± 3.06	6.40± 1.89**c**	1.56±0.02 **a**
	LT2	Admire 200 SL@ 1 ml/L water (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	97.00±9.17	31.00± 6.00	3.60± 0.93	2.40± 0.51	5.00± 1.48**c**	0	9.60± 1.50	17.00± 2.28	15.00±0. 71**bc**	1.50±0.16 **a**
	LT3	Larvae of *C. transversalis* (first round and second round)	106.20±6.33	93.60± 2.23	76.60± 3.40	57.00± 5.61	57.00± 3.00**b**	37.00± 4.36	36.60± 10.20	28.20± 5.85	40.60± 8.08**a**	1.05±0.09 **b**
	LT4	Larvae of *C. transversalis* (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	144.00±22.90	114.00± 14.70	76.00± 5.10	52.00± 7.18	43.00± 5.39**b**	30.00± 5.70	28.00± 8.00	25.60± 4.99	25.00±2. 24**b**	0.48±0.01 **c**
	LT5	Kerosinized ash (first round) and Tobacco leaf extract @ 1:10 W/V (second round)	166.00±10.80	146.00± 11.70	104.00± 5.10	76.00± 5.10	60.00± 7.07**b**	51.00± 4.00	24.60± 2.48	12.00± 1.22	26.00±1. 87**b**	0.46±0.05 **c**
	LT6	Control, spray water only (first round and second round)	167.00±10.70	114.00± 8.12	122.00± 9.70	108.00± 7.35	96.00± 10.30**a**	41.00± 6.40	23.00± 5.39	28.20± 8.90	18.00± 0.95**b**	0.34±0.02 **c**
							P=.000 F=36.979				P=.000 F=10.340	P=.000 F=47.799

- All figures are mean of five replications
- DAT – Days after treatment
- Means having the same letter(s) in a column are not significantly different at 0.05 probability level by DMRT.
- Average canopy size 0.85 square metre/plant.

Table 15. Yield (Mean ±S.E.) of bean (kg/ plant)in terms of date of sowing ,variety and treatments.

Date of sowing	Crop variety	Treatments					
		T_1	T_2	T_3	T_4	T_5	T_6
Early sowing 31.07.2003	BARI Seem-1	3.35±0.09a	2.74±0.18a	1.78±0.15a	1.60±0.09a	1.46±0.22a	1.14±0.06a
	BARI Seem-2	2.05±0.12b	1.45 ±0.12b	0.95±0.28c	0.55±0.05c	0.53±0.06c	0.36±0.04c
Mid sowing 15.08.2003	BARI Seem-1	3.10 ± 0.09a	2.72±0.44a	1.48± 0.14ab	1.46±0.05a	1.22±0.06b	1.0±0.03b
	BARI Seem-2	1.40±0.10c	1.25±0.08b	0.80±0.05c	0.52±0.02c	0.50±0.03c	0.40±0.06c
Late sowing 31.08.2003	BARI Seem-1	3.14±0.17a	2.62 ± 0.10a	1.28±0.19bc	1.18±0.07b	1.14±0.05b	0.88±0.05b
	BARI Seem-2	1.56 ±0.02c	1.50±0.16b	1.05 ±0.09bc	0.48±0.01c	0.46 ±0.05c	0.34±0.02c
		P=.000 F=45.97	P=.000 F=28.99	P=.002 F=5.27	P=.000 F=77.80	P=.000 F=74.06	P=.000 F=60.24

- All figures are mean of five replications
- Means having the same letters in a column are not significantly different at $P<0.01$ and $P<0.001$ level by DMRT
- Detailed description of treatments(T_1.T_6) were already mentioned in Table(9-14)

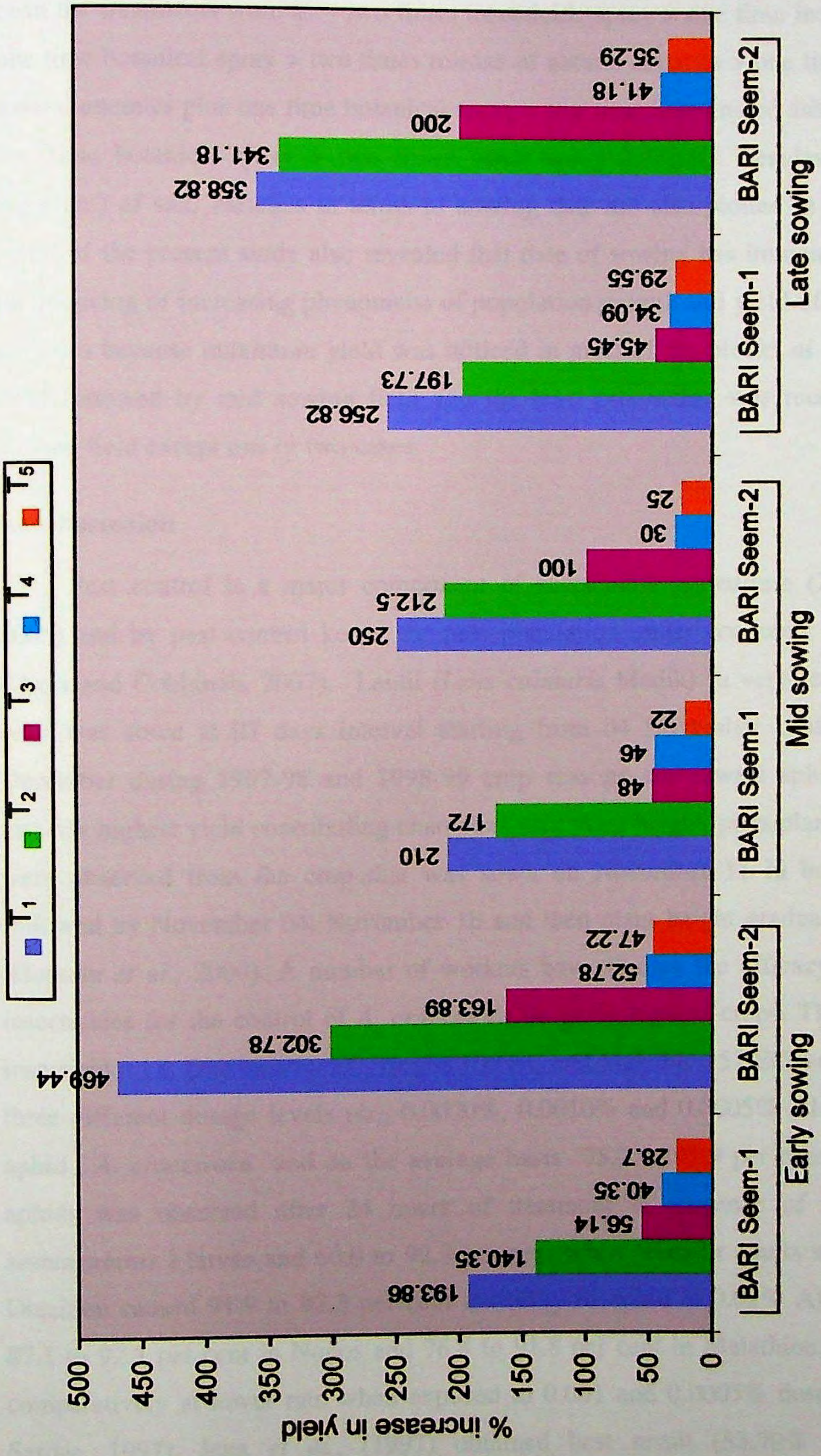


Figure 6: Percent increase in yield over control (T_6) in various treatments for BARI Seem-1 and BARI Seem-2.

A,B,C,D,E and F respectively (Fig.6). Thus in order of increasing efficacy on yield of bean the treatments were as – two times insecticide spray > one time insecticide plus one time botanical spray > two times release of natural enemies > one time release of natural enemies plus one time botanical spray > one time kerosinized ash dusting plus one time botanical spray > two times water spray (control). Besides mean yield (kg/plant) of said varieties in terms of sowing date are also plotted in Table15.The result of the present study also revealed that date of sowing has immense impact on the reducing or increasing phenomena of population growth and yield of bean in both varieties because maximum yield was noticed in most of the blocks of early sowing field followed by mid sowing field and the least production was recorded in late sowing field except one or two cases.

4.4. Discussion

Pest control is a major component of sustainable agriculture (Zhang *et al.*, 2005) and by pest control keeps the pest population under economic injury levels (Ofori and Cobbinah, 2007). Lentil (*Lens culinaris* Medik) a very related crop of bean was sown at 07 days interval starting from 04 November continued till 09 December during 1997-98 and 1998-99 crop seasons and lowest aphid infestation visa-vis highest yield contributing characters *viz.*, plant height, pods/plant, grain yield were observed from the crop that was sown on November 11 in both the years followed by November 04, November 18 and then plant height gradually decreased (Hossain *et al.,* 2000). A number of workers have studied the efficacy of different insecticides for the control of *A. craccivora* on grain legume crops. Three common insecticides i.e. Diazinon 60 EC, Nogos 100 EC and Malathion 57 EC were sprayed at three different dosage levels *viz.*, 0.0020%, 0.0010% and 0.0005% AI against bean aphid , *A. craccivora* and on the average basis 75.7 to 91.9 per cent mortality of aphids was observed after 24 hours of treatment in presence of predator (*M. sexmaculatus*) larvae and 60.0 to 92.7 per cent when predator adults were present . Diazinon caused 91.9 to 92.3 per cent mortality of aphid at 0.02% AI followed by 87.1 to 92.3 per cent in Nogos and 76.4 to 91.8 per cent in Malathion. Aphids died comparatively at lower rate when exposed to 0.001 and 0.0005% doses (Islam and Sardar, 1997). Jena *et al.*, (1997) obtained best result (83.70% reduction of infestation) by using Dimethoate 30 EC to control *A. craccivora* on groundnut at Bhubaneswar, India. Sarup *et al.,* (1974) assessed the biological efficacy of six insecticidal granular formulations *viz.,* Lindane, Phorate, Disulfoton, Aphidan, Dimethoate and Phosmamidon against some important predators and pest of pea cops including *A. craccivora* and recorded Disulfoton to be the most effective. Bari and Sardar (1998) worked on the control strategy of bean aphid, *A. craccivora* with predator *Menochilus sexmaculatus* (Fabr.) and insecticides Diazinon 0.002% AI and Malathion 0.002% AI and observed that Malathion was comparatively better than Diazinon and *M. sexmaculatus* had adequate reductive impact on *A. craccivora* particularly at low density. Lokhande and Mohan (1990) recorded each larva of *M. sexmaculatus* consumed on an average 8.50 adults and 73.52 nymphs of *A. craccivora* /day and the adult member of the predator consumed 24.34 adult aphids and 176.15 nymphs /day. Thakur *et al.,* (1984) carried out an experiment to determine the effectiveness of six insecticides against *A. craccivora* on lentil and observed that all the insecticides were effective against the pest as compared with untreated blocks. The most effective of the compounds 72 hour after treatment were Dimethoate and Phosmamidon while Dimeton-Methyl and Fenvalerate had an early knockdown effect. According to Khurana and Kaushic (1991), Monocrotophos (0.025%) and Endosulphan (0.05%) were very effective against *A. craccivora*. Abate and Ampofo (1996) worked on the management of insect pest of beans in Africa through the use of a traditional IPM approach that consists of appropriate sowing dates , varietals mixtures, intercropping , good crop husbandry , locally available materials, natural biological controlled and obtained a very excellent result. Ogenga-Latigo *et al.,*(1999) reported reduced aphid (*Aphis fabae* Scop.) infestation and damage when beans were intercropped with densely populated older maize. From the study of Shah *et al.,* (2001) on relative susceptibility of dolichos bean *Lablab purpureus* L. to black bean aphid, *A. craccivora* , it was found that lowest aphid population in genotype AC-120 followed by AC-134, AC-351 and AC-354. The maximum aphid population was recorded in S-27, (most susceptible genotype).

From the result of present observation it is evident that two times insecticidal treatments irrespective of sowing date gave an excellent result in reducing aphid population which in turn resulted in higher yields of bean. Next effective result was found from the treatment by one time insecticide spray plus one time botanical spray. But in the past no one took this sort of pest control measure using IPM concept to control *A. craccivora* infesting bean plant in Bangladesh. Das (2001) conducted an experiment on IPM of aphid pest on egg plant and concluded that the population of *A. gossypii* on the egg plant could be kept under economic threshold level by sowing date manipulation with minimum insecticide use and release of the effective natural enemies. Phadke and Prasad (1987) studied the effect of sowing date on aphid incidence in some varieties of rapeseed and mustard and mentioned that delayed sowings made the plants to suffer from higher injury at a younger crop stage. Results of the present study thus confirmed the findings of Phadke and Prasad (1987), Hossain *et al.*, (2000) and Das (2001) who strongly suggested that early sowing would be very effective to escape aphid infestation.

However in order to reduce the use of insecticide, 'one time insecticide spray plus one time botanical spray' or 'two times release of natural enemies' or 'one time release of natural enemies plus one time botanical spray' or 'one time dusting of kerosinized ash plus one time botanical spray' may be applied to control *A. craccivora* in the field. One time release of natural enemies plus one time botanical spray technique may be selected to control *A. craccivora* since this is harmless to the environment and less expensive.

CHAPTER 5 Integrated management of brinjal aphid, *Aphis gossypii* Glover

5.1. Introduction

5.1.1. Importance and cultivation of brinjal

Eggplant, *Solanum melongena* L. a solanaceous vegetable populary known as brinjal and extensively cultivated during both the rabi and kharif season in Bangladesh (Rahman *et al.*,2003).The name of egg plant derives from the fruit of some varieties which look like chicken eggs (Chen *et al.*, 2002). It is one of the most common and important vegetable sources in our country and occupy second highest place in terms of production following potato (Anonymous, 1994).Only in rabi 2000-2001 crop season, 103875 acres of land were under brinjal cultivation where the production was 269790 metric tons with the average yield of 2.60 metric tons/acre (B.B.S., 2004) . In rural areas it is grown for home consumption in almost all families near the homestead. In many localities this vegetable is grown commercially. A number of cultivars are grown throughout the country depending upon yield, consumers preference about the color, size and shape of the various cultivars. The brinjal is of much importance in the warm areas of Fareast being grown in India, Pakistan, China and the Philippines. It is also popular in France, Italy and USA.

