EFFECT OF POLYCULTURE ON THE MANAGEMENT OF BRINJAL PESTS AND ARTHROPOD DIVERSITY

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This is to certify that the thesis entitled, "Effect of polyculture on the management of brinjal pests and arthropod diversity" submitted to the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE in ENTOMOLOGY****, embodies the result of a piece of bonafide research work carried out by* ***MD.ABDUR RAZZAK*** *Registration No. 27531/00706 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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EFFECT OF POLYCULTURE ON THE MANAGEMENT OF BRINJAL PESTS AND ARTHROPOD DIVERSITY

By

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THESIS ABSTRACT

A field experiment was carried out at the Farm of Sher-e-Bangla Agricultural University, Shere Bangla Nagar, Dhaka during November 2006 to May 2007 to evaluate the effect of polyculture on brinjal pest management and arthropod diversity. Polyculture combinations were brinjal + coriander, brinjal + fenugreek, brinjal + chili, brinjal + radhuni. Monoculture of each component crop was also grown to compare the effectiveness of polyculture system. The experiment was laid out in Randomize Complete Block Design (RCBD) with three replications. The results revealed that polyculture had a lower pest population with more abundance of natural enemies as compared to monoculture. The maximum percent reduction of fruit infestation of brinjal by brinjal shoot and fruit borer in weight over sole brinjal was found in brinjal + coriander (40.23%) followed by brinjal + radhuni (37.06%) combination. Polyculture also showed comparatively greater diversity and higher equitability of arthropod community with the highest diversity index (7.20) and highest equitability (0.70) in brinjal + coriander system. All the polyculture combinations showed higher biological efficiency than monoculture where brinjal + fenugreek provided the highest economic return (TK-316320 ha^{-1}).

INTRODUCTION

Vegetables are the main source of vitamins and minerals that are essential for maintaining sound health of people. Though Bangladesh is an agro based country it has a serious shortage in vegetables. Nutrition council of Bangladesh recommended vegetable in take at least 235 g/day/person for Bangladeshi adult but the availability is only 65.5 g/day/person. The annual production is only 4.31 million tons including potato but we need around 11.5 million tons (Anonymous 2002). For this reason malnutrition is acute in Bangladesh. Around 88% are suffering from vitamin A deficiency, 90% from vitamin B, 87% from vitamin C, 93% calcium and 70% from iron deficiency (Anonymous 2002). Increased production and consumption of vegetables could alleviate malnutrition and improve nutritional standard of our people.

Brinjal (*Solanum melongena* L.) is one of the most popular and prime vegetable crops grown in Bangladesh and other parts of the world. It is the second most important vegetable crops after potato in terms of production and consumption. Bangladesh produced 3.92 lakh tons of brinjal which was approximately 28.8% of the total vegetables production of the country during 2000-2001 (Anonymous, 2002).

The major constraint of Brinjal production is that the crop is attacked by about 53 species of insect pests (Nayer *et al.* 1995). Among them, brinjal shoot and fruit borer (BFSB), *Leucinodes orbonalis* (Guenee) is the most destructive pest of brinjal in Bangladesh (Chattopadhyay 1987, Alam 1969) and India (Tewari and Sandana 1990) and also a major pest in other countries of the world (Dhanker 1988). Farmers usually spray chemical pesticides many times during the crop season to control the insect pests. This lead to environmental pollution and residual problems with consequent increase in health hazard to the growers and consumers. Moreover, it also leads to the development of resistance to target pests (David and Kumaraswami 1989) with also a negative impact on natural enemies (Tewari and Moorthy 1985) and other beneficial organism and causes disruption of biodiversity. Greater concern of the environment and growing awareness of the importance of the complex interrelationship of the organism within the ecosystem have lead to the realization that few pests could be eradicated totally without measure by natural control. The growing awareness of the shortcoming of chemical insecticides has necessitated with the exploration for alternative method of pest control, which is relatively safe from adverse side effects.

Among the various alternatives, the exploration of host plant resistance is perhaps the most effective, convenient, economical and environmentally acceptable method of insect control (Dhaliwal and Dilawari 1993). At present, effective control techniques other than insecticide application against insect pests in brinjal through agronomic manipulation may be considered as one of the possible alternate options.

An agronomic practice like polyculture or intercropping of diverse growth habit has been found as a very useful technique in controlling a large number of crop pests. Polyculture supports a lower herbivore load than monoculture. One factor explaining this trend is that relatively more stable population of natural enemies can persist in intercropping due to the continuous availability of food sources and microhabitats. The other possibility is that specialized herbivores are more likely to find and remain on pure crop stands provide concentrated resources and monotonous physical conditions (Altieri 1995, Altieri and Letourneau 1984).

Agricultural polycultures with combination in time and space involve varying degrees of niche differentiation and serious competition. Polyculture and mixed cropping offer an excellent opportunity of ecological maneuvering by bringing about changes in crop geometry and cropping system, which may have economically relevant impact on pest damage. There is a general agreement that species diversity in multiple cropping reduces the most insect pest problems almost insect are host specific. The cropping intensity of carefully designed multiple species mixture can successfully expose weed competition. In intercropping, two or more plant species in the field may disrupt the host plant finding behavior of insects. Intercropping can affect the microclimate of the agro-ecosystem, which ultimately produce an unfavorable environment for pest (Singh and Singh 1987). The olfactory stimulus offered by the main crop could be camouflaged by various intercrops (Aiyer 1949). Many photophillic pests avoid short crops when they are shaded by taller crops. The presence of non-host plant between two rows of a host plant may be another factor influencing pest incidence in intercropping system. Perrin and Philips (1979) outlined these effects of intercropping in relation to initial colonization of crops, feeding, reproduction, mortality and dispersal of pest within the crops. The species diversity of population level of natural enemies may be influenced by the complex environment of intercrop (Prince and Waldbauer 1975, Coaker 1981)

Any advantage from polycultures compared with monocultures depend on achieving a relative yield total (RYT)>1. It is most likely where soil resources are limiting and rooting habits differ, or one of the species is a legume (Vandermeer 1989). Considerable attention has also been given to whether RYT>1 can result through less disease or insect problems occur in monocultures. Within polyculture it is also possible that one plant species may serve as a trap for insects, reducing infestation of the other or that it may serve as breeding place for predators. In general, the greater number of hosts in the intercropping generally also means a greater diversity of pest and disease. Other advantages of intercropping are more efficient use of field and spreading of the risk of monocrop failure.

Under the above perspective, Polyculture has been thought to be an environment-friendly option for the management of insect pests. However very little attention has been given in this area in Bangladesh. Therefore the present study was undertaken with the following objectives:

1. to find out the effect of polyculture on the incidence of insect pests and natural enemies in brinjal specially in relation to brinjal shoot and fruit borer management.
2. to determine the diversity index and equitability (i.e., distribution) of arthropod community in a diversified agro ecosystem and
3. to observe the productivity and economies of polyculture system.

REVIEW OF LITERATURE

A number of studies polyculture or intercropping or mixed cropping and their relationship with pest management have been done and reported elsewhere in the world. However, studies in this area appeared very limited in Bangladesh. For a better understanding and to know the research status on impact of polyculture on insect pest management, the relevant available literature have been reviewed and presented below.

Relevant hypothesis

Polyculture (i.e., growing more than one crop simultaneously in the same area) is one way of increasing vegetational diversity. According to Van Emden (1965), polycultures are ecologically complex because interspecific and intraspecific plant competition occurs simultaneously herbivores, insect predators, and insect parasitoids. Southwood (1975) stated that elimination of alternate habitats might lead to decrease predator parasitoid populations and increased insect pest populations.

Risch *et al.* (1983) reported that population density of herbivorous insects are frequently lower in polyculture habitats Two hypotheses have been proposed to explain this phenomenon: (1) the associational resistance or resource concentration hypothesis (Roots1973) which propose that the specialist herbivores are generally less abundant in vegetationally diverse habitat because their food sources are less concentrated and natural enemies are more abundant. (2) The natural enemies hypothesis (Russell, 1989) which states that a diversity of plant species may provide important resources for natural enemies such as alternate prey , nectar and pollen or breeding sites.

Aiyer (1949) formulated a three part hypothesis to wit ; (1) host plants are more widely spread in intercrops, meaning they are harder to find, (2) the species serves as a trap crop to detour the pest from finding the other crop, and (3) one species serves as a repellent to the past.

According to Baliddwa (1985), a specialist insect is less likely to find its hosts in diverse plant communities because of the presence of confusing or masking chemical stimuli, physical barriers to movement, and other adverse environmental factors. Consequently, insect survival may be lower.

Altieri (1994) stated that a key strategy in sustainable agriculture is to restore functional biodiversity of the agricultural landscape. Most studies of the effects of biodiversity enhancement of insect populations have been conducted at the field level, rarely considering larger scales such as the landscape level. It is well known that spatial patterns of landscape level. It is well known that spatial patterns of landscape level. It is well known that spatial patterns of landscapes influence the biology of arthropods both directly and indirectly. One of the principal distinguishing characteristics of modern agricultural landscape is the large size and homogeneity of crop monocultures which fragment the natural landscape. This can directly affect the abundance and diversity of natural enemies as the larger the area under monoculture the lower the viability of given population. Diversity can be enhanced in time through crop rotations and sequence and in space in the form of cover crops, intercropping, agro forestry, crop/ livestock mixtures etc. Correct biodiversification results in pest regulation through restoration of natural control of insect pests, disease and nematodes and also produces optimal nutrient cycling and cycling and soil conservation and less dependence on external inputs.

Southwood and Way (1970) cited the type and abundance of biodiversity in agriculture will differ across agro ecosystems which differ in age, structure and management. In fact there is a great variability in basic ecological and agronomic patterns among the various dominant agro ecosystems depend on four characteristics of the agro ecosystem: 1) the diversity of vegetation within and around the agro ecosystem. (2) The permanence of the various crops within the agro ecosystem, (3) the intensity of management and (4) the extent of isolation of the agro ecosystem from natural vegetation.

Saxena (1972) stated that a proper combination of crop is important for the success of intercropping systems, when two crops are to be grown together.

It is imperative that the pick period of growth two crop species should be not coincided. Crops of varying maturity need to be chosen so that quick maturing crops complete its life cycle before the grand period of growth of the other crop starts. However, yield of both crops are reduced when grown as mixed or intercropped, compared with the crops when grown alone but in most cases combined yield per unit area from intercropping the higher.

The magnitude of yield advantage of intercropping system could be determined by the use of land equivalent ratio (LER) value (Ofori and Stern 1987). The concept of land equivalent ratio or relative yield total assumed to be an important method in evaluating the benefit of intercropping of two dissimilar crops grown on the same land (Fisher1997).

If LER is more than 1.00 then intercropping gives agronomic advantages over monoculture practice. The higher is the LER the more is the agronomic benefits of intercropping systems (Palaniappen, 1988). The land equivalent ratio is the most frequently used index to determine the effectiveness of intercropping relative to going crops separately (Willey, 1985)

Relationship between polyculture with insect pests and their natural enemies:

Experimental evidences

Insect pests

Letourneau (1986) examined the effect of crop mixtures on squash herbivore density in the topical low lands of Mexico. He found that *Diapahania hyalinata* (L.), the most abundant insect in the system, generally had lower population density in polyculture (maize + cowpea + squash) than in monoculture (squash alone) systems. The total crop yields in polyculture were higher when estimated as a land equivalent ratio.

Casagrande and Haynes (1976) pointed out an interesting potential for integration of plant resistance and polyculture practices. They compared damage by the cereal leaf beetle, *Oulema melanopus* L. in mixed and pure stands of resistant and susceptible wheat varieties. They reported that biological control was more effective in the mixed cropping of beetle- susceptible wheat varieties than in the mixed cropping of beetle-resistant and beetle-susceptible wheat varieties than in a pure stand of either one of those varieties on a region wide basis.

