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Effect of intercrops on damage potential of major insect pest of brinjal under the Gangetic alluvial zone of West Bengal

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Abstract
Brinjal shoot and fruit bore and leaf hopper is the most destructive and the major limiting factor in quantitative as well as qualitative harvest of brinjal. The objective of the study was to estimate the effect of intercrops on damage potential of major insect pest of brinjal. Field experiments was carried out with 7 treatments [T_1 (Sole Brinjal), T_2 (Brinjal + Cowpea), T_3 (Brinjal + Garlic), T_4 (Brinjal + Fenugreek), T_5 (Brinjal + Onion), T_6 (Brinjal + Coriander), T_7 (Brinjal + French bean)] following randomized block design with three replications. The results indicated that major insect-pest attributes were significantly influenced by intercropping system. Significant reduction of fruit and shoot borer and leaf hopper infestations was observed in brinjal + garlic intercropping system. Based on the performance of brinjal under different intercropping combinations, growing of brinjal with french bean was adjudged as the best treatment combination to maximize the growth, yield, quality and least infestation of major insect-pest.

Keywords: intercrop, brinjal, fruit and shoot borer, leaf hopper

Introduction
With shrinking farm sizes farmers find it difficult to generate enough income to provide for their households. The average size of farm size of operational holding has declined to 1.08 ha. in 2015-16 as compared to 1.15 in 2010-11 (Anonymous, 2018) [3]. On the other hand, the cultivable land is very limited as compared to current population. In the present context, farmers can be benefited economically by proper utilization of the resources as well as contributing to national food security and nutritional aspect for raising population within a short time.

The use of cultural practices like intercropping is one of alternative control measures. In West Bengal, the important vegetable crops are brinjal, cabbage, cauliflower, tomato, root crops, cucurbits, potato, peas, beans, leafy greens, etc. and spice crops such as turmeric, ginger, chilli, garlic, cumin black and coriander. The per capita land resources in India are very limited (0.12 ha) that will further be decreased by the turn of century due to explosive increase in population, which is an alarming situation.

At present, only 3% of our total arable land is under vegetable cultivation. Moreover, 76% farmers are marginal in West Bengal. In this context, an attempt may be made for increasing the area, but due to tremendous population pressure it is not an easy task to get horizontal expansion of cultivation area for vegetables. In addition to this, natural hazards, market fluctuations, pest and disease outbreak, etc. are also serious threats for getting the targeted output of the vegetable crops. Hence, effective land utilization through intensive cropping is urgently needed. Comprehending all these, multiple cropping may be one of the most important approaches to feed the billions of our country.

Brinjal or eggplant (*Solanum melongena* L.) is one of the common vegetable crops cultivated extensively by virtue of its wide adaptability to grow from plains to an altitude up to 1500 MSL. It is an important solanaceous crop of sub-tropics and tropics (Anonymous, 2008) [4]. It is a good source of minerals and vitamins and is rich in total water soluble sugars, free reducing sugars, amide proteins among other nutrients. It is locally known as "Begoon" and its early European name is “Egg plant” grown extensively in India, Bangladesh, Pakistan, China and the Philippines. It is also popular in other countries like Japan, Indonesia, Turkey, Italy, France, United States, Mediterranean and Balakan area (Bose and Som, 1986) [10]. India is one of the largest brinjal producing countries in the world covering an area of 0.66 million hectares with a production of 12.515 million tones and productivity of 18.96 t/ha (Anonymous, 2017) [5]. Among the Indian States, West Bengal covers the maximum area (1.62 lakh hectares) and production (30.03 lakh tonnes) having the productivity of 18.53 t/ha (Anonymous, 2017) [5] which is slightly below than national average. It is a long duration and wide spaced crop. So, there is a great possibility to cultivate minimum canopy spread herbaceous plant like coriander, garlic, fenugreek etc. in the inter-row space of brinjal. Productivity can be increased through utilization of these intercrops.