Brinjal has been a staple vegetable in our diet since ancient times. It is liked by both poor and rich contrary to the common belief; it is quite high in nutritive value and can well be compared with tomato (Chaudhury, 1976). Per hundred gram edible portion of a brinjal contains 92.7 gm moisture,1.4 gm protein, 0.3 gm fat, 0.3 gm minerals , 1.3 gm fiber, 4.0 gm carbohydrate, 18 mg calcium, 16 mg magnesium, 18 mg oxalic acid, 47 mg phosphorous, 0.9 mg iron, 3.0 mg sodium, 2.0 mg potassium, 0.17 mg copper, 44.0 mg sulphur, 52.0mg chlorine, 1249.4 vitamin A, 0.04 mg thiamine, 0.11 mg riboflavin, 0.09 mg nicotinic acid and 12.0 mg vitamin C respectively (Aykroid, 1963). The unripe fruit is primarily used as a cooked vegetable and it has got much potential as raw material in pickle making and dehydration industries (Sing *et al.*, 1963). It is supposed to contain medicinal properties and acts as an excellent remedy for those suffering from diabetes and liver complaints (Chauhan, 1981).

5.1.2. Diseases and pests of brinjal

The brinjal is subjected to the attack of bacterial, virus and fungal diseases affecting roots, leaves, steams and fruits. The severity in any particular disease depends on the season and the region in which the crop is grown. Insect pest infestation is one of the most limiting factors for accelerating yield potential of brinjal. The crop brinjal suffers from the damage due to pests of about two dozen different insect species, out of which *A. gossypii* has been considered as major one (Gapud ,1992).

5.1.3. *Aphis gossypii* Glover:Homoptera:Aphididae

The aphids are soft bodied yellowish insects each measuring 1.0-1.5mm with two cornicles at the abdomen. Initially they are found on the lower surface of the leaves but move to the upper surface, stem and flower when they increase in enormous number. They multiply by parthenogenesis instead of reproducing through eggs. These immature insects develop into adult aphid within a weak and start producing next generation.

5.1.4. Nature of damage by *Aphis gossypii* Glover

After transplantation, the seedlings of brinjal put forth new succulent leaves and grown vigorously and it is the succulent sappy tender leaves of young plants that are preferred by *A. gossypii* as against harden leaves of brinjal. Nymphs and adults are found to suck sap from the ventral surface of the leaves. The infested leaves, become curled up or wrinkled and the affected portion fade and gradually the whole twig becomes more or less blighted, thus causes great damage to the plant (Alam, 1969). Moreover, this aphid transmits many plant viruses which are also responsible for the loss of crop. The most interesting thing is *A. gossypii* leads anholocyclic life-cycle in Bangladesh and for this reason they are available in brinjal field throughout the year. *A. gossypii* reproduces partheno-genetically and give birth to young ones. Male morph of this species has yet not been reported from Bangladesh. Apterae, alatae, alatoid and normal nymphs are the general member of an aphid colony on brinjal in this country. The proportion of alatoid nymphs increase rapidly within short period of time offer the initiation of *A. gossypii* on brinjal. As a result, the entire brinjal plant of the field are severerely affected. The damage reaches its speak during mid to late winter.

5.1.5. Distribution and host plants of *Aphis gossypii* Glover

A. gossypii is a cosmopolitan polyphagous aphid and attacks about 220 host plants belonging to 46 families throughout the world (Roy and Behura, 1983). Ebert and Cartwright (1997) reported over 90 plant families in which at least one species was listed as a host. *A. gossypii* is wide spread in tropical and warm temperate regions (Schmutterer, 1978) and it is a polyphagous species occurring throughout the year on different host plants all over Bangladesh (Karim *et al.*, 2002). Das (2002), mentioned *A. gossypii* is distributed all over Bangladesh and infests 12 crops and 8 ornamental plants during winter season. These are : *Abelmoschus esculentus* L., *Capiscum annum* L., *Corchorus capsularis* L., *Coriaudrum sativum* L., *C. maxima, Cucurbita pepo* Dc, *Gossypium arboreum* L., *G. herbaceum* L., *Lagenaria leucantha* (Duch), *Rusby, M charantea, Solanum melongena Wall, S. tuberosum* L., *and Bellis perenms* L., *Cestrum nocturnum* L., *Chrysanthemum coronarium* L., *Codiaeum variegatum* Bl., *Hibiscus rosasinensis* L., *Rosa ceutifolia* L., *Tagetes patula* L., *Zinnia elegans* L respectively. According to him few trees *viz., Cassia alata* L., *C. fistual* L., *Lagerstromoea thorelli* Sm., *Ppsidium guajava* L and one medicinal plant, *viz., Eclipta alba* L. are also attacked by this aphid species.

5.1.6. Natural enemies of *Aphis gossypii* Glover

Eleven predators and two parasitoids are encountered in the *A. gossypii* infested crop fields in Bangladesh (Das, 1994). These are as follows:

Predators of *Aphis gossipii* Glover:

I) *Anatis sp.*

II) *Cocinella septempunctata* L.

III) *Coccinella transversalis* (Fabr.)

IV) *Cheilomenes sexmaculata*(Fabr.)

V) *Ischiodon scutellaris* (Fabr.)

VI) *Micraspis discolor* (Fabr.)

VII) *Scymnus pyrochellus* Mulsant

VIII) *Synharmonia octomaculata* (Fabr.)

IX)*Orius sp.*

X)*Paragus sp.*

XI)*Brumoids suturalis*

Parasitoids of *Aphis gossypii* Glover:

I) *Binodoxyrs indicus* (Subba Rao and Sharma)

II) *Aphelinus mali* (Haldmann)

5.1.7. *Aphis gossypii* Glover and IPM

Brinjal is the most common and important vegetable in Bangladesh. The production of this vegetable is seriously affected by two dozen insect pests, out of which *A. gossypii* has been considered as major one (Gapud, 1992). The aphid *A. gossypii* harm not only by direct feeding damage but also transmits many plant viruses which are also responsible for the loss of crop. So to control this aphid species, farmers of our country have to rely only on the insecticide spray in spite of its hazardous effect on the environment. In order to minimize this hazardous effect there is no other alternative of IPM. But an integrated pest management approach to control *A. gossypii* was not available in Bangladesh. Accordingly evaluation of impact of insecticides, botanicals, natural enemies, various indigenous materials either separately or in combination with one another on the population of *A. gossypii* and on yield of brinjal were carried out. The findings of this type of research may be helpful to develop an IPM package against a specific aphid species. These are the objectives of the present work.

5.2. Materials and Methods

The experiment was carried out at Rajshahi University Campus during rabi 2004-2005. The entire research work was divided into following heads.

Preparation of seed bed:

Seed beds were prepared by harrowing, followed by ploughing, cross ploughing and leveling since a sandy loam soil that is fertile, deep and well drained is ideal for egg plant. The size of each bed was 4m long and 1m wide. Cow dung @ 15 ton urea, TSP and MP @ 250, 150, 125 kg respectively per hectare were applied as recommended by Rashid (1993).

Seedling production and transplanting:

Certified seeds of two BARI brinjal cultivar, Nayantara and Kazla were collected from BARI, Joydebpur, Gazipur. Seeds of each cultivar were sown in three seedling beds at three different dates *viz.*, 1st September (Early sowing), 16th September (Mid sowing) and 1st October (Late sowing). A seedling of forty day-old (3/4 leaf stage) from each bed were transplanted in the soil of experimental earthen tubs of 120 cm diameter and 40 cm deep. Transplanting were done during late afternoon in order to minimize the transplanting shock. Besides, immediately after transplanting soil surface of the tubs were irrigated sufficiently to establish a good root to soil contact. Eighteen tubs were prepared by the seedling of each cultivar and each sowing date respectively and divided them further into six blocks (T_1 –T_6) i.e. three tubs comprised as a block. Tubs were arranged in such a manner that plant spacing were maintained as 60 cm between plants and 1 meter between rows. In order to ensure green and healthy conditions of plants, fertilizers including cow dung and irrigation were applied into the soil of the tubs as and when necessary throughout the investigation period.

Counting of aphids:

The brinjal plants of each block were checked regularly to observe the aphid infestation. Sampling of aphids were done just after immediate notice of *A. gossypii* in the field. Altogether three types of leaf (young, mature and old) from each plant of all the blocks were considered for the counting of aphids. The plants observed once were not taken for subsequent observation. In case of thick colonies aphids were taken carefully on a white plastic plate from the infested leaves by means of a soft camel hair brush (0 size), counted and thereafter they were placed back to the same place of the plant. Counts were taken before and after 1, 3, 7 and 20 days of treatment.

Details of treatments :

The experiment comprising six treatments including a control and treatments were done considering both the sowing date and age of plant. Hence treatment schedule varied from field to field. Sprays operations were conducted when wind velocity was normal and dew drops dried up to avoid insecticidal drift. The gap in between first round and second round treatment was twenty days in each. Each block of the experimental fields of respective sowing date was used for specific type of treatment.

Treatment block T_1 = Nimbicidine (0.03% EC Azadirachtin) @ 4ml/L water (1^{st} round and 2^{nd} round).

Treatment block T_2 = Nimbicidine (0.03% EC Azadirachtin) @ 4ml/L water (1^{st} round) and Bankalmi leaf extract @1:10 W/V (2^{nd} round).

Treatment block T_3 = Larvae of *C. transversalis* (1^{st} round and 2^{nd} round).

Treatment block T_4 = T_3 (1^{st} round) and Bankalmi leaf extract @1:10 W/V (2^{nd} round).

Treatment block T_5 = Kerosinized ash (1^{st} round) and Bankalmi leaf extract @1:10 W/V (2^{nd} round).

Treatment block T_6 = Control, spray water only (1^{st} round and 2^{nd} round).

Nimbicidine (Insecticide):

Nimbicidine is only an organic phyto based insecticide in Bangladesh marked by ACI Crop Care widely used to control rice and vegetable pests. It is systemic in nature and derived from the extract of neem (*Azadirachta indica* Juss) and each liter of Nimbicidine contains 0.03% EC Azadirachtin. It is safe to beneficial and fits thereby excellent to IPM programs. The insecticide was diluted as 4ml: 1000ml @ 2 liter per hectare.

Bankalmi leaf extract (botanical):

Leaves of the plant Bankalmi, *Ipomoea* spp. (Family Convolvulaceae) collected from Rajshahi University Campus were air dried at room temperature (20-34^0 C) and then made into fine powder by a hand grinder. The leaf powder was dissolved in normal water at room temperature for 10 days. The proportion of plant material and water was 1:10 (w/v). The dissolved material was then passed through a fine mesh nylon cloth to separate the extract from the plant debris. The extracted water was then poured into the sprayer and sprayed in block T_2, T_4 and T_5 (Second round) of each experimental field.

Natural enemies release :

Five third instar larvae of *C. transvresalis*, (Omker and Parvez, 2000) were released per plant in block T_3 (First round and second round) and T_4 of each field (First round only) with soft brush (0 size).

Kerosinized ash :

Certain mineral oils are well known to reduce aphid colonization on plants and thus the transmission of virus diseases (Simons and Zitter, 1980). Accordingly six tea spoon of kerosene were mixed with 1 kg of wood ash and applied manually by throwing in block T_5 (First round) of each field.

The control block T_6 of each field were also sprayed with water only at the time of treatment made on other blocks of respective field.

Yield counting :

The number of brinjal per plant from all the blocks were collected and their weight was recorded. Usually the very immature and abnormal brinjal were not recorded.

Data recording and analysis :

Data base upon both the number of aphids (Nymphs and adults) and crop yield per plant was averaged and presented in Table 16-21. Mean data expressed in counting aphids density and crop yield was analyzed statistically by analysis of variance (ANOVA) to test the significance in difference among the treatments. Mean separation was done by Duncan's Multiple Range Test (DMRT) at 0.05 probability level. All statistical works were done with the help of Statistical Software, SPSS (Ver. 11.5).

5.3. Results

Nayantara brinjal is rounded in shape and its color is bright purple. On an average twenty to thirty brinjals were produced by a single plant and weight of each brinjal varies from 120 gm to 130 gm. First harvesting were done within eighty to eighty five days of sowing. The shape of Kazla brinjal on the other hand is moderately elongated and blackish purpled colored. Seventy to eighty brinjals produced per plant and weight of each brinjal varies from 55 gm to 60 gm. After sowing, ninety to ninety five days are needed to produce brinjal by the variety Kazla. Effect of various treatments on the mean member of aphids per plant during 1, 3, 7 and 20 days of treatment and finally on yield in two varieties under three sowing dates have been plotted in Table 16-21. Among all the treatments, highest aphid population and minimum yield per plant were recorded in controlled block (T_6) irrespective of varietal difference and sowing date. However two times insecticide spray provided better effect on aphid population reduction and consequently on highest yield in early, mid and late sowing fields of two varieties compared to other treatments. Insecticide plus botanical treated block (T_2) stood in second position in aphid population reduction. Two times treatment by natural enemies (block T_3), one time natural enemies plus one time botanical treated block (block T_4) and one time kerosinised ash plus one time botanical treated block (block T_5) reduced aphid numbers and produced significantly different yield in comparison to untreated (controlled) blocks.

In case of early sowing fields of the variety Nayantara as shown in Table 16, highest yield of brinjal (3.17±0.17 kg/plant) was found in two times insecticide treated blocks (ET_1) and it was 89.82% increase in yield over control. This was followed by 79.64%, 54.49%. 49.70% and 19.76% (Fig.7) in the blocks having treatment by one time insecticide plus one time botanical treated block (ET_2),two times natural enemies treated block (ET_3), one time natural enemies plus one time botanical treated block (ET_4) and one time kerosinised ash plus one time botanical treated block (ET_5) respectively. Similar trends of yield of brinjal may be noticed in mid and late sowing fields of the same variety that have been depicted in Table 18 and 20.