Among the variety of factors that might be involved in the facilitative production principle, the one most cited and perhaps the best documented is the reduction in pest attack frequently found in intercrops (Risch *et al.* 1983).Earlier reviews found in intercrops similar results (Perin 1977, Litsinger and Moody 1976, Dempster and Coaker 1974 and Nickel, 1973,) that pests tend to be reduced in intercrops, although not by any means always. While these reviews tend to concentrate on insects, there is also evidence that intercrops reduce nematode attack (Mc Beth and taylor 1944, Khan *et al.* 1971, Atwal and Mangar 1967, Castillo *et al.* 1976, Egunjobi 1984) and diseases (Moreno and Mora 1984 Rheeneu *et al.* 1981).

Francis *et al.*, (1978) found lower attack rats of *Spodoptera frugiperda* in maize + bean intercrop as compared to a maize monoculture. Van Huis (1981) working in Nicaragua found the same pattern with the same pests in the same cropping system.

In an elegant experiment, Bach (1981) reasoned that plant "quality" might be affected by intercropping to such an extent that the individuals host plant in intercrops might be less desirable to their pests than individuals in monoculture. He found that *Acalymma vittatum* preferred cucumber leaves taken from monoculture to those taken from cucumber plants intercropped with tomatoes.

Dash *et al.* (1981) observed the highest pod infestation (45.80%) by *helicoverpa armigera* in the monoculture of arhar (*cajanus cnaja*) while the pod damage was the lowest (34.46%) when *C. cajan* was intercropped with blackgram (*Vigna mungo*).

Ofuya (1991) found that when cowpea was intercropped with tomato, damaged caused by *Helicoverpa armigera* was reduced and grain filling was increased compared to monocropped cowpeas.

Prasad and chand (1989) reported that intercropping of chickpea (*Cicer arietinum*) with barley, mustard and wheat suppressed numbers of chickpea *Helicoverpa armigera* by 59, 56 and 47% respectively .They concluded that barley, mustard and wheat are compatible crops for the intercrop of *C. arietinum.* In case of severe infestation in one crop, the financial return from the other the other crop is ensured.

Pawer (1993) showed that short duration pigeon peas grown adjacent to and strip-intercropped with sorghum suffered less damage by *Helicoverpa armigera.*

Similarly, Patnaik *et al.*(1989) observed the severest attack by *Helicoverpa armigera* on sole cropped pigeon peas, followed by pigeon peas intercropped with groundnuts, mug beans (*Vigna radiata*), black gram (*Vigna mungo*) while it was the lowest in pigeon peas intercropped with finger millet.

Hossain *et al.* (1998) reported that the intercropping exhibited a significant effect on pod borer infestation in chickpea in case of mid and sowing dates. The dates of sowing irrespective of the intercropping displayed a significant effect on pod borer infestation with the early sowing contributing to the significant reduction of pod borer infestation. In case of late sowing, chickpea should be preferably intercropped with wheat to protect it against chickpea pod borer infestation ensuring higher yield.

Andow (1991) found that polycultures had lower pest populations than monocultures, and even then, it occurred intermittently. Severe competition from the other plants in the polyculture might limit the ability of the crop to compensate for pest injury and crop tolerance, or resistance to pest injury might otherwise limit yield losses in polycultures. In addition, the data suggested that pest injury is likely to exceed economic injury thresholds in polycultures than in monocultures. Again he claimed that absolute yield benefits on polyculture were higher than yields in monocultures.

Mahadevan and Chelliah (1986) reported that growing sorghum in association with cowpea (*Vigna unguiculata*) or lablab (*Lablab purpureus*) reduced the infestation of the sorghum by the pyralid *Chilo partellus* in Tamil Nadu, India. On sorghum as a pure crop, 32.6% damage was recorded, as compared with lablab or cowpea, respectively. The corresponding yields were 3609, 4652 and 4567 kg grain/ha, respectively.

Raymundo and Aclcazar (1983) claimed that potato plants grown in association with tomato, onion, maize, soybean or bean (*Phaseolus*) had significantly less tuber damage from *Phthorimaea operculella* (Zell.) than for potato alone.

Sharma and Pandey (1993) carried out field studies in Navgaon, Rjasthan, India during 1984-86. The early maturing pigeon pea cv. UPAS-120 and the medium maturing cv. BDN-1 were intercropped with black gram (*Vigna mungo*), green gram (*V. Radiata*), pearl millet and sorghum and the infestation by Exelastis *atomosa* and *Melanagromyza obtusa* was compared with that of pigeon peas grown as a sole crop. They found no marked effect of intercropping on pest incidence. In the sole crop, insect infestation ranged between 42.5 to 52.66% inUPAS-120 and between 57.0 to 62.16% in BDN-1.

Lal (1991) reported that larval infestations of *Phathorimaea operculella* on potatoes were consistently reduced when potatoes were grown with chilies (*Capsicum*), onions and peas compared to potato alone. Similarly, tuber damage was significantly lower in plots associated with *Capsicum*, onions and peas (11, 11 and 13%, respectively) compared to 20% in potato alone.

Manisegaran *et al.* (2001) found that incidence of shoot Webber was significantly lower in sesame intercropped with pearl millet 4:1 (11.2%), pearl millet 6:1 (12.2%), black gram 4:1 (12.5%) and green gram (13.3%) compared with the sole sesame crop (24.9%). In general, the incidence of shoot webber was reduced in sesame when it was intercropped, although incidence increased in the groundnut intercropping system. Sesame yield was the highest as a sole crop (634 kg/ha) followed by intercropping with pearl millet (553-556 kg/ha).

Sardana (2001) observed a significantly lower incidence of root borer, *Emmalocera depressela* in sugarcane when intercropped with black gram compared to the sugarcane monocrop.

Natural enemies

Nampala *et al.* (1999) observed that abundance of coccinellidis and syrphid larvae were neither influenced by the cowpea genotype nor cropping systems. Contrastingly, the abundance of predatory *Orius sp.*, spiders and earwigs differed significantly among the cowpea pure stands and cowpea + green gram than in the cowpea + sorghum intercrops.

Andow and Risch (1985) observed that predaceous coccinellid beetles, *Coleomegilla maculate* (Dey.) and its prey (aphids) were more abundant on sole crops than on mixed maize and beans.

In Kenya, Kyamanywa *et al.*, (1993) evaluated the influence of cowpea + maize intercropping on generalist predators and population density of flower thrips, *Megalurothrips sjostedti* Tryborm. Interestingly, abundance of the *orius sp.*, ladybird beetles, earwigs and spiders were not enhanced by planting cowpea as a mixed crop with maize. In contrast, Ogenga-Latigo *et al.*, (1993) found *Aphis fabae* and coccinellid beetles at higher densities on sole crop *Phaseolus* beans than in a mixture with maize. Hansen (1983) clearly demonstrated the increased abundance of several predator species in an intercrop system of maize and cowpea in southern Mexico, suggesting an explanation for the over yielding of that system as reported by Vandermeer *et al.* (1983).

Gavarra and Raros (1975) reported spiders to be more effective against corn borers in an intercrop of corn and groundnuts than in monoculture of corn.

Alteiri *et al.* (1977), Smith (1969) and Speight and Lawton (1976) reported a higher abundance of predators in a weedy crop than in a comparable monoculture.

Perfecto *et al.* (1986) demonstrated that carabid beetles immigrated more rapidly from patches of monocultures of tomatoes and beans from intercrops of the two.

Srikanth *et al.*, (2000) examined that the incidence of shoot borer,*Chilo infuscatellus* Snellen (Lepidoptera: Crambidae) did not differ significantly when sugarcane intercropped with black gram, cowpea, green gram and soybean. The incidence of top borer *Scircophage excerptalis* Wlk.(Lepidoptera: pyralidae) was negligible in all combinations. Counts of predators, comprising spiders and coccinellidis, showed marginal differences. In another experiment, they also claimed that mean predator numbers did not differ significantly between intercrop and monocrop.

Mote *et al.* (2001) found that the population of sucking pests of cotton was minimum when insecticides sprays were imposed on main crop only. Intercropping of cowpea as well as green gram in cotton proved to be better in suppressing the population of sucking pests. The incidence of bollworm complex in fruiting bodies was the lowest in plots in which insecticides were applied but was the highest in untreated crop showed maximum number of predators followed by sprays on intercrop only, however, cowpea intercrop system showed maximum number. Spraying of insecticide on cotton only produced a higher yield. Cotton + green gram produced the same yield of karpas as sole cotton.

Turkar *et al.* (2000) studied the effects of intercropping of chickpea (gram) with coriander. They recorded significantly higher parasitic activity (5.7 cocoons per 5m row length), lower pest activity (2.33 larvae per 5m row length), minimum pod damage (12.7%) and higher grain yield chickpea (15.5 q/ha) in plots sown with coriander within the rows of gram as compared to the chickpea sole crop.

Polyculture and crop yield

Rathore *et al.* (1980) conducted intercropping experiment of maize with pulses and found maize + black gram combination to produce the highest grain yield.

Khehra *et al.* (1979) in an experiment found that black gram consistently gave higher yield when intercropped with maize, although the black gram as intercrop depressed the maize yield.

Study of Krishna and Raikhelkar (1997) in maize-legumes intercropping systems found that maize + blackgram (3.8 t ha -1), maize + green gram (3.6 t ha-1) and maize + pigeon pea (3.53 t ha-1) gave significantly higher seed yield than other systems. Considering maize equivalent yield, maize + pigeon pea (4.88 t ha-1) and maize + blackgram (4.66 t ha-1) gave significantly higher equivalent yield than the other intercropping systems.

Using LER as a criterion, Bhuiyan (1981) examined mixed crop combinations of lentil, gram and soybean with wheat under different properties and recorded the highest LER (1.47) in gram and wheat at 100:75 seeding ratio followed by lentil and wheat at 100:75, 100:25 seeding ratios with LER values 1.37, 1.23 and 1.15, respectively.

From the review of literature, it was observed that different polyculture systems had lower insect pest infestation and higher abundance of natural enemies. Polyculture systems have proven to show greater productivity and higher economic return than monocropping system. It can also reduce the dependency on chemical insecticides and ensure a greater environmental protection. As polyculture has a great scope in managing insect pests, it is therefore necessary to speculate the lower incidence of insect pests, abundance of natural enemies, and productivity and economics of polyculture systems.

MATERIALS AND METHODS

Location of the experimental field

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka situated at latitude 23.46 N and longitude 90.23E with an elevation of 8.45 meter the sea level. Laboratory studies were done in the laboratory of Entomology department, SAU. Required materials and methodology are described below under the following sub heading.

Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month of May to September and scattered rainfall during the rest of the year.

Soil of the experimental field

Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5, CEC-25.28.

Land preparation

The soil was well prepared and good tilth was ensured for commercial crop production. The target land was divided into 27 equal plots (3m×2m) with plot to plot distance of 1.0 m and block to block distance is 1.0 m. The land of the experimental field was ploughed with a power tiller. Later on the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was ready. The field layout and design of the experiment were followed immediately after land preparation.

Manuring and fertilization

Recommended fertilizers were applied at the rate of 500 kg urea, 400kg triple super phosphate (TSP) and 20kg muriate of potash (MP) per hectare (Rashid, 1993) were used as source of nitrogen, phosphorus and potassium, respectively. Moreover, well-decomposed cow dung (CD) was also applied at the rate of 10 ton/ha to the field at the time of land preparation. The N at the rate of 160 kg ha^{-1} in the form of urea was applied in 4 equal splits at 20 days after transplanting (DAT), 50 DAT, at flower bud emergence and after 1st harvest of brinjal fruits.