The brinjal crop is attacked by about 140 species of insect pests. Out of numerous insects, brinjal shoot and fruit borer (*Leucinodes orbonalis*), leaf hopper (*Amarasca bigutulla bigutulla*), aphid (*Aphis gossypii*), Hadda beetle (*Epilachna spp.*) and brinjal stem borer (*Euzophera pertialla*) have been reported as important insect pests of the brinjal (Alpuerto, 1994; Bustamante *et al*., 1994; Bhadauria *et al*., 1999 and Bharadiya and Patel, 2005) [1, 11, 7, 8]. Among these, *L. orbonalis* is the most destructive and the major limiting factor in quantitative as well as qualitative harvest of brinjal (Atwal and Dhaliwal, 2002; Chakraborty and Sarkar, 2011) [6, 12]. Brinjal crop losses by this insect-pest have been reported to an extent of 20.70% to 88.70% (Kaur *et al*., 1998; Chatterjee and Roy, 2004; Raju *et al*., 2007; Dutta *et al*., 2011 and Latif *et al*., 2010) [21, 13, 25, 16, 22]. Intercropping is one of the important cultural practices in pest management, reducing insect pests by increasing the diversity of an eco-system (Altieri and Letourneau, 1982) [2]. Intercropping affects the pests by changing micro-climate through change in crop canopies (Wu *et al*., 1999; Srinivas Rao *et al*., 2003) [31, 27], influencing the pest population build-up through physical factors like protection from wind, shading, sheltering, prevention of dispersal, alteration of colour, shape of the stand etc. and through biological factors like presence of natural enemies, production of adverse chemical stimuli, availability of alternate food etc. The present investigation was undertaken to determine the effect of intercrops on damage potential of major insect pest of brinjal.

Materials and Methods

Field experiments of the present investigation were carried out at Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal under the research field of All India Coordinated Research project on Vegetable Crops. The farm is located at 23.5 ˚N latitude and 89 ˚E longitude at an elevation of 9.75 m above MSL.

Topographic situation of the experimental site comes under the Gangetic new alluvial plains of West Bengal. Field experiments was carried out with 7 treatments [T_1 (Sole Brinjal), T_2 (Brinjal + Cowpea), T_3 (Brinjal + Garlic), T_4 (Brinjal + Fenugreek), T_5 (Brinjal + Onion), T_6 (Brinjal + Coriander), T_7 (Brinjal + French bean)] following randomized block design with three replications during 2016-17 and 2017-18. Agronomical practices were according to recommendations of Chattopadhyay *et al*. (2007) [14].

Data recording

Recording of fruit borer infestation

In case of fruit infestation, numbers of infested and non-infested fruits of each harvest was recorded and per cent damage was calculated. The grades were assigned for the fruit damage percentage based on the following rating (Mishra *et al*., 1988) [23].

Grade	Reaction	Fruit infestation (%)
Grade 1	Immune	0%
Grade 2	Highly resistant	1-10%
Grade 3	Moderately resistant	11-20%
Grade 4	Tolerant	21-30%
Grade 5	Susceptible	31-40%

Recording of leaf hopper infestation

For counting of leaf hopper population, ten plants in each replication was selected at random and tagged. The leaves was observed in such a way that, two leaves at upper portion of the first plant, two leaves in middle portion from the second plant and two leaves from bottom portion of the third plant of each variety was taken in to account. The average population was calculated by simple arithmetic means. The observation for mean leaf hopper (nymphs) and adult population per leaf was counted in the early morning hours at an interval of 15 days from three observational plants of each genotype starting by taking 6 leaves per plant at random (two each from top, middle and bottom) at 7±1 days interval. The leaf hopper injury index was calculated according to Bindra and Mahal (1979) [9].

Statistical analysis

The data were subjected to analysis of variance (Gomez and Gomez, 1984) [20]. The treatment variations were tested for significance by adopting F test (Cochran and Cox, 1957) [15]. For determination of critical difference at 5 per cent level of significance, Fisher and Yates (1963) [18] table was consulted. Least significant difference (LSD) was used to separate the treatment means at 5% level of probability by Tukey's HSD test. The analysis was performed by SAS (version 9.3).