On the other hand highest production (2.10±0.06 kg/plant) of Kazla brinjal was recorded from two times insecticide treated block (Table 17) of early sowing field (ET_1) followed by one time insecticide plus one time botanical treated block (ET_2), two times natural enemies (ET_3), one time natural enemies plus one time botanical (ET_4) and one time kerosinised ash plus one time botanical (ET_5) respectively. Regarding yield the mid and late sowing fields of the same variety also produced similar results (Table 19 and 21).Statistical analysis also revealed that yield of brinjal differed significantly ($P<0.01$ and $P<0.001$) within specific treatment blocks of early, mid and late sowing fields of both varieties (Table 22). From the pretreatment count,

Table 16. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of brinjal aphid, *Aphis gossypii* Glover after two treatments and yield of brinjal in field A (Var. Nayantara).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E)/plant									yield (kg/block) Mean ± S.E.
			Pre-treatment DBT	First round treatment (01.12.2004)				Second round treatment (22.12.2004)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
A 01.09.04 (Early sowing)	ET_1	Nimbicidine @ 4ml/L water (First round and second round)	7.33± 3.17	7.00± 1.00	5.67± 0.33	3.00± 1.73	7.00± 0.58**b**	3.00± 1.73	1.00± 1.00	0.00± 0.00	6.00± 3.00**a**	3.17± 0.17**a**
	ET_2	Nimbicidine @ 4ml/L water (First round and Bankalmi leaf extract @1:10 W/V (second round)	11.67± 2.19	8.33± 0.88	6.67± 4.06	5.00± 2.00	6.00± 0.00**b**	5.33± 1.20	5.00 ± 2.00	6.00± 0.00	10.00± 0.58**a**	3.00 ± 0.00**ab**
	ET_3	Larvae of *C. transversalis* (First round and Second round)	12.00± 0.58	10.00± 1.00	9.33± 2.85	10.00± 0.58	11.67± 2.40**ab**	12.00± 6.25	15.00± 5.00	20.00± 5.77	16.07± 3.33**a**	2.58± 0.30**abc**
	ET_4	ET_3 (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	8.33± 1.20	10.00± 0.00	9.33± 2.91	2.67± 1.76	5.33± 2.73**b**	5.00± 1.15	5.33± 2.33	6.00± 1.15	15.00± 5.00**a**	2.50± 0.02 **bc**
	ET_5	Kerosinized ash (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	11.67± 4.37	5.33± 0.33	5.00± 0.00	5.00± 2.52	8.33± 3.33**b**	5.00± 2.89	5.33± 2.91	6.00± 2.31	13.33± 8.33**a**	2.00± 0.29 **cd**
	ET_6	Control, Spray water only (First round and second round).	13.33± 3.33	11.67± 3.33	15.00± 2.89	16.67± 4.41	20.00± 5.00**a**	22.67± 7.42	20.00± 7.64	27.00± 6.51	24.67± 8.35**a**	1.67± 0.17 **d**
							P=.030 F=3.669				P=.323 F=1.312	P=.001 F=8.612

- All figures are mean of three replications.
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment.

Table 17. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of brinjal aphid, *Aphis gossypii* Glover after two treatments and yield of brinjal in field B (Var. Kazla).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									yield (kg/block) Mean ± S.E.
			Pre-treatment DBT	First round treatment (01.12.2004)				Second round treatment (22.12.2004)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
B 01.09.04 (Early sowing)	ET_1	Nimbicidine @ 4ml/L water (First round and second round)	6.67± 2.40	8.33± 3.53	5.00± 2.89	6.67± 1.20	6.67± 1.45**a**	5.00± 2.00	11.67± 6.01	13.33± 4.41	18.33± 1.20**a**	2.10± 0.06 **a**
	ET_2	Nimbicidine @ 4ml/L water (First round and Bankalmi leaf extract @1:10 W/V (second round)	13.33± 3.33	8.67± 1.33	8.33± 1.20	5.33± 0.88	6.67± 1.20**a**	8.33± 1.67	13.33± 3.33	6.67± 1.76	8.33± 2.03**a**	2.00 ± 0.00 **a**
	ET_3	Larvae of *C. transversalis* (First round and Second round)	10.00± 0.00	10.00± 6.08	9.33± 1.86	8.33± 1.20	13.33a ±.82**a**	10.00± 2.65	16.67± 9.28	16.67± 1.20	20.00± 7.64**a**	1.75± 0.14 **ab**
	ET_4	ET_3 (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	8.33± 2.33	8.33± 1.86	10.33± 0.67	6.67± 3.33	6.67± 3.33**a**	6.67± 0.33	6.67± 0.33	6.67± 2.91	10.00± 0.58**a**	1.42± 0.22 **bc**
	ET_5	Kerosinized ash (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	11.67± 4.26	6.67± 3.38	5.33± 2.73	5.00± 0.00	10.00± 3.21**a**	8.33± 4.41	6.67± 3.33	6.67± 1.20	13.33± 2.60**a**	1.17± 0.08 **c**
	ET_6	Control, Spray water only (First round and second round).	11.67± 4.26	11.67± 4.18	13.33± 3.84	6.67± 3.33	16.67± 4.37**a**	20.00± 10.40	20.00± 5.77	20.00± 6.43	16.67± 3.53**a**	1.10± 0.10 **c**

P= .526 F= .875 P=.241 F=1.571 P=.000 F=12.212

- All figures are mean of three replications.
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment.

Table 18. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of brinjal aphid, *Aphis gossypii* Glover after two treatments and yield of brinjal in field C (Var. Nayantara).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									yield (kg/block) Mean ± S.E.
			Pre-treatment DBT	First round treatment (16.12.2004)				Second round treatment (06.01.2005)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
C 16.09.04 (Mid sowing)	MT_1	Nimbicidine @ 4ml/L water (First round and second round)	23.33± 7.69	17.67± 4.33	16.67± 0.67	18.67± 1.33	22.33± 5.36**ab**	11.00± 2.08	19.33± 1.76	26.00± 3.06	27.50± 10.20**a**	2.97± 0.03 **a**
	MT_2	Nimbicidine@ 4ml/L water (First round and Bankalmi leaf extract @1:10 W/V (second round)	40.00± 5.77	21.67± 6.01	18.67± 3.18	17.00± 9.07	15.00± 2.89**b**	21.67± 4.41	12.67± 2.91	10.00± 4.00	11.67± 2.85**a**	2.67 ± 0.33 **ab**
	MT_3	Larvae of *C. transversalis* (First round and Second round)	26.67± 1.67	16.67± 4.41	18.33± 7.22	18.33± 3.84	26.67± 8.11**ab**	15.00± 8.66	20.00± 5.00	23.33± 8.41	30.00± 8.66**a**	2.50± 0.00 **ab**
	MT_4	ET_3 (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	10.00± 1.15	12.00± 3.46	10.00± 0.00	15.33± 2.91	16.67± 8.82**ab**	13.33± 3.33	10.00± 2.89	22.67± 3.71	35.00± 8.66**a**	2.33± 0.17 **abc**
	MT_5	Kerosinized ash (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	13.33± 3.38	6.67± 3.76	13.33± 1.67	20.00± 5.77	36.67± 6.01**a**	20.00± 10.40	13.33± 4.37	15.00± 0.00	28.33± 1.67**a**	2.17± 0.17 **bc**
	MT_6	Control, Spray water only (First round and second round).	11.67± 2.03	13.33± 3.33	20.00± 2.89	26.67± 6.67	28.33± 1.67**ab**	33.33± 3.33	36.67± 1.67	43.33± 6.01	40.00± 20.00**a**	1.67± 0.33 **c**
							P=.194 F=1.768				P=.483 F=.953	P=.018 F= 4.291

- All figures are mean of three replications.
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment.

Table 19. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of brinjal aphid, *Aphis gossypii* Glover after two treatments and yield of brinjal in field D (Var. Kazla).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									yield (kg/block) Mean ± S.E.
			Pre-treatment DBT	First round treatment (16.12.2004)				Second round treatment (06.01.2005)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
D 16.09.04 (Mid sowing)	MT_1	Nimbicidine @ 4ml/L water (First round and second round)	21.67± 4.41	13.33± 1.67	6.67± 1.45	15.67± 6.74	20.00± 2.89**ab**	10.00± 2.89	13.33± 3.38	3.33± 2.85	30.00± 11.50**ab**	2.00± 0.00 **a**
	MT_2	Nimbicidine @ 4ml/L water (First round and Bankalmi leaf extract @1:10 W/V (second round)	33.33± 4.41	23.33± 6.01	20.00± 5.77	10.00± 0.58	13.33± 3.53**b**	20.00± 5.00	10.00± 0.58	3.33± 2.40	21.67± 3.33**ab**	1.77 ± 0.12 **b**
	MT_3	Larvae of *C. transversalis* (First round and Second round)	21.67± 6.01	13.33± 1.67	20.00± 0.00	18.33± 6.01	26.67± 4.41**a**	15.00± 2.89	21.67± 4.41	13.33± 3.84	13.33± 4.06**b**	1.57± 0.03 **bc**
	MT_4	ET_3 (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	5.00± 2.00	10.00± 1.15	10.00± 0.58	13.33± 3.33	13.33± 2.40**b**	11.67± 2.03	5.00± 2.52	10.00± 1.00	15.00± 2.89**ab**	1.37± 0.03 **c**
	MT_5	Kerosinized ash (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	13.33± 1.76	2.67± 1.76	6.67± 1.20	6.67± 0.88	13.33± 2.40**b**	11.67± 1.45	20.00± 11.50	23.33± 6.01	36.67± 7.27**a**	1.33± 0.03 **c**
	MT_6	Control, Spray water only (First round and second round).	13.33± 3.84	13.33± 1.67	13.33± 1.67	13.33± 3.33	20.00± 2.89**ab**	16.67± 1.67	18.33± 1.67	30.00± 5.77	36.67± 7.27**a**	1.07± 0.12 **d**
							P=.057 F=2.957				P=.103 F=2.370	P=.000 F=20.752

- All figures are mean of three replications.
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment.

Table 20. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of brinjal aphid, *Aphis gossypii* Glover after two treatments and yield of brinjal in field E (Var. Nayantara).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									yield (kg/block) Mean ± S.E.
			Pre-treatment DBT	First round treatment (31.12.2004)				Second round treatment (21.01.2005)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
E 01.10.04 (Late sowing)	LT_1	Nimbicidine @ 4ml/L water (First round and second round)	25.00± 2.89	16.67± 3.33	18.33± 6.01	20.00± 5.77	26.67± 1.67**ab**	13.33± 3.84	26.67± 6.01	33.33± 14.50	40.00± 5.77**ab**	2.53± 0.03 **a**
	LT_2	Nimbicidine @ 4ml/L water (First round and Bankalmi leaf extract @1:10 W/V (second round)	46.67± 6.67	23.33± 4.41	20.00± 2.89	16.67± 3.33	16.67± 3.33**b**	26.67± 6.67	26.67± 6.67	30.00± 5.00	35.00± 2.89**ab**	2.17 ± 0.17 **ab**
	LT_3	Larvae of *C. transversalis* (First round and Second round)	25.00± 7.64	20.00± 5.77	23.33± 2.27	20.00± 5.77	33.33± 3.33**ab**	20.00± 5.77	26.67± 6.01	30.00± 10.00	45.00± 15.00a **b**	2.33± 0.33 **a**
	LT_4	ET_3 (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	13.33± 3.33	13.33± 1.67	13.33± 4.41	20.00± 5.77	28.33± 7.27**ab**	20.00± 2.89	8.33± 1.67	20.00± 5.00	30.00± 5.00**b**	2.33± 0.09 **a**
	LT_5	Kerosinized ash (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	15.00± 7.64	10.00± 0.00	16.67± 3.33	26.67± 6.67	40.00± 5.77**a**	26.67± 8.82	20.00± 7.64	30.00± 5.77	43.33± 8.82**ab**	2.07± 0.07 **ab**
	LT_6	Control, Spray water only (First round and second round).	20.00± 5.77	20.00± 5.77	20.00± 5.00	26.67± 6.01	33.33± 6.01**ab**	40.00± 5.77	53.33± 12.00	46.67± 3.33	70.00± 17.30**a**	1.63± 0.32 **b**
							P=.085 F=2.555				P=.200 F=1.739	P=.111 F=2.291

- All figures are mean of three replications.
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment.

Table 21. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population ofbrinjal aphid, *Aphis gossypii* Glover after two treatments and yield of brinjal in field F (Var. Kazla).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									yield (kg/block) Mean ± S.E.
			Pre-treatment DBT	First round treatment (31.12.2004)				Second round treatment (21.01.2005)				
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT	
F 01.10.04 (Late sowing)	LT_1	Nimbicidine @ 4ml/L water (First round and second round)	26.67± 3.33	20.00± 5.77	13.33± 3.33	10.00± 1.15	30.00± 2.89**ab**	20.00± 5.77	21.67± 6.01	23.33± 8.82	30.00± 11.50**a**	1.93± 0.07 **a**
	LT_2	Nimbicidine@ 4ml/L water (First round and Bankalmi leaf extract @1:10 W/V (second round)	40.00± 5.77	26.67± 7.27	23.33± 4.41	30.00± 11.50	40.00± 5.77**a**	20.00± 2.89	28.33± 6.01	28.33± 4.41	30.00± 11.50**a**	1.90 ± 0.06 **a**
	LT_3	Larvae of *C. transversalis* (First round and Second round)	20.00± 5.29	20.00± 2.89	20.00± 5.77	16.67± 3.53	20.00± 5.77**bc**	18.33± 6.01	21.67± 9.28	30.00± 11.50	46.67± 8.82**a**	1.70± 0.06 **b**
	LT_4	ET_3 (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	10.00± 5.77	6.67± 3.33	13.33± 3.33	13.33± 3.33	18.33± 6.01**bc**	10.00± 5.77	10.00± 0.00	11.67± 3.84	20.00± 5.77**a**	1.60± 0.06 **b**
	LT_5	Kerosinized ash (First round) and Bankalmi leaf extract @ 1:10 W/V (Second round)	8.33± 4.41	5.00± 2.89	6.67± 3.33	10.00± 0.00	13.33± 3.33**c**	5.00± 2.89	10.00± 2.89	11.67± 1.67	30.00± 5.77**a**	1.60± 0.06 **b**
	LT_6	Control, Spray water only (First round and second round).	8.33± 1.20	3.33± 3.33	10.00± 0.58	16.67± 4.41	36.67± 4.41**a**	13.33± 3.33	15.00± 2.89	18.33± 4.41	50.00± 20.20**a**	1.07± 0.07 **c**
							P=.011 F=4.914				P=.476 F=.965	P=.000 F=26.400

- All figures are mean of three replications.
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment.