Design of experiment and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The whole area of experimental field (Pate1) was divided into 3 blocks and each block was again divided into 9 unit plots. The size of the unit plot was (3m×2m). The block to block and plot-to-plot distance was 1.0 m and 1.0 m respectively. Row to row distance for brinjal (*Solanum melongena* L*)*, Chili (Capsicum frutescence), Coriander (*Coriandrum sativum*) Fenugreek (*Trigonella foenum-graecum*), radhuni (*Carum roxburgianum*) was 1m, 40cm, 30cm, 30cm, 30cm respectively and plant to plant distance within a row of brinjal, chilli was 60cm and 30cm. Coriander, fenugreek and radhuni were sown in a row continuously. In case of intercropping seedlings of chili, seeds of coriander, fenugreek and radhuni were planted in an alternate row arrangement (Plate2 – Plate4).

Treatments of the experiment:

The experiment was conducted with following treatments:

T1 – Brinjal + Coriander

T2 – Brinjal + Fenugreek

T3 – Brinjal + Chili

T4 – Brinjal + Radhuni

T5 – Sole Fenugreek

T6 – Sole Chili

T7 – Sole Radhuni

T8 – Sole Coriander

T9 – Sole Brinjal

Plate 1: Experimental field at a glance

Plate 2: Experimental field (Brinjal with coriander combination)

Plate 3: Experimental field (Brinjal with radhuni combination)

Plate 4: Experimental field (Brinjal with fenugreek combination)

Collection of seed, seedling and transplanting

The brinjal seedlings (var. Singnath), chili seedlings , coriander were collected from Horticulture Division of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and fenugreek, radhuni were from Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur. Brinjal seedlings were transplanted in sole and in intercropping on 21st November 2007, coriander, fenugreek, radhuni on 15th December 2007 and chili on 20th January 2007. After establishment of brinjal, the intercrops were sown/transplanted in between the brinjal lines

Cultural practices

After transplanting, a light irrigation was given on 21st November 2006. Subsequent irrigation was applied in all the plots as and when needed throughout the whole growing season in all the crop combination. Damaged seedlings were replaced immediately by new ones in the experimental field. Weeding and mulching in the plot were done, whenever necessary.

Data collection and calculation

Brinjal pests and associated natural enemies

After incidence of brinjal shoot and fruit borer, 8 plants were randomly selected in each sole and polyculture combination of brinjal for observing the number of infested shoot which was started from 22nd January 2007 and continued every 10 days interval until 14th March 2007. From each harvest, data on the number of infested fruits by brinjal shoot and fruit borer was recorded per plot per treatment (8 plants) started from 15th

March 2007 and continued at 7 days interval until 5th May 2007. Data were also collected from 10 leaves of brinjal from all treatments for recording the number of aphid, jassid and whitefly. Natural enemies were counted as well as at the same time.

Pests and associated natural enemies in coriander, fenugreek, chili and radhuni

10 plants of brinjal both from sole and polyculture combination were randomly selected for observing the pests and their natural enemies.

Harvesting and yield of the crops

Brinjal – Eight (8) were done throughout the fruiting season. Fruits were harvested at an interval of 7 days. At each harvest, data on the number of healthy and infested fruits and their weight were recorded separately per plot. The cumulative healthy, infested fruit and total fruit yield per plot was calculated.

Coriander, radhuni and fenugreek –

Coriander, radhuni and fenugreek were harvested after 130, 125, and 135 days respectively. The harvested coriander, radhuni and fenugreek were threshed manually and seeds are separated, clean and dried in bright sunshine. The dry seed yield thus obtained was converted into per hectare yield.

Chili – Four harvests were done during the fruiting season. In each harvest, fruits were weighted separately for each plot. The cumulative fruit yield thus obtained was converted into per hectare yield.

Diversity of arthropod community

The simplest measure of counting the number of species is species diversity. The concept was extended to order family level. It was performed by two relative methods viz., pit fall trap and sweeping net method.

Pitfall trap method

This method was used for the species that roam in the soil surface such as ground beetles, spiders, collembolan etc. Small aluminum pots having 6 cm diameter and 8 cm deep were used as pitfall traps (Plate5) each which was field with water. Three pots were placed in soil in each plot at early, mid and late stage of crops to trap the insects. After 48 hours of setting traps, insects were collected from each plot/ treatment and kept separately.

On the basis of phenotypic similarity, trapped insects were then sorted and identified to family and order they belong to with the help of identified specimens kept with the museum of the department of Entomology, BSMRAU and other standard taxonomic keys. Data were recorded against each treatment.

Plate 5: Pit fall trap

Sweeping net method

This method was used for counting flying and stationary insects on host plants to know the abundance pattern of insects in the present study, five (5) times return sweeping was done in each plot to make a composite sample by a sweeping net al early, mid and late crop stages. Each sample was examined separately without killing the insects and released then immediately after counting in the same plot. The individuals of each sample were counted by family.

Measurement of diversity index

To assess both [he abundance pattern and the species richness,

Simpson's diversity index was used (After Simpson's, 1949).

$$\text{Simpson's Index, (D)} = \frac{1}{\sum_{i=1}^{S} P_i^2}$$

Where Pi is the proportion of individual for the ith insect family and S is the total numbers of insect family in the community (i.e., the richness)

The value of index depends on both the richness and the evenness (equitability) with which individuals were distributed among the families. Equitability was quantified by expressing Simpson's index, D as a proportion of the maximum possible value of D.

$$\text{Equitability, E} = \frac{D}{D_{max}} = \frac{1}{\sum_{i=1}^{S} P_i^2}$$

[As $D_{max} = S$]

Land equivalent ratio

Land equivalent ratio (LER) was used to assess the performance of an intercrop relative to the corresponding sole crop (After Mead and Willey, 1980),

$$\text{LER} = \sum_{i=0}^{n} \frac{Y_{ji}}{Y_{js}}$$

When the numbers of component crops are two,

$$\text{LER} = \frac{Y_{ij}}{Y_{is}} + \frac{Y_{ji}}{Y_{js}}$$

Where, Y_{IJ} is the yield of component crop j in intercropping and Y_{JS} is the yield of the crop in sole cropping.

Relative yield (RY) was calculated using the following formula:

$$\text{RY} = \frac{\text{Yield of component crop}}{\text{Yield of sole crop}}$$

Total edible yield

Harvested yield of an individual crop and intercrops that we consume considered as total edible yield.

Equivalent yield

Yield of an individual crop was converted into equivalent yield by converting yield of intercrops into the yield of the sole crops on the basis of prevailing market price of individual crop (Anjaaneyulu *et al.* 1982) as follow

i)Brinjal equivalent yield for coriander = $Y_b + \dfrac{Y_{co} \times P_{co}}{P_b}$

ii)Coriander equivalent yield for brinjal = $Y_{co} + \dfrac{Y_b \times P_b}{P_{co}}$

iii)Brinjal equivalent yield for fenugreek = $Y_{fe} + \dfrac{Y_{fe} \times P_{fe}}{P_b}$

v) Brinjal equivalent yield for radhuni = $Y_b + \dfrac{Y_r \times P_r}{P_b}$

vi)Radhuni equivalent yield1 for brinjal = $Y_r + \dfrac{Y_b \times P_b}{P_r}$

vii)Brinjal equivalent yield for chili = $Y_b + \dfrac{Y_{ch} \times P_{ch}}{P_b}$

viii) Chili equivalent yield for brinjal = $Y_{ch} + \dfrac{Y_b \times P_b}{P_{ch}}$

STATISTICAL ANALYSIS

Data were statistically analyzed following through MSTAT-C software. The treatment means were separated by Duncan's multiple range test (Duncan, 1955) at 5% level of significance for interpretation of the result.

RESULTS AND DISCUSSION

The results on the effect of polyculture systems with brinjal + coriander, brinjal + fenugreek, brinjal + chili, brinjal + radhuni compared to its monoculture on insect pest and their natural enemy complex are presented and discussed under the following subheadings. Calculated diversity index (D) and equitability (E) are also presented and discussed.

Abundance of insect pest in polyculture system

Infestations of brinjal by brinjal shoot and fruit borer

Significantly, the lowest number of shoot infestation (2.75) from 6 plants in brinjal by brinjal shoot and fruit borer was recorded in brinjal + coriander system (Table- 1). On the other hand, the highest number of shot infestation (5.73) by brinjal shoot and fruit borer was recorded during this period when brinjal grown alone which was also significantly higher than that recorded from intercrop combinations of brinjal + radhuni, brinjal + chili, brinjal + fenugreek.

Infestation of brinjal fruit by brinjal shoot and fruit borer

Generally, the lowest fruit infestation (10.79) from 8 plants by brinjal shoot and fruit borer was recorded in brinjal + coriander system which differed significantly from brinjal sole, brinjal + radhuni. Brinjal + chili, brinjal + fenugreek intercrop combination (Table2). However the highest fruit infestation (20.54) was almost always observed in brinjal when grown as sole crop. Plate6 – Plate11 showed the infested and healthy fruits.

.Result of the current study is general conformity with that reported by Amin (2004) found that infestation of brinjal shoot by brinjal shoot and fruit borer was higher incase of monoculture of sole brinjal than brinjal + onion, brinjal + garlic, brinjal + chili, brinjal + coriander intercrop combination. The lowest infestation was found in brinjal + coriander combination. In case of fruit infestation in brinjal by brinjal shoot and fruit borer, Amin (2004) also found that lower fruit infestation in intercropping of brinjal + coriander, brinjal + chili, brinjal +onion, brinjal + garlic in comparision to that of brinjal alone. Ali *et. al.* (1996) evaluated the effect of intercropping of onion, garlic, and coriander with brinjal where brinjal + coriander combination performed the best in reducing the fruit infestation by brinjal shoot and fruit borer among other intercrop treatment.