Results and Discussion

Brinjal shoot borer infestation (%)

Experimental results related to brinjal shoot borer infestation presented in Table 1 and Fig 1 showed that minimum infestation of brinjal shoot borer was observed in brinjal grown with garlic (0.10% in 2016-17 and 0.13% in 2017-18 and 0.11% in pooled) preceded by brinjal + coriander system (0.21% in 2016-17 and 0.19% in 2017-18 and 0.20% in pooled) and brinjal with onion (0.31% in 2016-17 and 0.28% in 2017-18 and 0.30% in pooled) combination, and they were significantly superior to all other treatments. However, sole brinjal recorded with maximum brinjal shoot borer infestation value (0.60% in 2016-17 and 0.63% in 2017-18 and 0.62% as pooled). Intercropping affects the pests by changing micro-climate through change in crop canopies, influencing the pest population build-up through physical factors (Goel and Tiwari, 2004) [19]. Elanchezhyan *et al*. (2008) [17] recorded least shoot damage when brinjal intercropped with cluster bean (4:1). However, Paul *et al.* (2015) [24] observed minimum infestation of shoot borer in brinjal + coriander system. Brinjal plants were more dispersed in intercropped system (coriander, onion) which might have altered the visual stimuli received by the pests of brinjal, resulting less incidence of insect pests in brinjal intercropped either with coriander or onion. Brinjal intervened with either coriander or onion in the present study altered the crop architecture which in turn, diverted the orientation of herbivores towards brinjal, resulting less incidence of insect pests, as reported in various intercropping systems like mustard + coriander on mustard aphid (Goel and Tiwari, 2004) [19].

Table 1: Effect of intercropping on insect pest infestation of brinjal.

Treatments	Shoot borer infestation (%)			Fruit borer infestation (%)			Leaf hopper infestation (%)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
Sole Brinjal	0.60^{a}	0.63^{a}	0.62^{a}	27.21^{a}	25.94^{a}	26.58^{a}	3.25^{a}	3.19^{a}	3.22^{a}
Brinjal + Cowpea	0.42^{b}	0.44^{bc}	0.43^{b}	23.80^{bac}	24.46^{ba}	24.13^{bc}	2.83^{bc}	2.90^{b}	2.86^{b}
Brinjal + Garlic	0.10^{e}	0.13^{e}	0.11^{e}	19.97^{c}	18.61^{d}	19.29^{f}	2.16^{e}	2.11^{d}	2.14^{e}
Brinjal + Fenugreek	0.34^{cb}	0.32^{dc}	0.33^{c}	20.46^{c}	19.46^{dc}	19.96^{fe}	2.37^{de}	2.40^{c}	2.39^{d}
Brinjal + Onion	0.31^{c}	0.28^{de}	0.30^{c}	21.25^{bc}	22.24^{bc}	21.75^{de}	2.51^{dc}	2.48^{c}	2.50^{dc}
Brinjal + Coriander	0.21^{d}	0.19^{de}	0.20^{d}	25.40^{ba}	24.67^{ba}	25.04^{ba}	3.08^{ba}	3.14^{a}	3.11^{a}
Brinjal + French bean	0.55^{a}	0.56^{ba}	0.56^{a}	21.89^{bc}	22.87^{b}	22.38^{dc}	2.70^{dc}	2.57^{c}	2.64^{c}
SEm (±)	0.02	0.03	0.02	0.88	0.60	0.55	0.07	0.04	0.05
CD at 5%	0.06	0.09	0.07	2.70	1.85	1.70	0.22	0.14	0.16

Values in columns followed by the same letter are not significantly different, $p < 0.0001$, Tukey's post hoc test; Y_1=2016-17; Y_2=2017-18

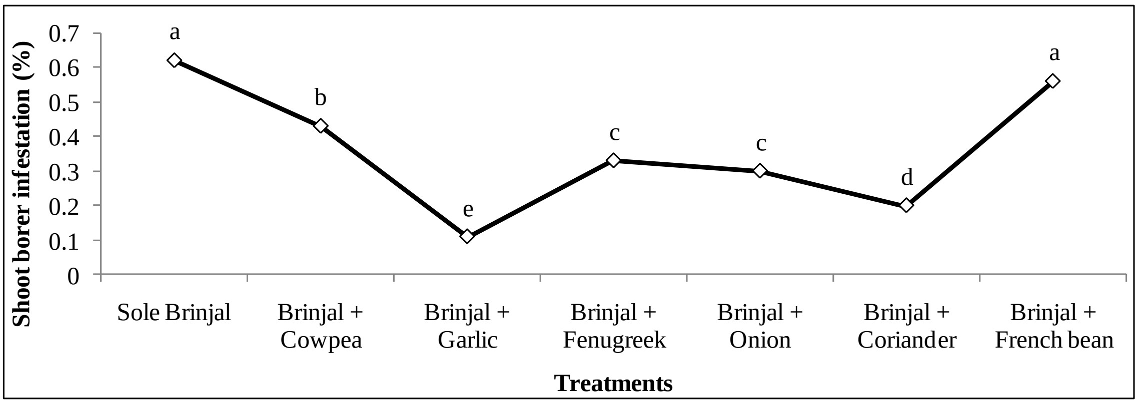

Fig 1: Effect of intercropping on shoot borer infestation (%) of brinjal

Brinjal fruit borer infestation (%)