Table 22. Yield (Mean ± S.E.) of brinjal (kg/plant)in terms of date of sowing, variety and treatments.

Date of sowing	Crop variety	Treatments					
		T_1	T_2	T_3	T_4	T_5	T_6
Early sowing 01.09.2004	Nayantara	3.17±0.17a	3.00±0.00a	2.58±0.30a	2.50±0.02a	2.00±0.29ab	1.67±0.17a
	Kazla	2.10±0.06c	2.00±0.00b	1.75±0.14bc	1.42±0.22b	1.17±0.08c	1.10±0.10a
Mid sowing 16.09.2004	Nayantara	2.97±0.03a	2.67±0.33a	2.50±0.00a	2.33±0.17a	2.17±0.17a	1.67±0.33a
	Kazla	2.00± 0.00c	1.77±0.12b	1.57±0.03c	1.37±0.03b	1.33±0.03c	1.07±0.12a
Late sowing 01.10.2004	Nayantara	2.53±0.03b	2.17±0.17b	2.33±0.33ab	2.33±0.09a	2.07±0.07ab	1.63±0.32a
	Kazla	1.93±0.07c	1.90± 0.06b	1.70±0.06c	1.60±0.06b	1.60±0.06c	1.07±0.07a
		P=.000 F=43.818	P=.001 F=8.898	P=.008 F=5.349	P=.000 F=18.145	P=.001 F=8.207	P=.115 F=2.255

- All figures are mean of three replications
- Means having the same letters in a column are not significantly different at P<0.01 and P<0.001 probability level by DMRT
- Detailed description of treatments(T_1-T_6) were already mentioned in Table(16-21)

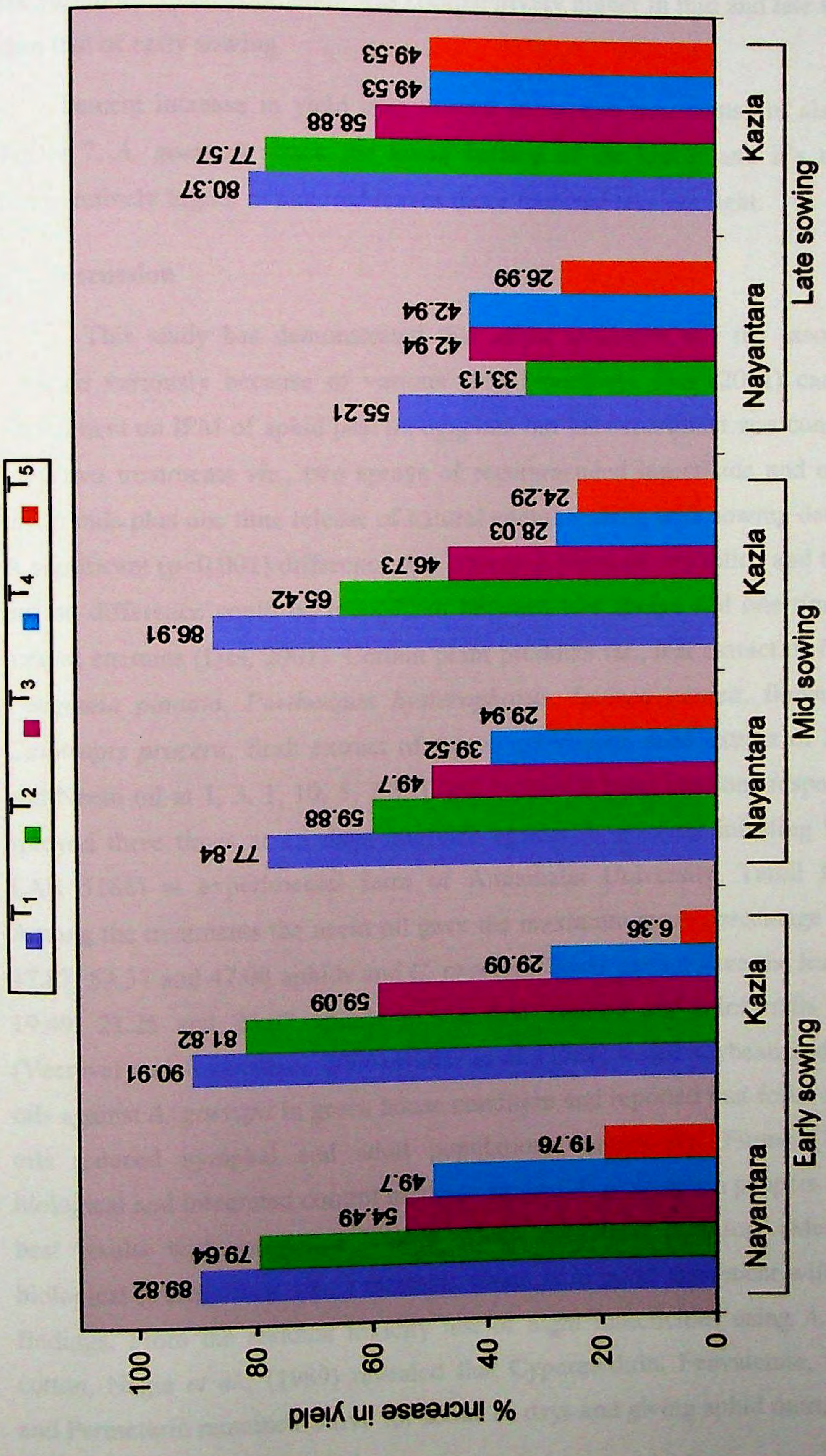


Figure-7: Percent increase in yield over control (T_6) in various treatments for BARI brinjal, Nayantara and Kazla.

it is also observed that early sowing plants received the least aphid infestation in both the varieties. Aphid population was comparatively higher in mid and late sowing field than that of early sowing.

Percent increase in yield over control in various treatments are also shown in Figure 7. *A. gossypii* attack the lower surface of the leaves and it's number was comparatively higher in matured leaves those received less sun light.

5.4. Discussion

This study has demonstrated that aphid incidence and the associated yield affected variously because of various IPM treatments. Das (2001) carried out an experiment on IPM of aphid pest on eggplant but his experiment was confined within only two treatments *viz.*, two sprays of recommended insecticide and one spray of insecticide plus one time release of natural enemies along with sowing date alteration. A significant ($p<0.001$) difference was observed between controlled and treated crops but no difference could be recognized between two sprays and one time release of natural enemies (Das, 2001). Certain plant products *viz.*, leaf extract of *Datura alba*, *Pongomia pinnata*, *Parthenium hysterophorus*, *Ipomea carnea*, flower extract of *Calotropis procera*, flesh extract of *Agave americana*, seed extract of *Datura alba* and Neem oil at 1, 3, 1, 10, 5, 2.5, 1 and 1 percent concentrations respectively were sprayed three times at 15 days intervals against *A. gossypii* infesting brinjal (Var. LAR 5166) at experimental farm of Annamalai University, Tamil Nadu, India. Among the treatments the neem oil gave the maximum mean percentage reduction of 47.87, 53.37 and 47.08 aphids and *C. procera* flower extract gave the least control of 19.49, 21.25 and 23.07 aphids in the first, second and third trails respectively (Veeravel and Jeganathan, 2006).Butler *et al.*,(1988) tested soybean and cotton seed oils against *A. gossypii* in green house condition and reported that foliar sprays of the oils reduced nymphal and adult populations remarkably. Fiume (1993) tested biological and integrated control methods against *A. gossypii* on peppers and obtained best results with integrated control which combined chemical (Methomyl) and biological (*Verticililum spp.*) methods which is in good agreement with the present findings. From the residual toxicity test of eight insecticides using *A. gossypii* on cotton, Nagia *et al.*, (1989) revealed that Cypermethrin, Fenvalerate, Deltamethrin and Permethrin remained active for about 10 days and giving aphid mortality between

61-86%. Monocrotophos, Endosulphan, Chlorpyriphos and Methyl Paration were effective for 14, 10, 8 and 4 days giving insect mortality of 96.4%, 79.3%, 62.9% and 83.3% respectively. Semada *et al.*,(1993) have shown that *A. gossypii* attacked the lower surface of unfurled leaves, especially in lower regions of the plants and was present for 8 and 5 weeks with 62.7 and 30.3 aphids/ square inch on maize crops planted on May 15 and June 15 respectively. The reason for more aphids in matured leaves in the lower part of the plant is probably due to the favorable microclimate for an aphid not for its natural enemies (Coaker, 1987).

Water and nitrogenous compounds are relatively high in young leaves and decline with leaf maturation (Scriber, 1984). Monophagous and oligophagous herbivores often show a strong preference for the more nutritious younger tissues that are also high in toxins, whereas polyphagous herbivores demonstrate a strong preference for the less nutritious mature leaves (Evans, 1984). Therefore, the highest population of *A. gossypii* on matured leaves might also be due to its polyphagous nature. Besides, the present observation was close to the observation of Raupp and Denno (1983) who reported that plant leaves under full sunlight are generally less attractive to aphids than those in shade though the nitrogen content may be higher. Webb (1994) did an experiment for the protection of squash from *A. gossypii* through various control measures and found that mineral oil in combination with Bifenthrin was very effective. Nagia *et al.*,(1994), suggested from their experiment , Dimethoate 30 EC and Oxydemeton methyl 25 EC may used either alone or in combination for the control of *A. gossypii* and *Myzus persicae* (Sulz.) when they occur simultaneously on potato. Jarande and Dethe (1994) carried out an experiment on brinjal sucking pests and showed that imidacloprid was highly effective in reducing the incidence of aphids, whiteflies and jassids on brinjal and increasing in seedling height and total leaf chlorophyll over those of untreated plants. However results of the present study tend to agree with the results of previous studies conducted by Das (2001) who reported that population of *A. gossypii* was significantly ($p<0.05$) lower on the early sowing transplanted egg plants than those of mid and late sowing plants. Finally it could be concluded that in combination of appropriate sowing time with minimum insecticide plus botanical or natural enemies release technique may be applied to control the population of *A. gossypii* in the field under economic threshold level and higher economic return.

CHAPTER 6	**Integrated management of mustard aphid, *Lipaphis erysimi* (Kalt.)**

6.1. Introduction

6.1.1. Importance and cultivation of mustard

Mustard and rapeseed are important oil seed crops in Bangladesh. The national economy of Bangladesh suffers from an acute shortage of edible oils in terms of domestic production. Nearly two-thirds of the total edible oil consume in the country are imported (Hossain, 1991). One of the reasons for such low yield is the constraint put up by the insect pests of these crops. Of the various oil seeds grown in the country, the mustard occupies the top position in respect of total yield and acreage. During 1996-97 crop season, only mustard cultivation covered about 336 thousand hectares of land in our country and the production was about 249 thousand metric tones (B.B.S., 1998). Mustard crop is conventionally grown for edible vegetable oil and green leaves are used both for human food and animal fodder (Nasir *et al.*, 1998). The residual cake of mustard is used as fish and cattle feed and as fertilizers (Haque *et al.*, 1979). According to Huxley and Levy (1992) this crop has ornamental and medicinal value.

6.1.2. Pests of mustard

Insects-pests are one of the major limiting factors influencing the production of mustard. About two dozen insects pests have been associated with this crop (Rai, 1976), only three are regarded as major pests. They are mustard saw fly, *Athalia proxima* Klug., the painted bug, *Bagrada cruciferarum* Kiru., and the mustard aphid, *L. erysimi* The first two pests occur only in the early stages of crop growth, but the mustard aphid appears on the crop for a considerable period of plant growth and incurs serious loss even up to 90-95 percent. Besides *L. erysimi*, another two species of mustard aphids are *Myzus persicae* Sulzer and *Brevicoryne brassicae* L. However of all the pests of mustard in Bangladesh, *L. erysimi* is most devasting (Alam *et al.*, 1964; Ahmed *et al.*, 1977; Haque *et al.*, 1979) which reduces the yield of mustard considerably.

6.1.3. Aphid, *Lipaphis erysimi* (Kalt.) : Homoptera, Aphididae.

This aphid is soft bodied yellowish green, grey green or olive green insect with a white waxy body coating measuring 1.2-2.4 mm (apterae female) and 1.4-2.2 mm (alatae forms) long (Blackman and Eastop, 1984). After emerging from the last moult, 1-2 days pass before the adult females begin producing young. They continue producing young for 13-20 days followed by a 2-3 day post reproductive stage. The total duration of the adult stage is 26-37 days (Sachan and Bansal, 1975). They also reported that wingless females produce 70-87 young in their life time. While winged females produce 31-40 young. Male aphids are considerably smaller than females and measure approximately 1.20-1.35 mm in length (Kawada and Murai, 1979).