Table 1. Effect of intercropping on shoot infestation by brinjal shoot and fruit borer at vegetative stage of brinjal during January/2007 to March/2007

Crop combinations	Number of infested shoots by brinjal shoot and fruit borer recorded from 8 plants						Mean no. of infested shoots during the crop season
	22nd January	2nd February	13th February	24th February	4th March	15th March	
Brinjal	5.67 A	6.01A	5.33 A	5.65 A	5.62 A	6.13 A	5.735 A
Brinjal +coriander	2.333 C	3.03 B	2.85 C	3.000 C	3.01 C	2.333 C	2.75 C
Brinjal + fenugreek	5.52 B	6.000 B	5.12 B	6.02 AB	5.333 AB	5.15 B	5.52 B
Brinjal + chili	4.667 BC	4.527 B	4.333 B	5.667 B	4.627 BC	4.333 B	4.69 B
Brinjal + radhuni	3.102 BC	2.667 B	4.001 BC	3.167 BC	3.667 BC	3.000 BC	3.26 BC

Figures in the same column accompanied the same letter (s) are not significantly different at 5% level as per Duncan's Multiple Range Test (DMRT)
Values are mean of three replications

Table 2. Effect of polyculture on fruit infestation in brinjal by brinjal shoot and fruit borer during March to April/2007

Crop combinations	Number of infested fruits by brinjal shoot and fruit borer recorded from 8 plants								Mean of infested fruit during the crop season
	15th March	23rd March	31st March	7th April	14th April	21st April	28th April	5th March	
Brinjal	24.00 A	20.33 A	18.67 A	21.67 A	20.33 A	20.00 A	19.00 A	20.33 A	20.54 A
Brinjal +Coriander	12.67 C	9.000 C	10.67 B	12.33 B	11.33 B	10.00 B	9.667 B	10.67 B	10.79 C
Brinjal + Fenugreek	20.00 AB	20.33 A	19.00 A	19.67 A	19.67 A	19.33 A	15.00 AB	18.00 A	18.87 AB
Brinjal + Chilli	18.00 BC	14.00 B	12.67 B	13.67 B	10.67 B	12.33 B	11.33 B	12.67 B	13.16 B
Brinjal + Radhuni	14.33 C	12.33 BC	10.67 B	11.67 B	11.00 B	9.000 B	11.00 B	11.67 B	11.45 BC

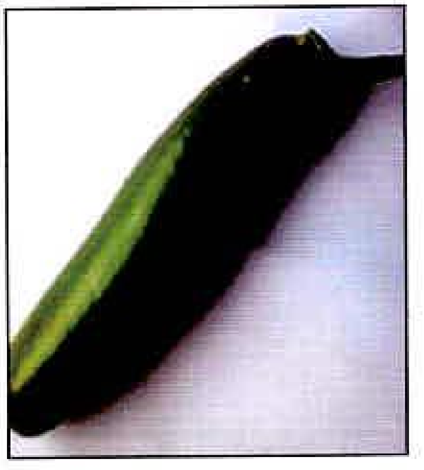
Figures in the same column accompanied by the same letter (s) are not significantly different at 5% level as per DMRT test

Values are mean of three replications

Plate 6: Infested fruit

Pate 7: Infested fruit with larvae

Plate 8: Infested fruit with larvae



pate 9: Fresh fruit

Plate10: Internal portion of affected Fruit

Pate 11: Fresh fruit

Table 3. Influence polyculture on the incidence of sucking pests of brinjal during January to March/2007

Crop combination	Number of insects recorded from 10 leaves/plant		
	Aphid	Jassid	White fly
Brinjal	7.89 B	6.533 A	6.801 A
Brinjal + Coriander	4.990 E	4.353 B	4.107 D
Brinjal + Fenugreek	19.75 A	5.960 A	4.877 C
Brinjal + Chili	14.75 C	6.567 A	6.043 B
Brinjal + Radhuni	6.995 D	4.577 B	3.193 E

Figures in the same column accompanied by the same letter (s) are not significantly different at 1% level as per DMRT

Values are mean of three replication.

Incidence of sucking pest of brinj1al

The mean numbers of aphid, jassid, and whitefly recorded on 10 leaves of brinjal during January to February 2007 under different crop combinations are presented in Table 3. Brinjal + coriander, brinjal + radhuni, and brinjal + chili systems were found to show significant effect in reducing aphid incidence. The lowest number of aphid was recorded in brinjal + coriander (4.990) followed by brinjal + radhuni (6.995) whereas the highest was in sole brinjal (19.75). However the lowest number of jassid was recorded in brinjal + coriander (4.35) followed by brinjal + radhuni (4.577). Brinjal + radhuni also had significantly the lowest incidence of whitefly (3.193) which was, however, statistically similar to that found from brinjal + coriander (4.107).

Table 4. Effect of polyculture on the yield performance of brinjal by number during mid March to mid April 2007.

Crop combinations	Number of fruits/plot ($6m^2$)/8 plants			Number of fruits decreased over brinjal sole (%)	Reduction of fruits infestation over brinjal sole (%)	Percentage of healthy fruits
	Healthy	Infested	Total			
Brinjal	125.33 A	246.7 A	372.03 A			33.75
Brinjal + Coriander	100.7 C	124.3 E	225 E	39.40	49.59	44.73
Brinjal + Fenugreek	120.7 B	200.54 B	321.24 B	13.48	18.69	37.57
Brinjal + Chili	106.7 D	172.3 C	279 C	24.84	30.13	38.23
Brinjal + Radhuni	98.67 E	154.3 D	252.97 D	s31.86	37.43	38.99

Figures in the same column accompanied by the same letter (s) are not significantly different at 1% level as per DMRT

Values are mean of three replications

Table 5. Effect of polyculture on the yield performance of brinjal by weight during mid March to mid May 2007.

Crop combinations	Weight of fruits kg/plot ($6m^2$)/8 plants			Yield decreased over brinjal sole (%)	Reduction of infestation over brinjal sole (%)
	Healthy	Infested	Total		
Brinjal	7.230 A	12.95 A	20.18 A		
Brinjal + Coriander	6.130 C	7.740 D	13.87 D	31.26	40.23
Brinjal + Fenugreek	7.067 A	11.197 B	18.264 A	49.49	13.53
Brinjal + Chili	6.807 B	9.993 C	16.8 B	16.50	23.84
Brinjal + Radhuni	6.027 C	8.153 D	14.18C	29.72	37.06

Figures in the same column accompanied by the same letter (s) are not significantly different at 1% level as per DMRT

Values are mean of three replications

Effect of polyculture on the yield performance of brinjal

Effect of polyculture treatments against the brinjal shoot and fruit borer infestation in brinjal and its subsequent impact on the yield performance by number of fruits and its weight are presented in Table 4 and 5, respectively. The highest number of infested fruits from $6m^2$ plot (8 plants) was recorded in sole brinjal (246.7 A) followed by brinjal + fenugreek (184.3 B) mentioned in Table 4. The result showed a significant variation among the treatments. Significantly the lowest (124.3 E) fruit infestation was found from brinjal + coriander system. Fruit infestation by weight ranged from 12.95 kg to7.740 kg and followed a similar trend with that of infestation by number (Table 5). The percent reduction of infestation by weight over sole brinjal was the highest in brinjal + coriander (40.23) followed by brinjal + radhuni (37.06) and the lowest was recorded from brinjal + fenugreek (13.53). The percent reduction of infestation caused by brinjal shoot and fruit borer was recorded maximum at the flowering stage of radhuni (72.23 %) and coriander (61.13 %) in Brinjal+ radhuni and brinjal + coriander combination (Figure 1)

The incidence of insect pest in intercropping under different crop combination, in the present study is in conformity with the findings of several studies conducted elsewhere. Andow (1991) and Risch *et al.* (1983) found that intercropping had lower pest infestation than monocultures. In the tropical low lands of Mexico, Letourneau (1986) was found the similar result in maize + cowpea + squash intercropping. In a maize + bean intercropping system, Van Huis (1981) and Francis *et al.* (1978) claimed lower attack rates of *spodoptera frugiperda* in this system compared to a maize monoculture.

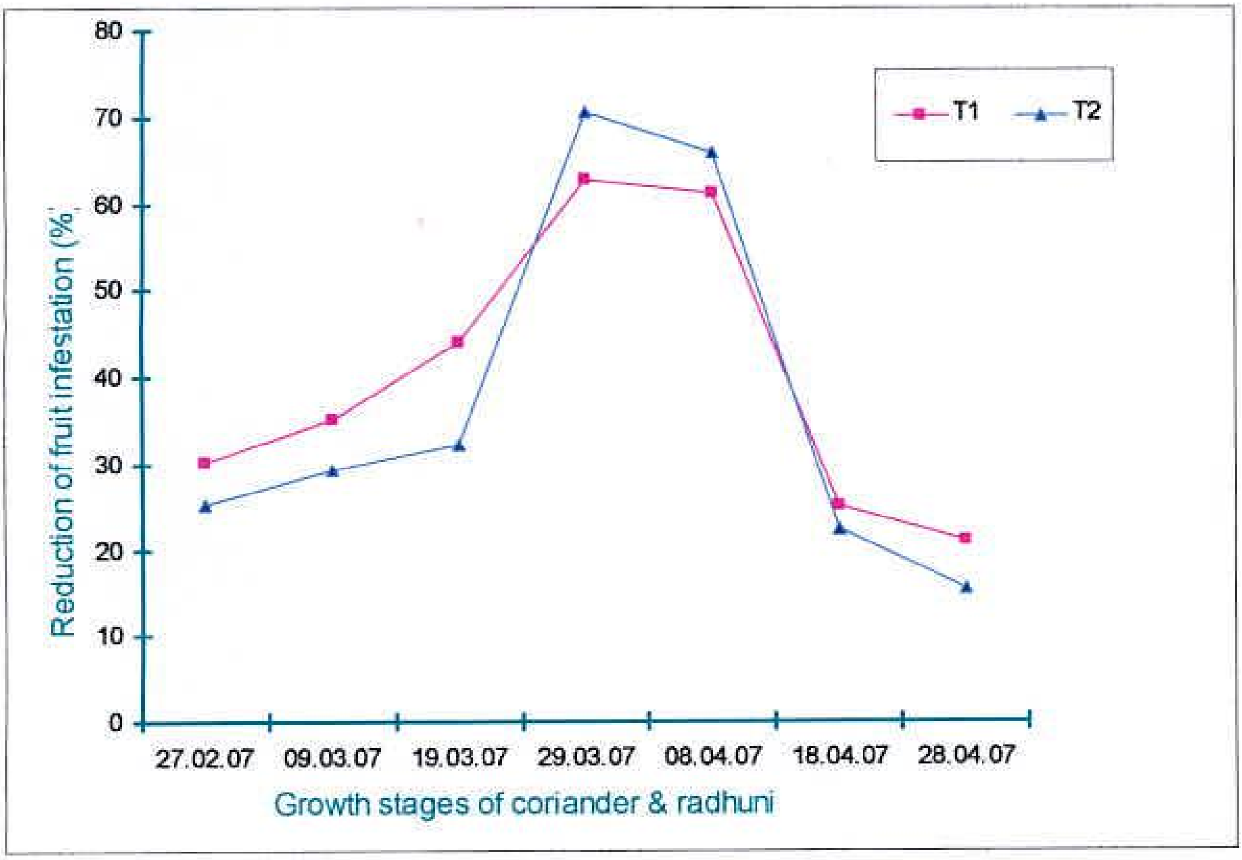


Figure 1. Reduction of fruit infestation (%) in weight under different growth stages of coriander & radhuni against BSFB.

- (27.02.07 - 09.03.07): Before flowering stage
- (19.03.07 – 08.04.07): Flowering stage
- (18.04.07 – 28.04.07): Fruiting stage
- T1 – Reduction of fruit infestation (%) by coriander
- T2 - Reduction of fruit infestation (%) by radhuni

Incase of fruit infestation in brinjal by brinjal shoot and fruit borer, the present study revealed less fruit infestation has found in intercropping brinjal + coriander, brinjal + radhuni, brinjal + chili and brinjal + fenugreek in comparison to that of brinjal alone. Ali *et al.* (1996) evaluated the effect of intercropping onion, garlic and coriander with brinjal where brinjal + coriander intercropping performed the best in reducing the fruit infestation by brinjal shoot and fruit borer among other intercrop treatments.

In all the crops of the present study, the abundance of insect pests in polyculture was lower as compared to monoculture which might be due to physical barriers to insect movement, plant quality affected by the intercrops, adverse environmental factors or less abundance of food sources etc. The fig.1 showed that the highest percent reduction of fruit infestation over control in weight basis recorded at the flowering stage of radhuni (72.01%) followed by coriander (62.21%). Plate12 and Plate13 showed the flowering stage of radhuni and coriander.