The data pertaining to brinjal fruit borer infestation of brinjal based intercropping experiments have been presented in Table 1 and Fig 2. Among intercropping systems, maximum infestation of brinjal fruit borer was observed in brinjal + garlic (19.97% in 2016-17 and 18.61% in 2017-18 and 19.29% in pooled) preceded by brinjal + fenugreek (20.46% in 2016-17 and 19.46% in 2017-18 and 19.96% in pooled) and brinjal with onion (21.25% in 2016-17 and 22.24% in 2017-18 and 21.75% in pooled) systems of intercropping. Maximum infestation of brinjal fruit borer was observed in sole brinjal system (27.21% in 2016-17 and 25.94% in 2017-18 and 26.58% in pooled). This was further supported by the findings of Elanchezhyan *et al.* (2008) [17] who recorded least infestation of fruit borer when brinjal intercropped with cluster bean (4:1). On the other hand, minimum infestation of shoot borer in brinjal + coriander system was recorded by Paul *et al.* (2015) [24]. More host preference of fruit borer to sole brinjal crop might be due to less biosynthesis of phenols in fruits. Higher amount of phenol biosynthesis in brinjal + garlic and brinjal + fenugreek systems and the smell emitted from garlic and fenugreek plants might be responsible for deterrent effect of fruit borer to these hosts or reduced rate of oviposition by the female adults which finally could have lead to least borer damage in these systems. The higher enzymatic activity is important firstly in the biosynthesis of orthodihydroxy phenols from monophenols and secondly in the oxidation of phenols to more toxic quinines which might have reduced fruit borer infestation and increased pest control in brinjal intercropped with garlic and fenugreek.

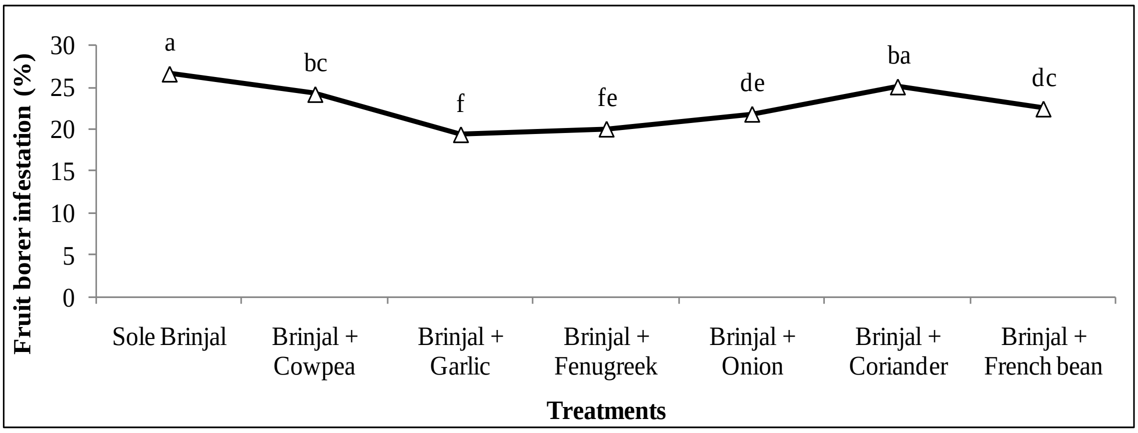

Fig 2: Effect of intercropping on fruit borer infestation (%) of brinjal

Brinjal leaf hopper infestation (%)