6.1.4. Common names of *Lipaphis erysimi*(Kalt.):

Lipaphis erysimi (Kalt.) has many common names, *viz,* Mustard aphid, cabbage aphid, false cabbage aphid, safflower aphid, turnip aphid, canola aphid (English); loodkleurige bladluis (Dutch); afido del repollo, pulgon del nabo (Spanish); nise-daikon-aburamusi (Japanese); puceron du navet (French) and Senf-Blattlaus (German).

6.1.5. Biology of *Lipaphis erysimi* (Kalt.)

In *L. erysimi*, although holocyclic forms have been observed, anholocycly predominates in warmer climates (Blackman and Eastop, 1989). It has two modes producing young: fertilization of females by males resulting in the production of eggs (sexual reproduction) and the birthing of live female nymphs by adult females without fertilization by males (parthenogenesis). Reproduction through parthenogenesis seems to be the norm as males are very rare and females are almost exclusively viviparous (birth live young) throughout the year and males have only been observed in the cooler months (Kawada and Murai, 1979).

Eggs (sexual reproduction) are laid along the veins of leaves (Kawada and Murai, 1979). There are four nymphal stages (instars). The general appearance of each stage is similar except for increase in size during subsequent instars. Minor variations in the duration of instars occur between winged and wingless forms when raised on cabbage, cauliflower, mustard and radish (Sachan and Bansal, 1975).

6.1.6. Nature of damage by *Lipaphis erysimi* (Kalt.)

L. erysimi is one of the most important pests of Brassicas leafy vegetables world wide (Blackman and Eastop, 1984) including Taxes (Yue and Liu, 2000). The aphids may stunt or kill plants in early stages of growth and later on their contamination reduces the market values, causing them to curl, forming pockets and folds that offer shelter to the aphids thus enabling them to escape insecticide treatment. *L. erysimi* feed on growing shoots, inflorescence and under side of the leaves. In severe infestation entire crop plants are densely covered with aphids causing stunting growth and poor pod formation (Malti *et al.*, 1988). Heavily attacked crop becomes week and exhausted and does not bear any seed (Hazarika, 1951).

In a recent study it was observed that the yield loss due to the infestation of *L. erysimi* in mustard ranged from 35.4 to 91.3% (Brar *et al.,* 1987; Sing and Sachan, 1994). Sometimes high incidence of this pest can cause complete loss of the crop (Rouf and Kabir, 1997). It was reported that the yield loss due to aphid attack ranged from 8.9 to 77.5% (Prasad and Phadke, 1983) and 8.6 to 57.5% (Vir and Henry, 1987). But in a recent investigation in Bangladesh it was found that the yield loss due to infestation in mustard by *L. erysimi* ranged from 87.16 to 98.16% (Anonymous, 1995). Both adults and nymphs feed on leaves, inflorescences and pods, which results in pale and curled leaves and consequently plant growth and development of flowers and pods is adversely affected. The yield may decrease up to 80% in case of severe infestation (Atwal, 1976). Besides, disease producing turnip mosaic virus is also carried by this species.

6.1.7. Distribution and host plants of *Lipaphis erysimi* (Kalt.)

L. erysimi is distributed in Bangladesh, Pakistan, India, U.S.A and many other countries of the world (Husain and Shahajahan, 1997). Cruciferous plants are the chief host plants of *L. erysimi* of which mustard (*Brassica campestris* L.), turnip (*Brassica rapa* L.) and reddish (*Raphanus sativus* L.) are most remarkable (Aslam and Ahmed, 2001). Besides *Brassica alba* Hook; *Brassica integrifolia* (West.) Schulz, *Brassica napus* L., *Brassica nigra* L., *Brassica oleracea* var. *Agrotis*, *Brassica oleracea* L. var. *Capittata*, *Brassica rugosa* Prain, var. *Cuneifolia*, *Lactuca sativa* L. are note worthy as host plants of *L. erysimi* in Bangladesh (Das, 1994).

6.1.8. Natural enemies of *Lipaphis erysimi* (Kalt.)

Predators:

i. Coccinellidae: Coleoptera

Brumoides suturalis (Fabricius): Agarwala and Bhattacharya (1999); Singh *et al.* (2003).

Cheilomenes sexmaculata (Fabricius): Tao and Chiu (1971); Agarwala and Bhattacharya (1999); Singh *et al.* (2003); Omkar and Bind (2004).

Coccinella repanda Thunberg: Tao and Chiu (1971); Saharia (1984); Agarwala and Bhattacharya (1999).

Coccinella septempunctata L.: Tao and Chiu (1971); Singh and Singh (1994a); Agarwala and Bhattacharya (1999); Singh *et al.* (2003); Srivastava and Srivastava (2003).

Coccinella transversalis Fabricius: Agarwala and Bhattacharya, (1999); Omkar and James (2004).

Coccinella tranversoguttata Faldermann: Agarwala and Bhattacharya (1999).

Coccinella undecimpunctata L.: Agarwala and Bhattacharya (1999); Solangi et al. (2007).

Coccinella octopunctata Müller: Tao and Chiu (1971); Agarwala and Bhattacharya (1999).

Harmonia octomaculata (Fabricius): Agarwala and Bhattacharya (1999)

Harmonia (Leis) dimidiata (Fabricius): Tao and Chiu (1971).

Hippodamia variegata (Goeze): Singh and Singh (1994); Agarwala and Bhattacharya (1999).

Lemnia biplagiata (Schwartz): Tao and Chiu (1971); Yu and Chen (2002).

Lemnia swinhoei (Crotch): Tao and Chiu (1971).

Micraspis discolor (Fabr.): Agarwala and Bhattacharya (1999); Hossain *et al.* (2001); Das (2002).

Pania luteopustulata (Mulsant): Agarwala and Bhattacharya (1999).

Propylea dissecta (Mulsant): Omkar and Pervez (2004); Mishra *et al.* (2005).

Propylea japonica (Thunberg): Tao and Chiu (1971).

Scymnus (Pullus) pyrocheilus Mulsant: Agarwala and Bhattacharya (1999).

Scymnus xerampelinus Mulsant: Agarwala and Bhattacharya (1999).

Scymnus spp.: Das (2002).

Synonycha grandis (Thunberg): Tao and Chiu (1971).

ii. Syrphidae:Diptera

Allograpta javana (Wiedemann): Agarwala and Bhattacharya (1999);

Singh *et al.*, (2003).

Betasyrphus serarius (Wiedemann): Agarwala and Bhattacharya (1999).

Dideopsis aegrota (Fabricius): Agarwala and Bhattacharya (1999).

Episyrphus balteatus (De Geer): Agarwala and Bhattacharya (1999);

Bisht *et al.* (2006); Samuel *et al.* (2005).

Episyrphus alternans Macquart: Agarwala and Bhattacharya (1999);

Kumar *et al.,* (1987).

Episyrphus viridaureus (Wiedmann): Agarwala and Bhattacharya (1999).

Eupeodes corollae (Fabricius) (=*Metasyrphus corollae* (Fabricius): Tao and Chiu (1971).

Ischiodon scutellaris (Fabricius): Tao and Chiu (1971); Agarwala and Bhattacharya (1999);

Kumer *et al.* (1987); Das (2002); Singh *et al.* (2003); Bisht *et al.* (2006).

Lasiopticus seleniticus Meigen: Bisht *et al.* (2006)

Melanostoma orientale (Wiedemann): Tao and Chiu (1971); Agarwala and Bhattacharya (1999).

Melanostoma univittatum Wiedemann: Tao and Chiu (1971); Bisht *et al.* (2006).

Metasyrphus confrater (Wiedemann): Kumer *et al.* (1987).

Metasyrphus latilunulatus (Collin): Kumer *et al.* (1987).

Paragus crenulatus Thomson: Agarwala and Bhattacharya (1999).

Paragus serratus (Fabricius): Tao and Chiu (1971); Agarwala and Bhattacharya (1999).

Paragus tibialis (Fallén): Tao and Chiu (1971); Agarwala and Bhattacharya (1999).

Scaeva albomaculata (Macquart): Agarwala and Bhattacharya (1999).

Scaeva latimaculata (Brunetti): Kumer *et al.* (1987).

Scaeva pyrastri (Linaeus): Agarwala and Bhattacharya (1999).

Scaeva selentica Meng: Bisht *et al.* (2006).

Sphaerophoria indiana Bigot: Kumer *et al.* (1987); Agarwala and Bhattacharya (1999).

Sphaerophoria scripta (Linnaeus): Agarwala and Bhattacharya (1999); Bisht *et al.,* (2006).

Sphaerophoria spp.: Das (2002).

Sphaerophoria vockerothi Joseph: Agarwala and Bhattacharya (1999).

Syrphus confrater Wiedemann: Das (2002).

Syrphus corollae Fabricius: Bisht *et al.* (2006).

Syrphus isaaci Bhatia: Bisht *et al.* (2006).

Syrphus spp.: Bisht *et al.* (2006).

iii. Chrysopidae: Neuroptera

Chrysoperla carnea (Stephens): Agarwala and Bhattacharya (1999); Liu and Chen (2001a); Singh *et al.* (2003).

Chrysopa septempunctata Wesmael: Tao and Chiu (1971).

Chrysoperla rufilabris (Burmeister): Liu and Chen (2001a).

iv. Anystidae: Prostigmata

Anystis spp.: Tao and Chiu (1971).

Parasitoids:

i Aphelinidae: Hymenoptera

Aphelinus spp. nr. *flavipes* Kurdy: Agarwala and Bhattacharya (1999).

ii. Braconidae: Hymenoptera

Aphidius avenae Haliday: Subhrani *et al.* (2006).

Aphidius colemani Viereck: Subhrani *et al.* (2006).

Aphidius gifuensis Ashmead: Agarwala and Bhattacharya (1999); Subhrani *et al.*, (2006).

Aphidius hortensis Marshall: Subhrani *et al.* (2006).

Aphidius matricariae Haliday: Agarwala and Bhattacharya (1999); Kavallieratos *et al.* (2001).

Diaeretiella rapae (M'Intosh): Agarwala and Bhattacharya (1999); Kavallieratos *et al.* (2001); Olmez and Ulusoy (2003); Singh *et al.* (2003);

Biradar and Dhanorkar (2004); Subhrani *et al.* (2006).

Ephedrus minor Stelfox: Subhrani *et al.* (2006).

Ephedrus plagiator (Nees): Agarwala and Bhattacharya (1999); Subhrani *et al.* (2006).

Fungi:

iAncylistaceae: Entomophthorales

Conidiobolus obscurus (Hall and Dunn): Scorsetti *et al.* (2007).

ii. Entomophthoraceae: Entomophthorales

Entomophthora planchoniana Cornu: Scorsetti *et al.* (2007).

Entomophthora spp.: Agarwala and Bhattacharya (1999).

Pandora neoaphidis (Remaud. and Hennebert): Scorsetti *et al.* (2007).

Zoophthora radicans (Brefeld): Scorsetti *et al.* (2007).

iii. Neozygitaceae: Entomophthorales

Neozygites fresenii (Nowak): Scorsetti *et al.* (2007).

iv. Niessliaceae: Hypocreales

Cephalosporium aphidicola Petch: Agarwala and Bhattacharya (1999).

6.1.9. Importance of the present study

In Bangladesh, mustard aphid is generally controlled by using insecticides (Alam *et al.*, 1964; Ahmed *et al.*, 1977; Haque *et al.*,1979). But the use of insecticides is hazardous as they leave many undesirable side effects such as (i) development of resistance in pest populations, (ii) destruction of beneficial species, (iii) resurgence, (iv) outbreaks of secondary hosts, (v) residues in feeds, foods and the environment and (vi) hazards to humans and the environment (Luckman and Metcalf,1975; Husain and Begum, 1984). Highly toxic insecticides with long residual effect are believed to hamper pollination in mustard and cause seed sterility. On the other hand, less toxic insecticides are found less effective in controlling aphids when the incidence becomes very high. Moreover, the insecticides and spraying equipments are very costly, hence sometimes it becomes quite unaffordable for our farmers to purchase these materials (Husain, 1984). In addition the insecticides are lipophilic in nature and may leave hazardous residues in oils. Thus it is urgently required to find out an effective, cheapest and environmentally safe alternative in place of insecticidal control which will strengthen the bases of integrated pest management (IPM) programme. But till today no body did any work for the integration of different control techniques *viz.*, cultural, biological, chemical, botanical in Bangladesh. So there is enough scope to explore the impact of these on mustard aphid, *L. erysimi*.

6.2. Metarials and Methods

The experiment was conducted during October 2005 to March 2006 at Rajshahi University Campus, Rajshahi a northwestern district of Bangladesh. The investigation was aimed to assess the impact of some IPM parameters either alone or in combination with one another on the population abundance of mustard aphid, *L. erysimi* and on the yield of mustard. Accordingly seeds of two mustard cultivars, BARI sharisha-6 (*Brassica campestris*) and BARI Sharisha-7 (*Brassica napus*) were sown at three different dates *viz.*, 16.10.2005 (Early sowing), 01.11.2005 (Mid sowing) and 16.11.2005 (Late sowing) on separate plots. The research trial was laid out in randomized block design with six treatments including a control and replicated thrice, each having the size of 1.5 × 1 meters. Thus eighteen blocks were made from each cultivar and each sowing date respectively. The spacing were maintained as 30 cm and 15 cm for rows and plants respectively. Usual irrigation and weeding were done whenever necessary. The chemical fertilizers were applied at the rate 84:66:34 kg/ha of N:P:K. respectively (Anonymous, 1987). Half of nitrogen and total amount of P(phosphate) and K (murate of potash) were applied at the time of final land preparation. The rest of the nitrogen was applied just before flowering. The experimental plots were visited regularly to detect the arrival of *L. erysimi* and application of under mentioned treatment parameters was started as soon as their incidence was noticed. The interval in-between first round and second round treatment was 20 days. For the application of watery solution like insecticide, botanical and water (for controlled block) Manseok Sprayer was used and procedure of application including calibration of insecticide was followed as per Mathews (1988).