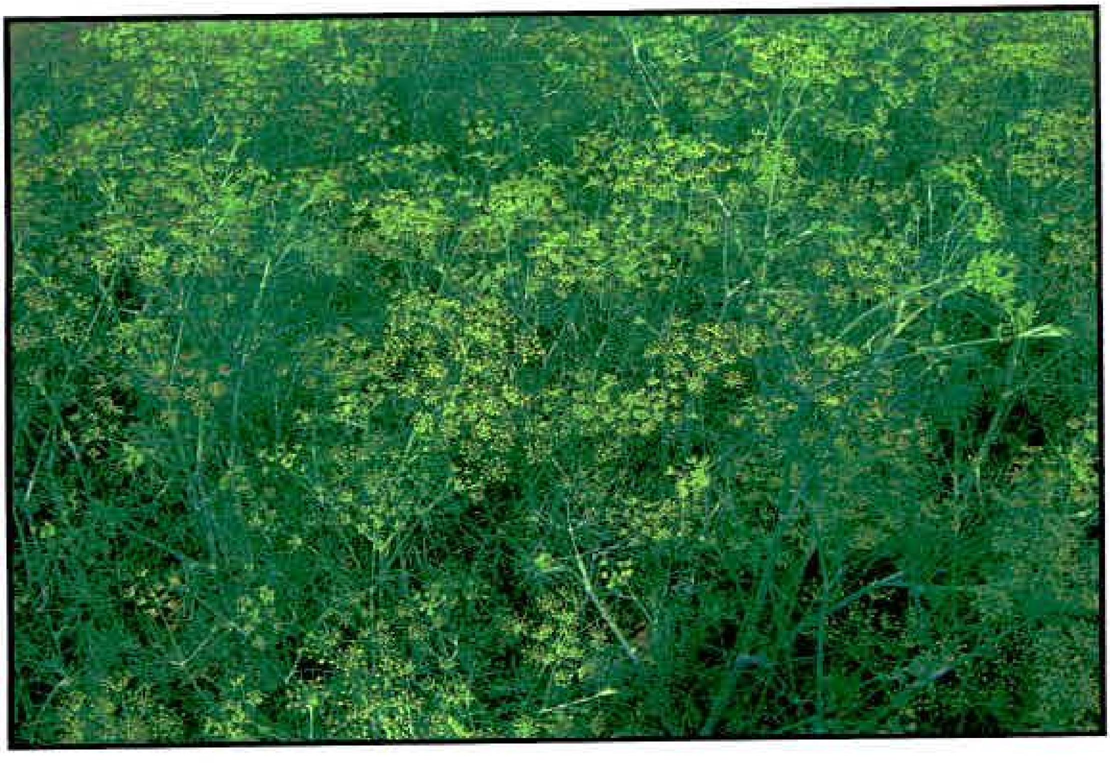


Plate 12: Flowering stage of radhuni

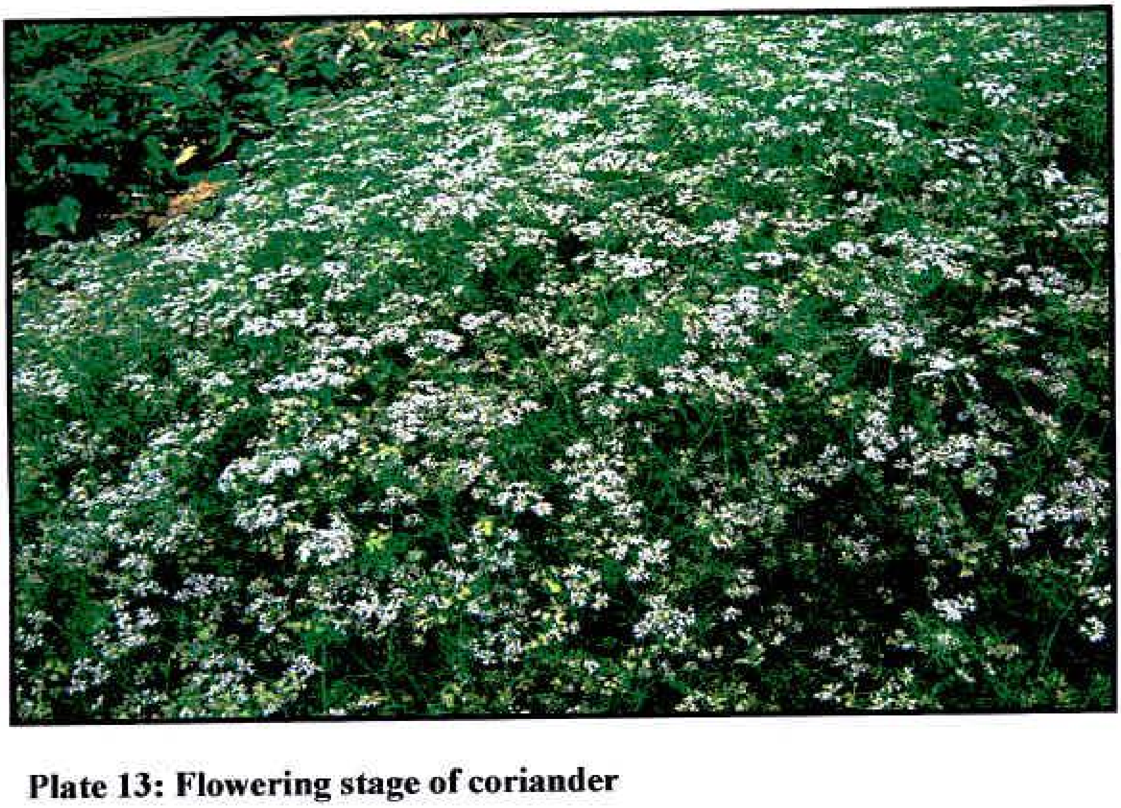


Plate 13: Flowering stage of coriander

Table 6.Effect of polyculture on brinjal with other crops in the incidence of natural enemies during January to May 2007

Crop combinations	Number of natural enemies recorded on 8 plants/plot	
	Spider	Lady bird beetle
Brinjal	2.087 C	3.217 C
Coriander	1.000 D	3.063 CD
Radhuni	0.7633 E	2.067 F
Chilli	0.3333 F	2.513 E
Fenugreek	0.9233 DE	1.003 G
Brinjal + Coriander	2.993 A	5.137 B
Brinjal + Fenugreek	2.367 B	2.800 D
Brinjal + chilli	1.957 C	5.467 B
Brinjal + Radhuni	2.930 A	6.673 A

Figures in the same column accompanied by the same letter are not significantly different at 1% level as per DMRT

Values are mean of three replications.

Effect of polyculture on the abundance of natural enemies

The mean numbers of spider per 8 plants/plot differed significantly among the treatments. The highest incidence of spider was observed in brinjal when grown with coriander (2.993 A) followed by brinjal + radhuni (2.930 A) (Table 6). Significantly lower numbers of spiders were observed in chili, radhuni, fenugreek and coriander when grown as sole crop than that with brinjal. The mean numbers of lady bird beetle per 8 plants /plot was recorded from different crop combinations are also shown in Table 6. The highest number of lady bird beetle was recorded in brinjal + radhuni (6.673) followed by brinjal + chili (5.467 B) and the lowest in sole fenugreek (1.003 G).Other sole crops also showed a lower abundance of Lady bird beetle. Brinjal + Radhuni statistically, however, were found similar to brinjal + chilli and brinjal + Coriander. Plate14 – Plate17 showed the gathering of different natural enemies in polyculture combinations.

It is evident from Table 6 that generally a higher number of spiders and lady bird beetles were found in intercrop situation in comparison to that of sole crops. This might be due to the fact that diversity of plant species provided important resources for natural enemies such as alternate prey, nectar and pollen or breeding sites as pointed out by Russel (1989). Dempstar and Coaker (1974) found that the predating activity of ground beetle were enhanced when cabbage were sown with white and red clover resulting in regulation of population of *Erioschia brassicae* and *pieris rapae.*

Results of the present study are in general conformity with that reported by Nampala *et al.* (1999) and Hansen (1983). Nampala *et al.* (1999) found that the abundance of predatory *Orius* sp., spiders and earwigs differed significantly among the cowpea cropping systems, being more common in the cowpea pure stands and cowpea + green gram than in the cowpea + sorghum intercrops. This reflects a difference between intercrop combinations. Hansen (1983) observed an increased abundance of several predator species in an intercrop system of maize and cowpea in Southern Mexico.

In several other studies, however, it has been shown that higher density of natural enemies occurred in sole crop than in mixed crops, appeared opposite to the general prediction. Kyamanywa *et al.* (1993) worked with cowpea + maize intercropping and found that the abundance of *Orius* species, lady bird beetles, spiders and earwigs were not enhanced by planting cowpea as a mixed crop with maize. This trend has been partially reflected for spider population in brinjal + chilli and brinjal + fenugreek and for lady bird population in brinjal + fenugreek system in the present study.

Plate 14: Lady Bird beetle on coriander flower

Plate 16: Lady Bird beetle on coriander flower

Plate 15: Honey bee on Coriander flower

Plate 17: Pupal stage of lady bird beetle

Table 7. Diversity and equitability of arthropod community under different crop combinations using relative method at early stage of crop growth.

Treatment	Numbers of insect family recorded	Diversity index (D)	Equitability (E)
Brinjal + coriander	11	3.21	0.30
Brinjal + Fenugreek	10	2.74	0.27
Brinjal + Chili	9	2.41	0.26
Brinjal + radhuni	11	2.89	026
Sole fenugreek	7	2.39	0.34
Sole chilli	8	2.45	0.30
Sole radhuni	9	2.95	0.32
Sole Coriander	11	3.47	0.31
Sole Brinjal	9	3.60	0.36

Table 8. Diversity and equitability of arthropod community under different crop combinations using relative method at middle stage of crop growth.

Treatment	Numbers of insect family recorded	Diversity index (D)	Equitability (E)
Brinjal + coriander	14	7.20	0.51
Brinjal + Fenugreek	14	6.12	0.43
Brinjal + Chilli	14	6.55	0.46
Brinjal + fennel	15	6.95	0.46
Sole fenugreek	10	5.50	0.55
Sole chilli	10	5.73	0.57
Sole Radhuni	9	5.94	0.66
Sole Coriander	11	6.2	0.56
Sole Brinjal	14	6.98	0.49

Table 9. Diversity and equitability of arthropod community under different crop combinations using relative method at late stage of crop growth.

Treatment	Numbers of insect family recorded	Diversity index (D)	Equitability (E)
Brinjal + coriander	7	3.92	0.70
Brinjal + Fenugreek	9	4.68	0.52
Brinjal + Chilli	6	3.95	0.65
Brinjal + Fennel	7	4.00	0.57
Sole fenugreek	7	4.2	0.60
Sole chilli	6	3.98	0.66
Sole Fennel	7	4.08	0.58
Sole Coriander	8	4.10	0.51
Sole Brinjal	8	3.6	0.60

Diversity of arthropod community

Trends in diversity pattern of insect in intercropping under different crop combination using relative method viz. pitfall trap and sweeping net at early, mid and late stages of crop growth are shown after combining the data from collected samples in Table 7 to 9 and appendixes 1a to 1c. Some neutral insect which are not regarded as crop pest, were also found to be trapped incidentally in both the methods. These were also included in data because the relative significance of their presence in a particular ecosystem is not clearly known to us.

Diversity of arthropod community at early stage of crop growth

From Table 7, it is evident that the higher richness and also the highest diversity index were observed in brinjal (3.60) and coriander (3.47) when grown as sole crop with the equitability of (0.36) and (0.31) respectively. On the other hand, coriander + brinjal and radhuni +brinjal showed the diversity index of 3.21 and 2.89 with equitability of 0.30 and 0.26 respectively.

Diversity of arthropod community at mid stage of crop growth

In the mid stage of crop growth, the highest equitability (0.66) was observed in the sole radhuni although with low species richness (Table 8). On the other hand brinjal sole and brinjal + coriander showed a very high species richness but with comparatively lower equitability. The results indicated lower abundance of insect family in sole fenugreek, chilli and radhuni while a higher of families was found in brinjal and its treatment combination with radhuni chilli and fenugreek.