The data pertaining to leaf hopper infestation of brinjal based intercropping experiments have been presented in Table 1 and Fig 3. Among intercropping systems, brinjal + garlic recorded with minimum infestation of leaf hopper (2.16 in 2016-17 and 2.11 in 2017-18 and 2.14 in pooled) followed by brinjal + fenugreek (2.37 in 2016-17 and 2.40 in 2017-18 and 2.39 in pooled) and brinjal + onion (2.51 in 2016-17 and 2.48 in 2017-18 and 2.50 in pooled) systems and they were significantly different to all other treatments. Maximum infestation of leaf hopper was recorded in brinjal + french bean (3.25 in 2016-17 and 3.19 in 2017-18 and 3.22 in pooled) intercropping system. Results showed that all the intercropping models recorded leaf hopper infestation values less than sole crop, signifying intercropping was advantageous over sole cropping. Our results are in accordance with the findings of Sujayanand *et al.* (2015) [28] who observed the least cumulative mean leaf hopper population when maize was sown as border crop, and coriander was intercropped with brinjal. The repellent effects of garlic and fenugreek resulted least infestation of leaf hopper in these intercropping systems. It was accepted by some researchers that herbivore damage was reduced in diverse systems because of increased efficiency by natural enemies (Root, 1973 and Tahvanainen and Root, 1972) [26, 29]. It was also hypothesized that diverse environments would provide a greater variety of habitats and victims to predators and parasitoids through time, as well as alternate food sources such as pollen and nectar (van Emden,1965) [30], and so sustain more stable populations of natural enemies than monocultures which supported the present proposition.

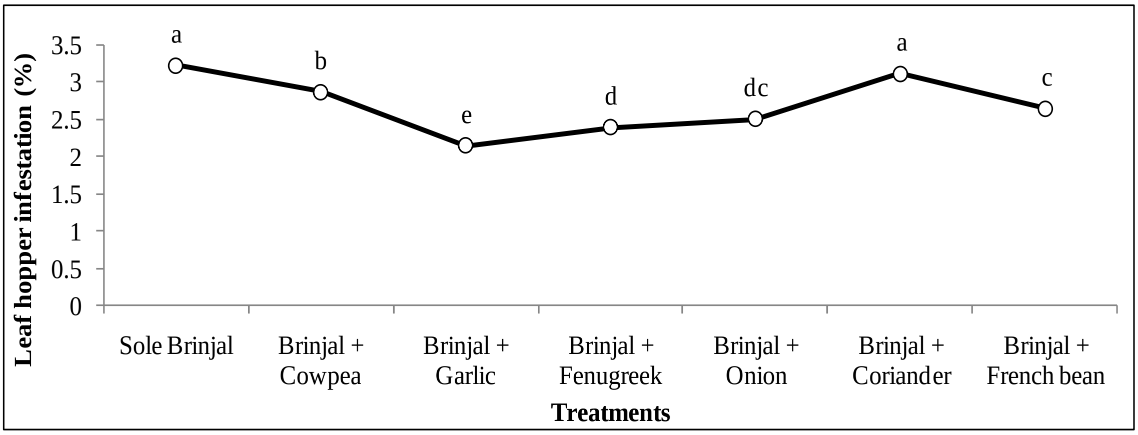

Fig 3: Effect of intercropping on leaf hopper infestation (%) of brinjal

Conclusion

Observation on the incidence of brinjal fruit and shoot borer and leaf hopper infestation started in the month of November and continued up to March in 2016-17 and 2017-18. It was found that the level of fruit infestation was always higher than that of shoot infestation.

The shoots and fruits of brinjal plant were found to be infested by brinjal fruit and shoot borer throughout the year although the level of infestation varied. The shoot infestation was highest 0.62% in sole brinjal and minimum in brinjal + garlic based intercropping system (0.11%). Then it started to increase steadily up to the month of November when maximum shoot infestation was observed. Then a marked decline was observed in December which showed a further slow decline thereafter up to the month of January. In case of fruit infestation, numbers of infested and non-infested fruits of each harvest were recorded and per cent damage was calculated at 150 days after transplanting (DAT). The fruit infestation was found maximum in sole brinjal (26.58%) and minimum in brinjal + garlic based intercropping system (19.29%). Then it started to increase steadily up to the month of November when maximum shoot infestation was observed. Then a marked decline was observed in December which showed a further slow decline thereafter up to the month of January.

Both nymphs and adults of the leaf hopper suck the sap from the lower leaf surfaces through their piercing and sucking mouthparts. While sucking the plant sap, they also inject toxic saliva into the plant tissues, which leads to yellowing. It was found that the insect was active throughout the crop season. Maximum infestation of leaf hopper was observed in sole brinjal (3.22%), whereas minimum infestation was found for brinjal + garlic based intercropping system (2.14%). Therefore, significant reduction of FSB and leaf hopper infestations was observed in brinjal + garlic intercropping system.

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