Each of the blocks of experimental plots was used for specific type of treatment and named as-

Treatment block T_1 = Two times insecticide spray (Classic 20 EC @ 2ml/L Water (First round and second round)

Treatment block T_2 = One time spray of insecticide (Classic 20 EC @ 2ml/L water (first round) and one time spray of botanical (Dhutura leaf extract) @ 1:10 W/V (Second round).

Treatment block T_3 = Two times release of natural enemies (Larvae of *C. transversalis* (First round and second round).

Treatment block T_4 = One time release of natural enemies (Larvae of *C. transversalis* (First round) and one time spray of botanical (Dhutura leafextract) @ 1:10 W/V (Second round).

Treatment block T_5 = One time dusting of kenosinized ash (first round) and one time botanical spray (Dhutura leaf extract) @ 1:10 W/V (second round)

Treatment block T_6 = Two times spray of water only (first round and second round).

Insecticide (Chloropyriphos) :

Chloropyriphos is a organophosphorus compound forms an important class of pesticide. It is commercially marketed as Classic 20 EC by ACI crop care in Bangladesh and indicated for the control of wide variety of pests specially aphids and other sucking insects. This insecticide has a contact, stomach and fumigant action. The chief advantage of this insecticide is highly toxic against target organism and non-toxic to vertebrate and do not accumulate in the animal body. The prescribed dose rate of Classic 20 EC is 2ml/L water against aphids and thus 100 ml/ha.

Botanical (Dhutura leaf extract) :

Datura metel L. (Family Solanaceae) is a genus of herbaceous plant which includes 10 to 12 species of plants. They are distributed throughout the tropical and temperate regions in both the old and new worlds. In Bangladesh they grow wild in waste places and roadsides all over the country. Fully grown plant of the *Datura metel* L. attains height of 2-6 feet. Principal chemical constituents of the plant are a large number of alkaloids including hyoscyamine, hyoscine, scopolamine, atropine and vitamin C (Gupta *et al.*, 1992; Mahmood *et al.*, 1998; Sharma 2003). Dhutura leaves have narcotic, antispasmodic and anodynic properties. They are smoked to relieve spasmodic asthma and used in rheumatic swellings, lumbago, sciatica, neuralgia, painful tumors and also in earache. These promising attributes led the author to evaluate the potential use of *D. metel* leaf extract against *L. erysimi* in the present investigation.

Fresh leaves Dhutura plant were collected from the botanical garden and roadsides of Rajshahi University Campus. The collected leaves were washed and cleaned with tap water. The plant materials were then cut in small pieces with sharp knife and dried in shade. The shade dried materials were ground into powder by a hand grinder. The leaf power was dissolved in normal water and kept at room temperature (20^0C-34^0C) for 10 days. The proportion of plant material and water was 1:10 (W/V). It was then filtered to separate the extract from the plant debris. The extracted was then sprayed in experimental block $T_{2,}$ T_4 and T_5 (Second round) of each plot.

Natural enemies :

Agarwala and Bhattacharya (1999) emphasised the importance of *Coccinella transversalis* (Fabr.) (=*Coccinella repanda* Thunb.) and *Micraspis discolor* (Fabr.) as potential predator of mustard aphid with other natural enemies. Accordingly five third instar larvae of *C. transversalis* were taken from the stock culture and released them on scheduled date in experimental block T_3 (first round and second round) and T_4 (first round of each plot).

Kerosinized ash :

Uses of ash and sand as mechanical control method of insect pests has a history of many years (Hossain *et al.*, 1994; Hossain *et al.*, 2003). Six tea spoon of kerosine were mixed with 1kg of wood ash and applied it manually by throwing in block T_5 (first round) of each plot.

Counting of aphids and yield:

For counting the number of aphids, three plants were randomly selected per variety/per sowing date /per block. Aphids were counted before and after 1, 3, 7 and

20 days of treatment from the top of 5 cm apical twig and three types of leaf (young, mature and old) from each of the selected plants. In case of thick colonies, magnifying glass was used in counting procedure. The plants observed once were not taken for subsequent observation. Seed yield from each treatment was weighed after the harvest and finally converted in quintal per hectare.

Data recording and analysis:

To compare yield among the treatments, data were pooled, analyzed statistically using an analysis of variance (ANOVA) procedure and significantly (0.05) different means were separated by Duncun's (1951) Multiple Range Test (DMRT) with the help of Statistical Software SPSS (Ver. 11.5).

6.3. Results

Plant height of the variety BARI Sharisha-6 is comparatively longer than the variety BARI-7. Flower color of BARI –6 is yellow but in case of BARI Sharisha-7 it is white colored. Yield attributing characters like branches per plant, seeds per siliqua is more in BARI Sharisha–6 than in BARI Sharisha-7. Seeds of both varieties become mature within ninety five days from the date of sowing. The population of mustard aphid, *L. erysimi* was reduced in all the blocks of early, mid and late sowing plots of both varieties just after the introduction of first round treatment. Thereafter the population increased slightly towards the end of first round treatment. The population of mustard aphid again started to decrease after the initiation of second round treatment. The polled data on the aphid counts of two varieties after 1, 3, 7 and 20 days of treatment along with yield of mustard in different blocks/ plot based on sowing date are presented in Table 23-28. Pretreatment counts were done just one day before treatment in all cases. Within a plot, two times insecticide treated blocks had the lowest aphid population followed by one time insecticide plus one time botanical treated blocks when compared with the population recorded on controlled blocks. Among all the treatments of early sowing plots, two times insecticide treated block (ET_1) provided the maximum increased seed yield of mustard 9.76 q/ha for BARI Sharisha-6 and 9.14 q/ha for BARI Sharisha-7, while one time insecticide plus one time botanical treated block (ET_2), two times natural enemies treated block (ET_3), one

Table 23. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of mustard aphid, *Lipaphis enysimi* (Kalt.) after two treatments and yield of mustard in plot A (Var.BARI Sharisha-6).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									yield (kg/ block) Mean ± S.E.	Average yield q/ hectare
			Pre-treatment DBT	First round treatment (08.12.2005)				Second round treatment (29.12.2005)					
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT		
A 16.10.2005 (Early sowing)	ET_1	Classic 20 EC @ 2ml/L water (First round and second round)	98.33± 41.11	36.67± 12.03	9.00± 00.58	5.33± 1.77	14.00± 2.31**d**	.67± 00.67	1.67± .33	4.00± 1.16	6.67± 2.41**c**	.48± 0.01 **a**	9.76
	ET_2	Classic 20 EC@ 2ml/L water (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	133.33± 48.13	22.33± 4.34	24.67± 4.38	6.33± 2.73	12.67± 1.77**d**	4.00± 1.16	5.67± 1.77	6.33± 1.77	11.00± 1.16**c**	.44 ± 0.01 **ab**	8.94
	ET_3	Larvae of *C. transversalis* and (First round and Second round)	126.67± 43.77	43.33± 8.83	50.00± 5.78	46.67± 8.82	50.00± 5.78**bc**	18.33± 6.01	18.33± 6.01	40.00± 11.56	80.00± 5.78**b**	.39± 0.00 **b**	7.92
	ET_4	Larvae of *C. transversalis* (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	123.33± 41.82	43.33± 3.33	50.00± 15.29	40.00± 5.78	43.33± 8.88**c**	31.66± 9.29	56.67± 14.55	76.67± 8.83	70.00± 5.78**b**	.36 ± 0.00 **c**	7.32
	ET_5	Kerosinized ash (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	153.33± 12.03	70.00± 5.78	40.00± 5.78	56.67± 21.88	68.33± 9.29**b**	56.67± 17.65	46.67± 12.03	35.00± 2.89	53.33± 167.65**b**	.32 ± 0.01 **c**	6.50
	ET_6	Control, Spray water only (First round and second round).	83.33± 31.84	93.33± 17.66	126.67 ± 3.33	135.00 ± 2.89	143.66± 3.18**a**	152.00± .58	130.00± 35.16	90.00± 26.49	146.67± 8.83**a**	.20± 0.01 **d**	4.07
							P=.000 F=64.917				P=.000 F=34.473	P=.000 F=49.571	

- All figures are mean of three replications.
- Size of each experimental block 1.5 × 1 meters
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment

Table 24. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of mustard aphid, *Lipaphis erysimi* (Kalt.) after two treatments and yield of mustard in plot B (Var. BARI Sharisha -7).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									yield (kg/block) Mean ± S.E.	Average yield q/hectare
			Pre-treatment DBT	First round treatment (08.12.2005)				Second round treatment (29.12.2005)					
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT		
B 16.10.2005 (Early sowing)	ET_1	Classic 20 EC @ 2ml/L water (First round and second round)	35.00± 2.89	5.00± 5.01	0.00± 0.00	3.00± 1.53	4.00± 3.06**c**	0.00± 0.00	0.00± 0.00	0.00± 0.00	6.33± 2.03**c**	.45±0.03 **a**	9.14
	ET_2	Classic 20 EC@ 2ml/L water (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	50.00± 5.78	6.67± 3.34	11.00± 2.08	15.00± 2.89	30.00± 5.78**ba b**	2.33± 0.88	0.00 ± 0.00	1.00± 0.57	5.67± 1.45**c**	.42 ± 0.02 **ab**	8.53
	ET_3	Larvae of *C. transversalis* (First round and Second round)	58.33± 43.77	15.00± 8.83	16.67± 5.78	30.00± 8.82	33.33± 5.78**ab**	36.66± 6.01	13.33± 6.01	15.00± 11.56	13.33± 5.78**bc**	.39 ± 0.00 **b**	7.92
	ET_4	Larvae of *C. transversalis* (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	100.00± 50.39	23.33± 4.41	28.33± 6.01	35.00± 2.89	36.67± 6.67**ab**	20.00± 5.78	9.67± 2.73	3.33± 1.77	9.33± .67**c**	.33 ± 0.02 **c**	6.71
	ET_5	Kerosinized ash (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	116.67± 43.77	53.33± 23.54	30.00± 2.89	31.67± 13.66	43.33± 8.83**ab**	11.67± 9.29	7.33± 3.85	5.67± 2.19	20.00± 2.89**b**	.26 ± 0.00 **d**	5.29
	ET_6	Control, Spray water only (First round and second round).	120± 36.09	123.33 ± 21.88	90.00± 37.90	113.33 ± 27.32	55.00± 7.65**a**	93.33± 6.67	70.00± 5.78	73.33± 6.01	90.00± 5.78**a**	.16± 0.00 **e**	3.25
							P=.006 F=5.786				P=.000 F=107.981	P=.000 F=42.822	

- All figures are mean of three replications.
- Size of each experimental block 1.5 × 1 meters
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment.

Table 25. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of mustard aphid, *Lipaphis erysimi* (Kalt.) after two treatments and yield of mustard in plot C (Var. BARI Sharisha-6).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									yield (kg/block) Mean ± S.E.	Average yield q/ hectare
			Pretreatment DBT	First round treatment (13.12.2005)				Second round treatment (03.01.2005)					
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT		
C 01.11.2005 (Mid sowing)	MT_1	Classic 20 EC @ 2ml/L water (First round and second round)	126.67± 23.36	30.00± 5.78	6.67± 3.34	2.67± 2.67	8.00± 1.16**d**	00± 00	1.00± 0.58	3.00± 0.58	9.33± 0.67**c**	.41± 0.01 **a**	8.33
	MT_2	Classic 20 EC@ 2ml/L water (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	120.00± 41.68	26.00± 4.93	25± 7.65	6.67± 3.34	19.33± 0.67**d**	8.00 ± 1.56	6.00± 1.56	8.67± 0.67	13.33 ± 1.67**c**	.39± 0.01 **a**	7.93
	MT_3	Larvae of *C. transversalis* (First round and Second round)	116.67± 16.68	46.67± 9.29	33.33± 3.34	46.67± 8.82	56.67± 6.02**bc**	15.00± 2.89	18.33± 6.02	43.33± 10.15	65.00± 25.69**b**	.37 ± 0.01 **a**	7.52
	MT_4	Larvae of *C. transversalis* (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	226.67± 37.16	46.67± 1.67	53.33± 13.66	43.33± 6.01	46.67± 9.29**c**	53.33± 16.93	78.33± 4.41	73.33± 4.41	80.00± 5.78**b**	.38 ± 0.01 **a**	7.72
	MT_5	Kerosinized ash (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	123.33± 49.84	33.33± 23.36	41.667 ± 4.41	50.00± 15.29	70.00± 7.65**b**	60.00± 18.95	50.00± 10.42	36.67± 4.41	63.33± 19.24**b**	.32 ± 0.01 **b**	6.50
	MT_6	Control, Spray water only (First round and second round).	216.67± 44.15	150.00 ± 00	135.00 ± 7.65	140.00 ± 00	148.33 ± 6.02**a**	153.33 ± 1.67	135.00 ± 35.16	106.67 ± 17.65	146.67 ± 8.83**a**	.19± 0.01 **c**	3.86
							P=.000 F=68.279				P= .000 F=13.281	P=.000 F=51.094	

- All figures are mean of three replications.
- Size of each experimental block 1.5 × 1 meters
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment.