Diversity of arthropod community at late stage of crop growth

Incase of late stage of crops, the higher diversity index was found mostly in all the sole crops (Table 9). On the other hand, lower diversity index was observed in all the intercropped systems except brinjal + fenugreek with highest value (4.68) among all the treatments. The highest equitability was observed in brinjal + coriander (0.70) followed by chili sole (0.66) and the lowest in sole corianders.

Relationship between richness with diversity index and equitability

The relationship between richness with diversity index and equitability/arthropod community at different crop growth stages are presented in Table 10 and 11.

Table 10. Relationship between the number of families (x) and diversity index (y) at different crop growth stages.

Crop growth stages	Relationship between	Correlation	Probability
Early stage	no. of insect families (x) and diversity index (y)	Y = 0.33 + 0.39x; r=0.66	NS
Mid stage	,,	Y = 3.10 + 0.43x; r = 0.91	P< 0.01
Late stage	,,	Y = 1.83 + 0.47x; r = 0.82	P< 0.05
Whole crop Period	,,	Y = 1.02 + 42x; r = 0.75	P<0.001

NS = Non significant

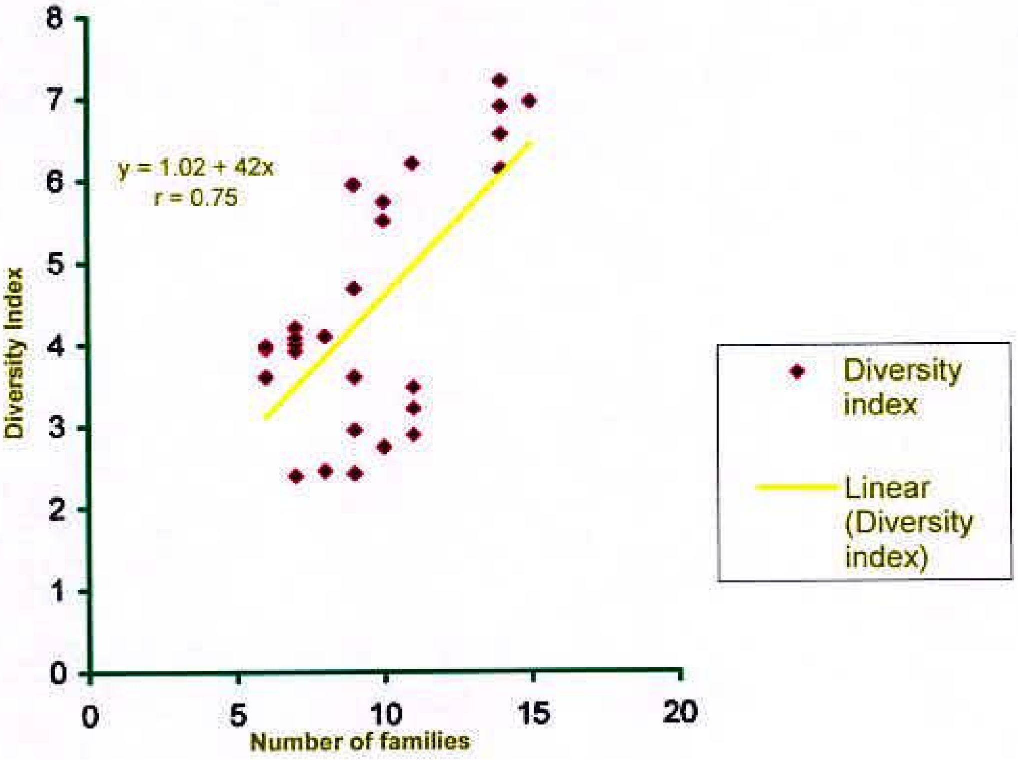


Figure 2. Relation between the number of families and diversity index of arthropod community in brinjal sole and polyculture combinations for whole crop period.

Table 11. Relationship between the number of families (x) and equitability (y) at different crop growth stages.

Crop growth stages	Relationship between	Correlation	Probability
Early stage	No. of insect families (x) and equitability (Y)	$Y = 1.02 - 0.04x; r = -0.65$	NS
Mid stage	,,	$Y = 1.21 - 0.19x; r = -0.82$	$P<0.05$
Late stage	,,	$Y = 0.82 - 0.035x; r = -0.31$	NS
Whole crop Period	,,	$Y = 1.12 - 0.073x; r = -0.83$	$P<0.05$

NS = Non significant

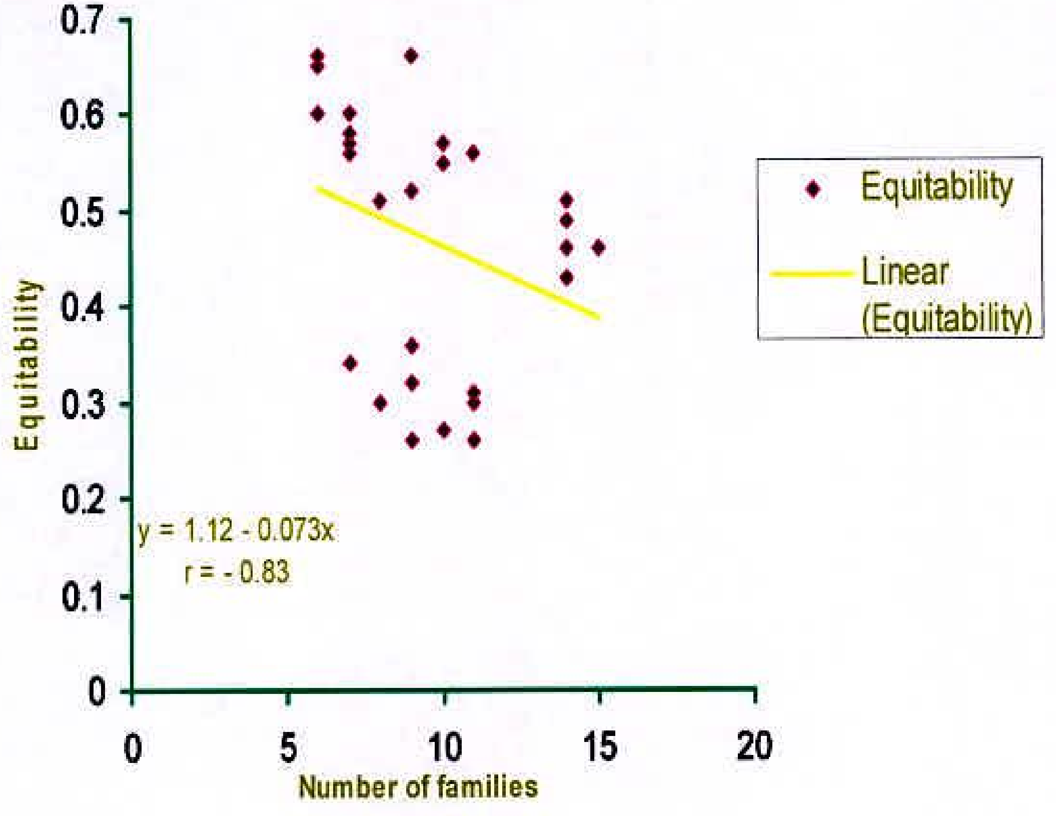


Figure 3. Relation between the number of families and equitability of arthropod community in brinjal sole and polyculture combinations for whole crop period

Relationship between numbers of families with diversity index

A positive relationship was found between the number of families and diversity index in all the crop growth stages (Table 10). In all the crop growth stages, except the early stage, significant relationship between richness and diversity index of arthropod community was observed (r= 0.66 to 0.91). Assessment of the whole crop period also revealed a highly significant relationship (r= 0.75) between richness and diversity index (Fig. 1). It is clearly evident that diversity index of insect community is influenced by the number of insect families (i.e. species richness) in diversified agro ecosystems.

Relationship between numbers of families with equitability

A negative relationship was observed between the numbers of families with equitability in all the crop growth stages (Table 11). However, the results during mid stage of crop growth revealed a significant relationship (r= - 0.82) between richness and equitability. The value of diversity index depends on both the species richness and the evenness (equitability) with which individuals are distributed among the species. For a given richness, 'D' increases with richness (Begon *et al.,* 1990). In the present study , when diversity was assessed by relative method, sole brinjal and coriander showed generally higher diversity index in all the growth stages of crop although brinjal + coriander system showed comparatively lower diversity index in early and late stages compared to sole brinjal and coriander. The results indicated that the pest insects were less abundant in intercropping and greater numbers belong to the different families of natural enemies and beneficials.This results are conformity with Roots (1973) hypothesis. He proposed that the specialist herbivores are generally less abundant in vegetationally diverse habitats because their food sources are less concentrated and natural enemies are more abundant. Whittaker (1972) and May (1975) showed that the relationship between species number (S): abundance of individuals (N) has two features (1) Species richness – The total number of species present in the area (S_T) and (2) equitability or evenness – the pattern of distribution of the individuals between the species. They also claimed that the equitability of the species: abundance of relationship will be a reflection of the underlying distribution. May (1975) also report that diversity index is strongly influenced by species richness. A completely novel concept of Taylor *et al.* (1976) is that of viewing diversity as a reflection of basic environmental structure, the two meaningful characteristics are not species richness and evenness, but (1) diversity as represented by the 'common', the slope of the line as dominated by the moderately common species and (2) the functions in numbers, from occasion to occasion (e.g., year to year).

Table 12. Total edible yield, relative yield and land equivalent ratio of sole and polyculture combinations.

Crop combinations	Total edible yield ton/ha	Relative yield					*LE*
		Brinjal	Coriander	Radhuni	Chilli	Fenugreek	
Brinjal + Coriander	23.54	0.75	0.29				1.04
Brinjal + fenugreek	31.04	0.95				0.26	1.21
Brinjal + chili	25.35	0.82			0.17		0.99
Brinjal + Radhuni	24.02	0.77		0.24		1.01	
Brinjal	30.63	1					1
Coriander	1.52		1				1
Radhuni	1.67			1			1
Chili	5.5				1		1
Fenugreek	1.72					1	1

Yield and economics:

In the present study, total edible yield, relative yield, land equivalent ratio, equivalent yield and gross return were considered in evaluating productivity and economics of intercropping systems. Total edible yield, relative yield and land equivalent ratio are presented in Table 12. Among the sole and intercropping systems, the highest total edible yield was found in brinjal + Fenugreek (31.04) followed by brinjal + Chilli (25.35). The lowest edible yield (23.54) was recorded in brinjal + Coriander intercropping system. Relative yield indicates the competitive of component crops in an intercropping system (Wahua and Miller, 1978).There is a general trend of decreasing competitive ability of crop with increasing number of crops in the intercropping systems. The lowest relative yield of brinjal (0.75) and coriander (0.29) in brinjal + Coriander intercropping system also indicated the poor competitive ability of component crops. Among the component crops brinjal was found to be more competitive (0.95) than other crops. Higher competitive ability of brinjal may be attributed to its taller and bushy structures which dominated over the under storied crops. Similar result also reported by the Haque and Hamid (2001) in maize + sweet potato intercropping system where tall maize are more competitive than the shorter sweet potato crop.