Table 26. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of mustard aphid, *Lipaphis erysimi* (Kalt.) after two treatments and yield of mustard in plot D (Var. BARI Sharisha-7).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error((S.E.)/plant									yield (kg/block) Mean ± S.E.	Average yield q/hectare
			Pre-treatment DBT	First round treatment (13.12.2005)				Second round treatment (03.01.2005)					
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT		
D 01.11.2005 (Mid sowing)	MT_1	Classic 20 EC @ 2ml/L water (First round and second round)	48.33± 8.34	11.67± 1.67	11.67± 1.67	16.67± 4.41	25.00± 2.89**b**	2.00± 1.16	5.33± 1.77	6.00± 2.65	8.00± 0.58**c**	.39± 0.01 **a**	7.92
	MT_2	Classic 20 EC@ 2ml/L water (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	53.33± 6.02	10.00± 00	11.67± 1.67	16.67± 4.41	31.67± 4.41**b**	4.00 ± 1.16	7.33± 2.9	5.33± 2.34	7.67± 1.45**c**	.37± 0.01 **a**	7.52
	MT_3	Larvae of *C. transversalis* (First round and Second round)	76.67± 14.55	15.00± 00	20.00± 2.89	33.33± 8.82	40.00± 6.02**b**	38.33± 2.89	16.67± 6.02	16.67± 10.15	21.66± 25.69**b**	.33 ± 0.01 **b**	6.71
	MT_4	Larvae of *C. transversalis* (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	81.67± 10.15	23.33± 3.34	31.667 ± 4.41	40.00± 7.65	23.33± 3.34**b**	11.67± 1.67	11.00± 2.08	10.00± 00	11.00± 2.08**c**	.31 ± 0.01 **c**	6.30
	MT_5	Kerosinized ash (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	123.33± 12.03	40.00± 5.78	31.67± 4.41	50.00± 5.78	46.67± 10.15**b**	18.33± 6.01	13.33± 3.33	11.66± 1.67	26.67± 2.27**b**	.29 ± 0.01 **c**	5.89
	MT_6	Control, Spray water only (First round and second round).	123.33± 37.16	116.67 ± 16.69	156.67 ± 14.55	113.33 ± 17.66	73.33± 12.03**a**	60.00± 11.56	73.33± 7.27	75.00± 5.00	100.00 ± 00**a**	.18± 0.01 **d**	3.65
							P=.011 F=4.943				P=.000 F=107.324	P= .000 F=85.606	

- All figures are mean of three replications.
- Size of each experimental block 1.5 × 1 meters
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment.

Table 27. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of mustard aphid, *Lipaphis erysimi* (Kalt.) after two treatments and yield of mustard in plot E (Var. BARI Sharisha-6).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									yield (kg/block) Mean ± S.E.	Average yield q/hectare
			Pre-treatment DBT	First round treatment (18.12.2006)				Second round treatment (08.02.2006)					
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	XX DAT		
E 16.11.2005 (Late sowing)	LT_1	Classic 20 EC @ 2ml/L water (First round and second round)	113.33± 13.35	31.67± 6.02	26.67± 6.67	11.67± 1.67	19.33± 0.67**c**	2.00± 2.00	00± 00	4.00± 1.16	10.00± 1.16**c**	.35±0.01 **a**	7.11
	LT_2	Classic 20 EC@ 2ml/L water (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	126.67± 62.35	28.33± 4.41	30.00± 7.65	18.33± 1.65	19.33± 0.67**c**	10.00 ± 0.00	.33± 0.33	3.00± 0.58	18.33 ± 1.67**c**	.34±0.01 **ab**	6.91
	LT_3	Larvae of *C. transversalis* (First round and Second round)	123.33± 14.55	46.67± 9.29	35.00± 2.89	50.00± 10.01	53.33± 6.67**bc**	11.67± 1.67	00± 00	8.33± 3.67	68.33± 24.58**b**	.32 ± 0.01 **b**	6.50
	LT_4	Larvae of *C. transversalis* (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	223.33± 29.67	46.67± 3.34	61.67± 19.24	60.00± 00	46.67± 6.67**bc**	55.00± 12.60	70.00± 2.89	75.00± 2.89	83.33± 8.83**b**	.28 ± 0.01 **c**	5.69
	LT_5	Kerosinized ash (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	116.67± 16.69	60.00± 20.23	43.33± 4.41	53.33± 13.66	73.33± 1.67**b**	61.67± 15.91	53.33± 8.83	36.77± 1.67	70.00± 15.29**b**	.25 ± 0.01 **d**	5.08
	LT_6	Control, Spray water only (First round and second round).	233.33± 44.15	60.00± 11.56	91.67± 36.37	140.00 ± 5.78	140.00 ±30.59 **a**	126.67 ±37.16	103.33 ±3.34	90.00± 5.78	156.67 ±21.89 **a**	.18± 00 **e**	3.66
							P=.000 F=11.811				P=.000 F=11.977	P=.000 F=62.451	

- All figures are mean of three replications.
- Block size 1.5 × 1 meters
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatment.

Table 28. Effect of insecticide, botanical, natural enemies and kerosinized ash on the population of mustard aphid, *Lipaphis erysimi* (Kalt.) after two treatments and yield of mustard in plot F (Var. BARI Sharisha-7).

Plot/Field based on sowing date	Tr. block	Treatments	Mean number of aphids with standard error(S.E.)/plant									yield (kg/block) Mean ± S.E.	Average yield q/ hectare
			Pre treatment DBT	First round treatment (18.01.2006)				Second round treatment (08.02.2006)					
				I DAT	III DAT	VII DAT	XX DAT	I DAT	III DAT	VII DAT	2XX DAT		
F 16.11.2005 (Late sowing)	LT_1	Classic 20 EC @ 2ml/L water (First round and second round)	60.00± 11.56	11.67± 1.67	15.00± 2.89	16.67± 6.67	33.33± 3.34**b**	6.00± 2.31	3.33± 2.41	6.67± 2.41	9.33± 0.67**c**	.34± 0.01 **a**	6.91
	LT_2	Classic 20 EC@ 2ml/L water (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	76.67± 8.83	11.67± 1.67	13.33± 1.67	16.67± 4.41	33.33± 3.34**b**	5.33 ± 1.77	7.33± 2.67	6.33± 2.19	10.00 ± 0.00**c**	.34± 0.01 **a**	6.91
	LT_3	Larvae of *C. transversalis* (First round and Second round)	85.00± 8.67	16.67± 4.41	21.66± 4.41	36.67± 3.33	43.33± 18.58**b**	36.67± 13.35	20.00± 0.00	20.00± 0.00	25.00± 2.9**bc**	.30 ± 0.01 **b**	6.1
	LT_4	Larvae of *C. transversalis* (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	130.00± 5.78	30.00± 5.78	33.33± 3.34	45.00± 7.65	26.67± 3.34**b**	11.67± 1.67	15.00± 2.89	14.33± 3.48	13.33± 1.67**c**	.27 ± 0.01 **c**	5.49
	LT_5	Kerosinized ash (First round) and Dhutura leaf extract @ 1:10 W/V (Second round)	146.67± 27.32	43.33± 8.83	33.33± 3.34	51.67± 4.41	48.33± 11.68**b**	25.00± 5.01	15.00± 5.00	13.33± 3.34	31.67± 10.15**b**	.24± 0.01 **c**	4.88
	LT_6	Control, Spray water only (First round and second round).	136.67± 18.58	110.00 ±20.84	153.33 ±3.34	133.33 ±16.69	86.67± 6.67**a**	61.67± 2.27	78.33± 9.29	78.33± 4.41	106.67 ±6.67 **a**	.15±0.01 **d**	3.5
							P=.010 F=5.068				P=.000 F=52.661	P=. 000 F=49.441	

- All figures are mean of three replications.
- Size of each experimental block 1.5 × 1 meters
- DBT – Day before treatment.
- Means having the same letter (s) in a column are not significantly different at 0.05 probability level by DMRT.
- DAT –Days after treatmen

Table 29. Yield (Mean ±S.E.) of mustard (kg/block)in terms of date of sowing ,variety and treatments.

Date of sowing	Crop variety	Treatments					
		T_1	T_2	T_3	T_4	T_5	T_6
Early sowing 16.10.2005	BARISharisha -6	.48±0.01**a**	.44 ±0.01**a**	.42±0.00**a**	.36±0.00**ab**	. 32±o.o1**a**	..20±0.01**a**
	BARISharisha -7	.45±0.03**a**	.42±0.02**ab**	.39±0.00**ab**	.33± 0.02**bc**	.26±0.00**bc**	.16±0.00**b**
Mid sowing 01.11.2005	BARI Sharisha-6	.41±0.01**b**	.39±0.01**bc**	.37± 0.01**b**	.38±0.01**a**	.32±0.01**a**	.19±0.01**a**
	BARISharisha -7	.39±0.01**bc**	.37±0.01**cd**	.33±0.01**c**	.31±0.01**cd**	.29±0.01**ab**	.18±0.01**ab**
Late sowing 16.11.2005	BARI Sharisha-6	.35±0.01**cd**	.34±0.01**d**	.32±0.01**c**	.28±0.01**dc**	.25±0.01**bc**	.18±0.00**ab**
	BARISharisha -7	.34±0.01**d**	.34±0.01**d**	.30±0.01**c**	..27±0.01**e**	24±0.01**c**	.15±0.01**b**
		P=.000 F=16.74	P=.000 F=11.98	P=.000 F= 12.84	P=.000 F=14.584	P=.001 F=8.178	P=.018 F=4.292

- All figures are mean of three replications
- Means having the same letters in a column are not significantly different at P<0.05;P<0.01and P<0.001 probability level by DMRT
- Detailed description of treatments(T_1-T_6) were already mentioned in Table(23-28)

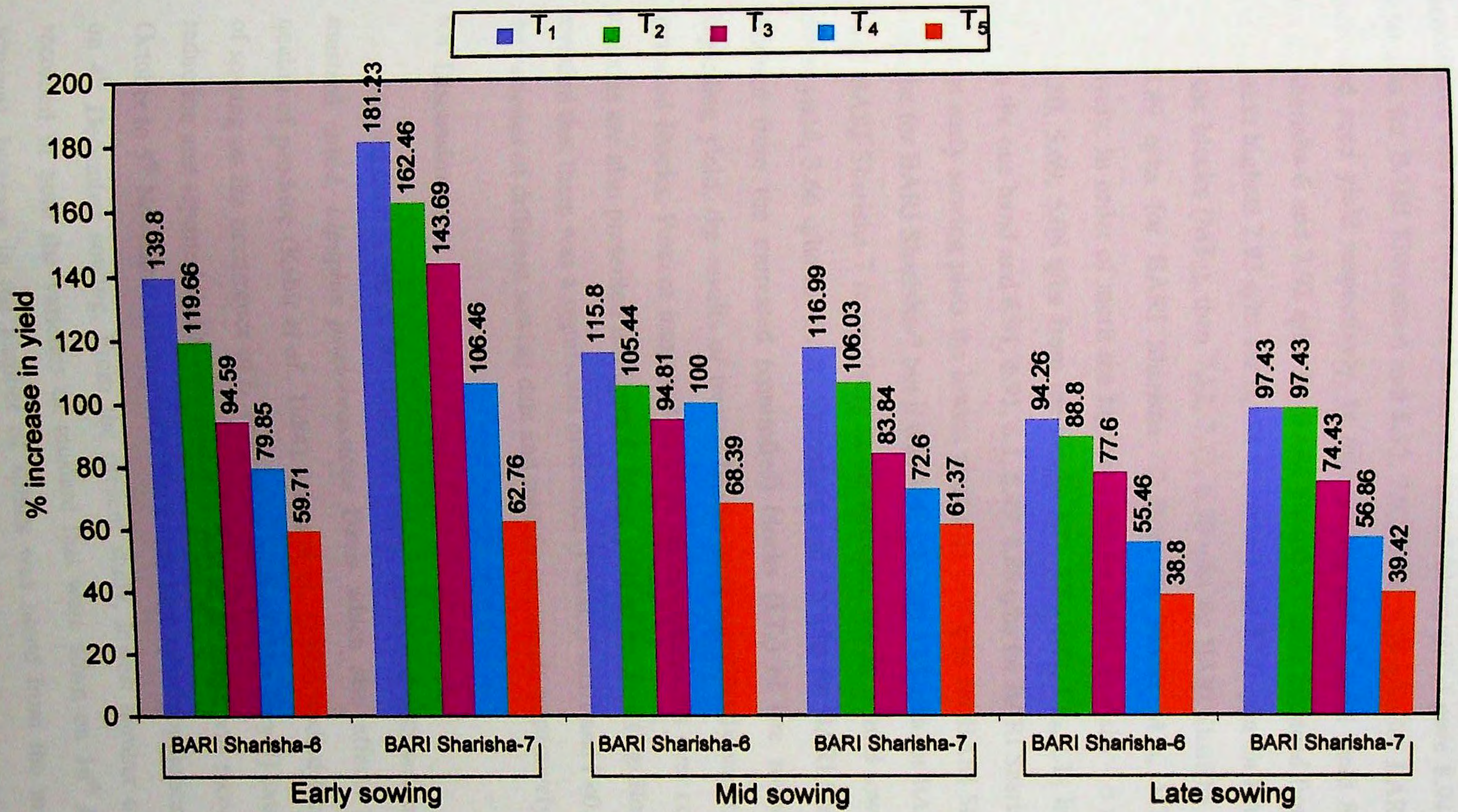


Figure 8: Percent increase in yield over control (T_6) in various treatments for BARI Sharisha-6 and BARI Sharisha-7.

time natural enemies plus one time botanical treated block (ET_4), one time kenosinized ash plus one time botanical treated block (ET_5) gave 8.94, 7.92, 7.32, 6,50 q/ha for BARI Sharisha-6 and 8.53, 7.92, 6.71, 5.29 q/ha for BARI Sharisha-7 increased seed yield respectively. In mid sowing plot, highest yield 8.33 q/ha for BARI Sharisha-6 and 7.92 q/ha for BARI Sharisha-7 were obtained from the blocks (MT_1), next highest 7.93 q/ha for BARI Sharisha-6 and 7.52, q/ha for BARI Sharisha-7 from the blocks (MT_2), then 7.52, 7.72, 6.50 q/ha for BARI Sharisha –6 and 6.71, 6.30, 6.89 q/ha for BARI Sharisha –7 from the blocks MT_3, MT_4 and MT_5 respectively. In order of merit the highest yield for BARI Sharisha – 6 were as 7.11, 6.91, 6.50, 5.69, 5.08 q/ha from the blocks LT_1, LT_2, LT_3, LT_4, LT_5 in late sowing plots on the one hand and 6.91, 6.91, 6.1, 5.49, 4.88 q/ha for BARI Sharisha –7 on the other. In early sowing plots the lowest yield was 4.07 q/ha for BARI Sharisha-6 and 3.25 q/ha for BARI Sharisha-7 but it was 3.86 q/ha and 3.65 q/ha for BARI Sharisha - 6 and BARI Sharisha-7 respectively in the untreated blocks of mid sowing plot. The lowest yield, 3.66 q/ha for BARI Sharisha-6 and 3.5 q/ha for BARI Sharisha-7 were obtained from the untreated (controlled) blocks (LT_6) of late sowing plot also. Regarding yield, the results of treated blocks were significantly superior above the untreated blocks. Percent increased yield in various treatments over control of both varieties are also presented in Figure 8. Mean yield of mustard (Kg/Block)(Table 29) revealed that there was a significant difference ($P<0.05$;$P<0.01$ and $P<0.001$) between the varieties of different sowing date and specific treatments respectively.

6.4. Discussion

Sowing time is one of the important factors associated with serious incidence of mustard aphid, *Lipaphis psudobrassicae* Davis which also affects the yield and quality of produce (Kabir *et al.*, 1984). Islam *et al.*, (1991) studied the effect of date of sowing on the occurrence of *L. erysimi* on mustard (Var.Tory 7) extent of its yield reduction and reported that a very minimum and or no aphid was recorded from 15th October to 5th November sowing time. But a very high aphid population was recorded on 4th December sowing. From the present study, lowest number of aphids were recorded in both the varieties of mustard that were sown on 16th October (early sowing). Increase in the number of aphids was noted from the mid sowing (1st

November) plots and the then highest aphid infestation was found in the crop sown on 16th November (Late sowing plots). So the results of the present study are in good agreement with the findings of Islam *et al.,* (1991) in spite of varietal difference. Miani (1985) and Bhattacharjee (1961) who strongly suggested that early sowing would be very effective to escape aphid infestation in mustard. Significant decrease in the seed yield of mustard was observed with successive delay in sowing from 08 October to 18 December at 10 days interval during all three years of study (1995-96, 1996-97 and 1997-98) even under protected condition (Patel *et al.,* 2004).On the mean basis sowing on 08 November produced seed yield of 1409 kg/ha that was 40.2, 63.4, 76.6 and 85.9 per cent higher than the seed yield sowing on 18 and 28 November and 08 and 18 December respectively.

Generally time of sowing varies with the climate of a region and the variety used. Reports regarding the effect of sowing time on the incidence of aphids of mustard and rape seed in Bangladesh is not adequate. Effect of four seeding dates (25th October, 4th November, 14th November and 24th November) on the aphid (*Lipaphis pseudobrassicae* Davis) infestation and seed yield of mustard (local Var. Rai 5) and rapeseed (BARI Var. SS-75 and Local Var. LS-14) showed that sowing on October and early November gave highest yield and low aphid infestation while sowing on mid and late November gave lowest yield and highest aphid infestation (Rahman *et al.,* 1989). High seed yield obtained in earlier sowing dates suggests that early sown crop escaped severity of aphid on slaught at its crucial period of flowering, since peak infestation is reached by the time flowering is over and most of the pods have been formed. With the delay in sowing date, growing stage and flowering period coincided with the peak infestation period (Sing *et al.*, 1984; Bhattacharjee, 1961). Few genotypes of *Brassica* cultivars *viz.*, Ys-Pb-24, Ys-B-9, Yss-8, BSH-1, BS-113, Pusa Kalyani, Sangam, RH-30 and Pusa bold that were sown on 10 days interval starting from 05 October continued till 15 November during 1978-79 and 1979-80 crop seasons manifested that delayed sowing exposed the crop to a high aphid infestation resulting in lower yield irrespective of varietal differences (Phadke and Prasad, 1987). From the experiment of Hussain and Shahjahan (1997) on susceptible check of ten *Brassica* varieties/ mutants against mustard aphid, it was found that Nap-3 was moderately susceptible; Tori-7,BS-5, Sangam highly susceptible; Sampad, Agrani, SS-75, Safal, BINA-2, and Ys-52 were less susceptible to aphid *L. erysimi*. In order to minimize the attack of *L. erysimi* infesting oil seed Brassica crops, Singh and Sharma (2002) emphasized the need based use of safer insecticides along with cultural, biological, behavioral and biotechnological approach. Islam *et al*., (1990) evaluated eight foliar insecticides *viz*., Marshal 20 EC (Carbosulfun), Pillacron 100 EC (Phosphamidon), Sumicidin 20 EC (Fenvalerate), Maladan 57 EC (Malathion), Polygor 40 EC (Dimethoate), Metasystox 25 EC (Oxydemeton methyl), Benicron 100 WSC (Phosphamidon) and Hekthion 57 EC (Malathion) against *L. erysimi*. Among the insecticidal treatments, Hekthion 57 EC (Malathion) treatment gave the highest yield of mustard (63.11%) above the untreated crop yield. Imidacloprid 200SL @ 0.25ml/l water; Azadirachtin 5F @ 1.0ml/l water and Fenpropathrin 30EC @ at four different dosage levels *viz*., 0.25 ml/l, 0.50 ml/l, 0.75 ml/l, and 1.0 ml/l were sprayed once in November-December 2003 and again in January-February, 2004 at Nadia, India against Mustard aphid (*L. erysimi*) and the highest reduction in aphid population was found in case of Fenpropathrin @ 1.0 ml/l water followed by Fenpropathrin @ 0.75 ml/l of water. Regarding seed yield, highest production (10.45 q/ha) was achieved from the treatment @ 1.0 ml/l and second highest (10.02 q/ha) from @ 0.75 ml/l of water respectively (Sahu *et al*., 2006). Singh (2006) recorded the highest grain yield of mustard 8.85 q/ha in IPM field whereas it was 7.05 q/ha in farmers traditional field. The cost benefit analysis revealed that farmer's practices resulted cost benefit ratio of 1:7.34 whereas it was 1:18.32 in IPM adopted field. From the results of present investigation it was also observed that between the two varieties aphid infestation index was relatively more on BARI Sharish-6 than on BARI Sharisha-7. Besides, differences in yield were found to be very significant among the treatments of each plot. Thus it could be concluded that irrespective of varietal difference, mustard should be sown within mid October and treated with judicious use of pesticide in order to get maximum seed yield as well as higher environmental safety.

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APPENDICES

Plate-I. Experimental tubs with bean plants.

Plate-II. Infested twigs of bean plant by *Aphis craccivora* Koch.

Plate-III. Infested immature bean pod by *Aphis craccivora* Koch.

Plate-IV. Colony of *Aphis craccivora* Koch on bean pod.

Plate-V. Apterous morph of *Aphis craccivora* Koch.

Plate-VI. Alatae morph of *Aphis craccivora* Koch.

Plate-VII. Treatment materials including Manseok sprayer.

Plate-VIII. Spraying insecticide on a block by Manseok sprayer.

Plate-IX. Treated bean plants with insecticide.

Plate-X. Untreated bean plants (controlled).

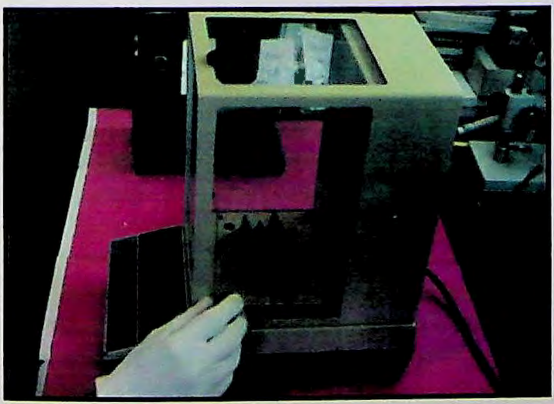

Plate-XI. Weighing of bean by electronic balance.

Plate-XII. Bean plants on scaffold.

Plate-XIII. Early sown brinjal plant (Var.Kazla).

Plate-XIV. Mid sown brinjal plant (Var. Nayantara).

Plate-XV. Late sown brinjal plant (Var. Kazla).

Plate-XVI. Plants with Kajla brinjal.

Plate-XVII. Adult of *Scymnus coccivora* Ayyar preying on *Aphis craccivora* Koch.

Plate-XVIII. Early sown mustard field (Var.BARI-Sharisha 6).

Plate-XIX. Early sown mustard field (Var.BARI-Sharisha 7).

Plate-XX. Dried leaves of Tobacco, Dhutura and Bankalmi.

Plate-XXI. Infested twig of mustard (BARI Sharisha-7).

Plate-XXII. Infested twig of mustard (BARI Sharisha-6).

Plate-XXIII. Adult of *Coccinella transversalis* (Fabr.).

Plate-XXIV. Mating of *Coccinella transversalis* (Fabr.).

Plate-XXV. Egg mass of *Coccinella transversalis* (Fabr.).

Plate-XXVI. Larva of *Coccinella transversalis* (Fabr.).

Plate-XXVII. Pupae of *Coccinella transversalis* (Fabr.).

Plate-XXVIII. An infested mustard twig was cased by a plastic container for functional response study.

Plate -XXIX. Larva of *Micraspis discolar* (Fabr.).

Plate-XXX. *Micraspis discolar* (Fabr.) on bean plant.

Plate-XXXI. Parasioid, *Tryoxys (Binodoxys) indicus* (SubaRao and Sharma).

Plate-XXXII. Searching behavior of *Tryoxys (Binodoxys) indicus.*

Plate-XXXIII. *Tryoxys (Binodoxys) indicus* ovipositing on aphid.

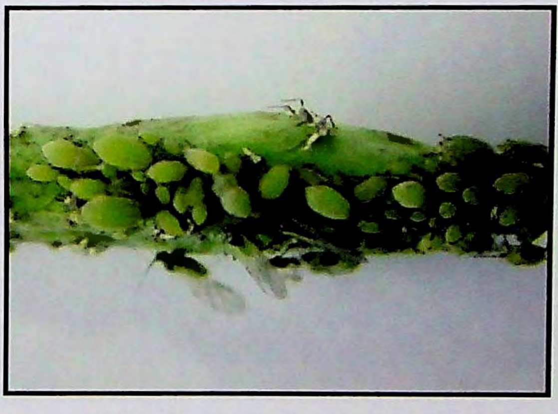

Plate-XXXIV. An infested mustard pod (Var.BARI Sharisha-6) by *Lipaphis erysimi*(Kalt.).

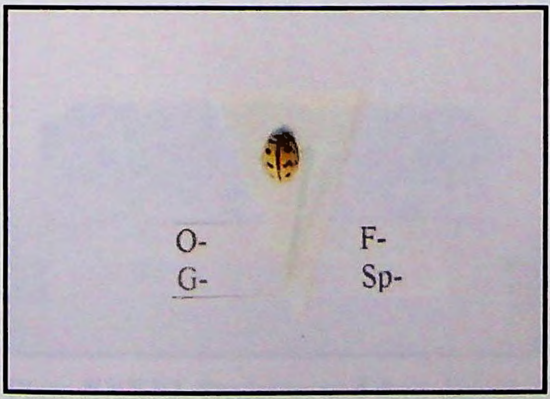

Plate-XXXV. *Cheilomenes sexmaculata* (Fabr.).

Plate-XXXVI. *Coccinella septempunctata* L.

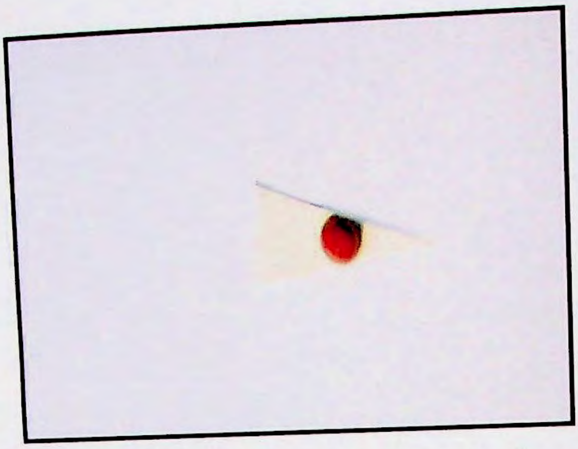

Plate-XXXVII. *Micraspis yasumatsui* Sasajii.

Plate-XXXVIII. *Ischiodon scutellaris* (Fabr.)

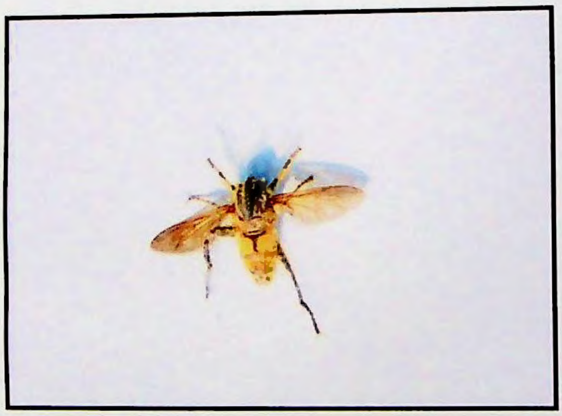

Plate-XXXIX. *Syrphus confracter* Wiedemann.

Plate-XXXX. Larva of *Syrphus confracter* on bean aphid colony.

Plate-XXXXI. Predators and their larvae rearing container.

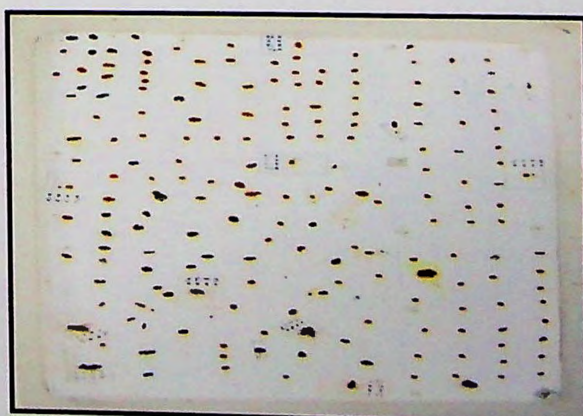

Plate-XXXXII. Insect preservation box.