Table 13. Equivalent yield and gross return in intercropping of brinjal under different crop combinations

Crop combinations	Equivalent yield (t ha^{-1})					Gross return (Tk ha^{-1})					
	Brinjal	Coriander	Fenugreek	Chilli	Radhuni	Brinjal	Coriander	Fenugreek	Chilli	Radhuni	Total
Brinjal +Coriander	25.21	5.12				151500	102400				253900
Brinjal + Fenugreek	32.02		6.9			192120		124200			316320
Brinjal + Chilli	26.23			6.25		157380			93750		251130
Brinjal +Radhuni	25.04				5.2	150240				104000	254240
Brinjal	30.63					183780					183780
Coriander		1.52									30400
Fenugreek			1.61								32200
Chilli				3.5							52500
Radhuni					1.67						30060

Price of commodities (Tk kg^{-1}): Brinjal: 6.00, Coriander: 20, Fenugreek 18, Chili: 15, Radhuni: 20

In the studied intercropping systems, brinjal + coriander and brinjal+ radhuni were more compatible than brinjal + chili and brinjal + fenugreek intercropping.

Land equivalent ratio (LER) is the most frequently used index to determine the effectiveness of intercropping system relative to growing crop separately. Land equivalent ratio indicates the land advantage and measures the biological efficiency of land use by intercrops in comparison to sole crops. In the present study, LER was more than 1 in brinjal + Coriander, brinjal + fenugreek and brinjal + radhuni systems indicating greater biological efficiency and yield advantage over the monoculture (Table 12). In the present study the highest LER (1.21) was obtained from brinjal + fenugreek indicated the most compatible intercropping system.

The highest brinjal equivalent yield (32.02 ton ha^{-1}) was obtained from brinjal + fenugreek combination followed by brinjal + chilli (26.23 ton^{-1}ha) and the lowest in brinjal + radhuni (25.04) intercropping system (Table13). Equivalent yield for coriander, fenugreek, radhuni, and chilli in all intercropping was higher than sole crops. Lower equivalent yield of brinjal in brinjal + coriander, brinjal + radhuni and brinjal + chilli than brinjal sole indicated that brinjal yield was suppressed when it was grown in association with other crops. Yield advantage or yield reduction of intercropping system depends on complimentary or competitive behavior of component crops (Spitters, 1983).

In the present study, brinjal have failed to get any complementary effects from coriander, chilli and radhuni and reduced the equivalent yield.

From the economic point of view, it was observed that intercropping of different combinations gave higher economic return than monoculture (Table 13). The results agreed well with the finding of Haque and *et al.* (2001) and Shah *et al.* (1991) where they found a higher gross return from intercropping than their corresponding sole crops. The highest gross return (Tk 316320 ha^{-1}) was recorded from the brinjal + fenugreek intercropping system followed by brinjal + radhuni (Tk 254240 ha^{-1}). Though the maximum percent reduction of shoot and fruit of brinjal by brinjal shoot and fruit borer was found in brinjal + coriander followed by brinjal + radhuni combination but the highest return was come from brinjal +fenugreek combination. It might be happened due to some physiological causes. The nutrient competition of brinjal with coriander and radhuni might be higher than brinjal with fenugreek combination. The branch of coriander and radhuni are more dense and profuse than fenugreek. These profuse and dense branch of coriander and radhuni might be suppressed the normal growth of brinjal in brinjal + crioander and brinjal + radhuni combination in comparison to brinjal + fenugreek combination. During study some brinjal plant of brinjal + coriander and brinjal +radhuni combination were found to be attacked by mycoplasma whereas in brinjal + fenugreek combination was not found so. So these might be the causes of more yield of brinjal in brinajls + fenugreek combination. However further study should be conducted to find out the more significant reason. In sole cropping, the highest gross return (TK 183780 ha^{-1}) was recorded from brinjal followed by fenugreek and the lowest (TK 30400 ha^{-1}) from coriander.

SUMMARY AND CONCLUSION

A field experiment was conducted at the Shere-Bangla Agricultural University farm to investigate the diversity of arthropod community under the influence of polyculture system with brinjal and also to find its impact on the management of insect pests and natural enemies of brinjal. The crop combinations were brinjal + coriander, brinjal + fenugreek, brinjal + chili, brinjal + radhuni, and sole brinjal, coriander, fenugreek, chili, and radhuni. The experiment was laid out in a Randomized Complete Block Design with three replications. Two relative methods namely pitfall trap and sweeping net method were used for sampling insects/arthropods to estimate the diversity index and equitability under different crop combinations.

Significantly lowest number of shoot infestation (2.75) in brinjal by brinjal shoot and fruit borer was recorded in brinjal + coriander system. On the other hand, the highest number of shoot infestation (5.73) by brinjal shoot and fruit was recorded in brinjal when grown alone. The lowest fruit infestation (10.79) by brinjal shoot and fruit borer was recorded in brinjal + coriander system which differed significantly from all the combinations. However the highest fruit infestation (20.54) was observed in sole brinjal. The lowest number of aphids was recorded in brinjal + coriander (4.990) followed by brinjal + radhuni (6.995) but in sole brinjal the infestation was so high (17.89). The lowest number of jassid was recorded in brinjal + coriander (4.353) followed by brinjal +radhuni (4.577) where as in sole brinjal the number jassid is comparatively more

(6.533). Brinjal + radhuni had significantly the lowest incidence of whitefly (3.193) which was however statistically similar to that found from brinjal + coriander. The highest number of infested fruit was recorded in brinjal sole (246.7). Significantly the lowest fruit infestation was found from brinjal + coriander (124.3) system followed by brinjal + radhuni (154.3). Fruit infestation by weight ranged from 7.74 kg/plot to 12.95 kg/plot. The percent reduction of infestation by weight over sole brinjal was the highest in brinjal + coriander (40.23%) followed by brinjal + radhuni, (37.06%), and the lowest was recorded from brinjal + fenugreek (13.53%).

The highest incidence of spider was observed in brinjal + coriander (2.993) followed by brinjal + radhuni (2.930). The highest number lady bird beetle was recorded in brinjal + radhuni (6.673) followed by brinjal + chili (5.467) and the lowest in sole fenugreek (1.003).

At the early stage of crop growth, the highest diversity index was observed in sole brinjal (3.60) and in sole coriander (3.47) with the equitability of (0.36) and (0.31) respectively. On the other hand, coriander + brinjal and radhuni + brinjal showed the diversity index of 3.21 and 2.89 with equitability of 0.30 and 0.26 respectively. In the mid stage of crop growth, the highest diversity index (D) was observed in brinjal + coriander (7.20) followed by sole brinjal (6.98). Where as highest equitability was observed in sole radhuni (0.66) although with low species richness. On the other hand, sole brinjal showed a very high species richness but with comparatively lower equitability.

In the late stage of crop growth, the highest diversity index was found mostly in brinjal + fenugreek (4.68) followed by sole fenugreek sole coriander and sole radhuni. The highest equitability was observed in brinjal + chili (0.66), followed by sole chili (0.65), and the lowest in sole coriander (0.51). In all the crop growth stages, except the early stage, significant relationship between number of families and diversity index (D) of arthropod community was observed (r= 0.66 to 0.91). Assessment of whole crop period also revealed a highly significant relationship (r = 0.75) between number of families and diversity index. Mid stage crop growth revealed a significant negative relationship (t = -0.82) between number of families and equitability.

Among the sole and polyculture systems, the highest total edible yield was found in brinjal + fenugreek (31.01ton ha^{-1}) followed by brinjal + chili (26.23 ton ha^{-1}). The lowest edible yield (25.04 ton ha^{-1}) was recorded in brinjal + radhuni polyculture system. Among the component crop brinjal was found to be more competitive (0.95 t ha^{-1}) than the other crops. LER was more than 1 in brinjal + coriander and brinjal + fenugreek, brinjal + radhuni systems indicating greater biological efficiency and yield advantage over monoculture. In the present study, the highest LER (1.21) was obtained from brinjal + fenugreek indicated the most compatible polyculture system. The highest brinjal equivalent yield (32.02 t ha^{-1}) was obtained from brinjal + fenugreek combination followed by brinjal + chili (26.23 t ha^{-1}) and the lowest in brinjal + radhuni (25.04 t ha^{-1}) polyculture system.

The highest gross return (Tk 316320 ha^{-1}) was recorded from the brinjal + fenugreek polyculture system followed by brinjal + radhuni (Tk 254240 ha^{-1}). In sole cropping, the highest gross return (Tk 183780 ha^{-1}) was recorded from brinjal followed by chilli and the lowest (Tk 30400 ha^{-1}) from coriander.

From the above study it may concluded that incidence of insect pests were less in polyculture system definitely in case of brinjal shoot and fruit borer (BSFB) infestation. Rate of shoot and fruit infestation by BFSB were lower in polyculture as compared to monoculture. The abundance of natural enemies was higher in polyculture system. In most of the polyculture systems under different crop combinations, the diversity index of insect/arthropod community and their equitability were higher but with less species richness compared to the combination of their component crops. The total edible yield, equivalent yield, land equivalent ratio and gross return were generally higher in polyculture system than their corresponding sole cropping. The overall study revealed polyculture system as an eco-friendly pest management practice for brinjal by which we can significantly reduce pest infestation without use of chemical insecticide.

Further study is recommended to asses the environment friendly management practices of important agricultural pests in various polyculture systems prevailing in different agro ecosystem in Bangladesh.

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Diversity and equitability of arthropod/ insect community under different crop combinations using relative method at early stage of crop growth

Crop combinations	Insect families	No. of individuals	Proportion of individuals (Pi)	Pi²	Diversity index (D)	Equitability (E)
Brinjal	Lycosidae	3	0.08	0.0064		
	Culicidae	1	0.03	0.009		
	Formicidae	3	0.08	0.0064		
	Scarabidae	3	0.08	0.0064	3.60	0.36
	Thripidae	19	0.49	0.01		
	Forficulidae	4	0.10	0.2401		
	Caraboidae	2	0.05	0.0025		
	Muscidae	2	0.05	0.0025		
	Tettigidae	2	0.05	0.0025		
Fenugreek	Lycosidae	2	0.043	0.0018		
	Thripidae	28	0.608	0.3705		
	Forficulidiae	2	0.043	0.0018		
	Formicidae	9	0.195	0.038	2.39	0.34
	Coraboidae	1	0.02	0.004		
	Gryllidae	1	0.02	0.004		
	Scarababidae	2	0.043	0.0018		
	Chrysomilidae	3	0.265	0.0042		
Radhuni	Formicidae	4	0.111	0.0121		
	Scarabaeidae	2	0.055	0.0030		
	Thripidae	1	0.027	0.0007		
	Muscidae	1	0.027	0.0007	2.95	0.32
	Culicidae	3	0.833	0.0065		
	Forficuldae	1	0.027	0.3086		
	Coccinilidae.	20	0.555	0.0007		
	Lycocidae	2	0.055	0.003		
	Formicidae	2	0.055	0.003		
Chili	Lycosidae	3	0.08	0.0064		
	Formicidae	1	0.029	0.0008		
	Scarabaeidae	4	0.117	0.0138		
	Thripidae	21	0.617	0.617	2.45	0.30
	Muscidae	1	0.029	0.0008		
	Caraboidae	1	0.029	0.0008		
	Staphylinidae	2	0.58	0.058		
	Tettigidae	1	0.029	0.0008		
Coriander	Scarabaeidae	3	0.07	0.0049		

Contd.

	Thripidae	22	0.5	0.25		
	Muscidae	3	0.07	0.0049		
	Culicidae	6	0.136	0.183	3.47	0.31
	Forficulidae	2	0.05	0.0025		
	Caraboidae	1	0.02	0.0004		
	Gryllidae	2	0.05	0.0025		
	Formicidae	1	0.02	0.0004		
	Tettigidae	1	0.02	0.0004		
	Coccinilidae	2	0.05	0.0025		
	Syrphidae	1	0.02	0.0004		
Brinjal + Coriander	Lycosidae	9	0.189	0.0285		
	Formicidae	4	0.075	0.0056		
	Scarabaeidae	2	0.037	0.0013		
	Thripidae	28	0.52	0.270		
	Culicidae	2	0.037	0.0013	3.21	0.30
	Forficulidae	1	0.018	0.0003		
	Muscidae	1	0.018	0.0003		
	Caraboidae	3	0.056	0.0031		
	Chrysomilidae	1	0.018	0.0003		
	coccinilidae	1	0.018	0.0003		
	Syrphidae	1	0.018	0.0003		
Brinjal + Fenugreek	Gryliidae	3	0.0652	0.0042		
	Culicidae	4	0.0869	0.075		
	Cocci nilidae	5	0.1086	0.0118		
	Lycosidae	1	0.02	0.0004	2.74	0.27
	Formicidae	1	0.02	0.0004		
	Scarabacidae	2	0.043	0.0018		
	Thripidae	27	0.58	0.3364		
	Culicidae	1	0.02	0.0004		
	Forficulidae	1	0.02	0.0004		
	Caraboidae	1	0.02	0.0004		
Brinjal + Chili	Staphylinidae	2	0.043	0.0018		
	Lycosidae	2	0.043	0.0018		
	Fomiicidae	9	0.1956	0.0382		
	Scarabaeidae	1	0.02	0.0004	2.418	0.26
	Thripidae	28	0.6086	0.3705		
	Culicidae	1	0.02	0.0004		
	Tettigigidae	1	0.02	0.0004		
	Coccinilidae	1	0.02	0.0004		
	Muscidae	1	0.02	0.0004		
Brinjal + Radhuni	Lycosidae	3	0.06	0.0037		
	Formicidae	2	0.04	0.0016		
	Scarabaeidae	1	0.02	0.0004	2.89	0.26
	Thripidae	28	0.571	0.3226		
	Culicidae	1	0.02	0.0004		

Contd.

Forficuilidae	3		0.06	0.0037
Muscidae	3		0.06	0.0037
Gryllidae	2		0.04	0.0016
Tettigidae		2	0.04	0.0016
Chrysomilidae		2	0.04	0.0016
Coccinilidae		1	0.02	0.0004

Appendix-Ib

Diversity and equitability of arthropod/ insect community under different crop combinations using relative method at mid stage of crop growth

Crop combinatios	Insect families	No. of individual	Proportion of individual (Pi)	Pi^2	Diversity index (D)	Equitability (E)
Brinjal	Lycosidae	15	0.20	0.0400		
	Staphylinidae	2	0.03	0.0007		
	Scarabaidae	12	0.16	0.0256		
	Culicidae	12	0.56	0.0256		
	Formicidae	8	0.11	0.0114		
	Tlhripidae	8	0.11	0.0114	6.98	0.49
	Muscidae	4	0.05	O.C028		
	Coccinilidae	3	0.04	0.0016		
	Forficulidiae	1	0.01	0.0002		
	Pyrallidae	2	0.03	0.0002		
	Aphididae	1	0.01	0.0007		
	Jassidae	3	0.04	0.0016		
	Tettigidae	2	0.03	0.0007		
	Gryllidae	1	0.01	0.0002		
Fenugreek	Scarabaidae	12	0.26	0.0652		
	Culicidae	6	0.13	0.0163		
	Formicidae	9	0.19	0.0367		
	Thripidae	7	0.15	0.0222		
	Chrysomilidae	6	0.!3	0.0163	5.50	0.55
	Gryllidae	1	0.02	0.0005		
	Muscidae	1	0.02	0.0005		
	Anthicidae	2	0.04	0.001S		
	Arctidae	1	0.02	0.0005		
	Coccinilidae	1	0.02	0.0005		
Radhuni	Staphylinidae	4	0.10	0.0091		
	Scarabaidae	1	0.02	0.0006		
	Formicidae	9	021	0.0459		
	Thripidae	4	0.10	0.0091	5.94	0.66
	Muscidae	7	0.17	0.0278		
	Coccinilidae	2	0.05	0.0023		
	Culicidae	3	0.07	0.005!		
	Arctidae	9	021	0.0459		
	Jassidae	1	0.02	0.0006		
Chili	Lycosidae	2	0.03	0.0010		
	Scarabaidae	9	0.12	0.0324		
	Culicidae	6	0.12	0.0144		
	Thripidae	9	0.18	0.0324		

Contd.

	Muscidae	13	0.26	0.0676		
	Formicidae	2	0.04	0.0016	5.73	0.57
	Gryllidae	6	0.12	0.0144		
	Anthicidae	1	0.02	0.0004		
	Coccinilidae	1	0.02	0.0004		
	Chrysomilidae	3	0.06	0.0036		
Coriander	Lycosidae	12	0.19	0.0363		
	Scarabaidae	7	0.11	0.0123		
	Culicidae	9	0.14	0.0204		
	Formicidae	9	0.34	0.0204		
	Thripidae	13	0.17	0.0305	6.2	0.56
	Muscidae	3	0.05	0.0023		
	Gryliidae	3	0.05	0.0023		
	Anthicidae	1	0.02	0.0003		
	Forficulidiae	1	0.02	0.0003		
	Aphid idea	3	0.05	0.0023		
	Syrphidae	1	0.02	0.0003		
Brinjal + Coriander	Lycosidae	15	0.20	0.0390		
	Scarabaidae	9	0.12	0.0 140		
	Culicidae	9	0.12	0.0140		
	Formicidae	7	0.09	0.0085		
	Thripidae	13	0.17	0,0293	7.20	0.51
	Muscidae	3	0.04	0.0016		
	Tettigidae	1	0.01	0.0002		
	Gryllidae	2	0.03	0.0007		
	Anthicidae	1	0.01	0.0002		
	Arctidae	1	0.01	0.0002		
	Forficulidiae	1	0.01	0.0002		
	Coccinilidae	6	0.08	0.0062		
Brinjal + Fenugreek	Lycosidae	15	0.22	0.0473		
	Scarabaidae	9	0.13	0.0170		
	Culicidae	13	0.19	0.0355		
	Formicidae	5	0.07	0.0053		
	Thripidae	11	0.16	0.0254		
	Chrysomilidae	1	0.01	0.0002	6.12	0.43
	Muscidae	2	0.03	0.0008		
	Anthicidae	2	0.03	0.0008		
	Tettgidae	1	0.0!	0.0002		
	Forficulidiae	3	0.04	0.0039		
	Staphylinidae	1	0.01	0.0002		
	Gryllidae	1	0.01	0.0002		
	Coccinilidae	2	0.03	0.0008		
	Pyrallidae	1	0.01	0.0002		
Brinjal + Chili	Lycosidae	13	0.19	0.0345		
	Staphylinidae	2	0.03	0.0003		
	Scarabaidae	7	0.10	0.0100		
	Culicidae	11	0.16	0.0247		
	Thripidae	5	0.07	0.0051		

Contd.

	Muscidae	15	0.21	0.0459		
	Coccinilidae	4	0.06	0.0033	6.55	0.46
	Anthicidae	3	0.04	0.0018		
	Forficulidae	1	0.04	0.0012		
	Tettigidae	1	0.01	0.0002		
	Pyrallidae	1	0.01s	0.0002		
	Jassidae	1	0.01	0.0002		
	Aphididae	1	0.01	0-0002		
	Gryllidae	1	0.01	0.0002		
Brinjal + Radhuni	Lycosidae	15	0.24	0.0567		
	Scarabaidae	6	0.10	0.0091		
	Culicidae	12	0.19	0.0363		
	Thripidae	15	0.24	0.0567		
	Muscidae	1	0.02	0.0003		
	Formicidae	4	0.06	0.0040	6.95	0.46
	Anthicidae	2	0.03	0.0010		
	Coccinilidae	1	0.02	0.0003		
	Gryllidae	1	0.02	0.0003		
	Staphylinidae	1	0.02	0.0004		
	Arctidae	1	0.02	0.0003		
	Jassidae	2	0.03	0.0010		
	Aphididae	2	0.03	0.0010		
	Tettigidae	1	0.02	0.0004		
	Forficulidae	2	0.03	0.0010		

Diversity and equitability of arthropod /insect under different crop combinations using relative method at the late stage of crop growth

Crop combinations	Insect families	No. of individuals	Proportion of individuals (pi)	(Pi^2)	Diversity index (D)	Equitability (E)
Brinjal	Chrysomilidae	1	0.05	0.002		
	Formicidae	5	0.23	0.052		
	Scarabaidae	5	0.23	0.052	3.6	0.60
	Forficulidiae	2	0.09	0.002		
	Culicidae	1	0.05	0.002		
	Lycosidae	1	0.05	0.002		
	Anthicidae	6	0.32	0.1000		
	Gryliidae	1	0.05	0.002		
Fenugreek	Lycosidae	6	0-32	0.100		
	Culicidae	1	0.05	0.003		
	Scarabaidae	5	0.26	0.06	4.2	0.60
	Anthicidae	1	0.05	0.003		
	Formicidae	3	0.16	0.025		
	Forficulidiae	1	0.05	0.003		
	Chrysomilidae	1	0.05	0.003		
Radhuni	Lycosidae	4	0.25	0.063		
	Formicidae	3	0.19	0.035		
	Staphylinidae	1	0.06	0.004	4.08	0.58
	Scarabaidae	4	0.25	0.063		
	Anthicidae	1	0.06	0.004		
	Gryllidae	1	0.06	0.004		
	Chrysomlidae	1	0.06	0.004		
Chili	Gryliidae	1	0.04	0.002		
	Lycosidae	7	0.39	0.151		
	Formicidae	4	0.22	0.049	3.98	0.66
	Culicidae	1	0.06	0.003		
	Scarabaidae	2	0.11	0.012		
	Forficulidae	1	0.06	0.003		
Coriander	Coccinilidae	1	0.06	0.004		
	Lycosidae	7	0.30	0.093		
	Formicidae	4	0.17	0.030		
	Culicidae	1	0.04	0.002	4.10	0.51
	Coccinilidae	1	0.04	0.002		
	Scarabaidae	4	0.17	0.030		

Contd.

Brinjal + Fenugreek	Anthicidae	4	0.17	0.030	4.68	0.52
	Chrysomilidae	I	0.04	0.002		
	Coccinilidae	1	0.06	0.003		
	Lycosidae	5	0.23	0.052		
	Formicidae	3	0.36	0.132		
	Chrysomilidae	2	0.09	0.008		
	Scarabaidae	2	0.09	0.008		
	Coccinilidae	1	0.06	0.003		
	Culicidae	1	0.06	0.003		
	Anthicidae	3	0.36	0.132		
	Gryllidae	2	0.09	0.008		
Brinjal + Coriander	Culicidae	1	0.05	0.002	3.92	0.70
	Coccinilidae	1	0.05	0.002		
	Lycosidae	5	0.28	0.077		
	Formicidae	5	0.28	0.077		
	Chrysomilidae	4	0.22	0.049		
	Forficulidae	1	0.06	0.003		
	Scarabaidae	3	0.17	0.028		
Brinjal + Chili	Lycosidae	7	0.39	0.151	3.95	0.65
	Formicidae	4	0.22	0.049		
	Chrysomilidae	2	0.11	0.012		
	Forficulidae	1	0.06	0.003		
	Staphylinidae	1	0.06	0.003		
	Scarabaidae	2	0.11	0.012		
Brinjal + Radhuni	Chrysomilidae	4	0.19	0.036	4.00	0.57
	Forficulidiae	1	0.05	0.002		
	Staphylinidae	1	0.05	0.002		
	Scarabaidae	3	0.14	0.020		
	Ambicidae	I	0.05	0.002		
	Culicidae	1	0.05	0.002		
	Coccinilidae	1	0.05	0.002		