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ROLE OF INSECT POLLINATORS AND PESTS ON THE YIELD AND SEED QUALITY OF EGGPLANT (*Solanum melongena* L.)

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Abstract

The research work was conducted in the experimental field of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur to identify the insect pollinators abundant in eggplant field, and to know the effect of insect pollinators and pests on the yield and seed quality of the crop. Eggplants were cultivated in three conditions viz., open, enclosed in net without supplemented insect pollination, and enclosed in net with supplemented insect pollination. In total 8 species of insects belonged to 6 families in 3 orders were found as pollinator on eggplant and their abundance varied from 0.6±0.1 to 1.6±0.3 /30 sweeps. Among the pollinator insects, ant showed the highest abundance and longest foraging duration per flower. The plant infestation among the treatments varied from 2.6±2.6 to 12.8±1.6% and the highest and the lowest levels were observed in open condition and enclosed condition respectively. The fruit infestation ranged from 11.3±1.6 to 43.7±3.0% and the highest infestation was observed in open condition. Insect pollination produced the higher number of fruits per plant (14.4±0.4/plant) as well as larger fruits (length: 27.6±0.7 cm and breadth: 11.6±0.2 cm), and thus produced higher yield (11.6±0.4 tha^{-1}) and higher germination (82.0± 2.5%) of seeds.

Keywords: Eggplant fruit, insect species, foraging, infestation, germination.

Introduction

Eggplant (*Solanum melongena* L.), also called aubergine or brinjal is one of the top ten vegetables in the world. It grows throughout the year in Bangladesh and also adapted to high rainfall and high temperature (Hanson *et al*., 2006). The average yield of brinjal in Bangladesh is 9.1 tha^{-1} and the annual production area and amount of production are 49.4 thousand ha and 450.2 thousand tons, respectively (BBS, 2016). There are diversified insects present in eggplant field which are categorized as pest, predator, parasitoid and pollinator. In the tropics, eggplant production is severely hampered by several insect and mite pests. The major insect and mite pests include shoot and fruit borer, leafhopper, whitefly, thrips, aphid, spotted beetles, leaf roller, stem borer, blister beetle, mealy bug and mite which cause 20 to 60% yield loss (Roy and Pande, 1994).

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Insect pollinators help in transferring pollen from anther to stigma within a flower or between flowers of the same plant or different plants of the same species. Pollination is a key driver in the maintenance of biodiversity and ecosystem function. Insects pollinate about 80% of flowering plants, and assisted pollination is necessary when natural pollination is insufficient (Klein *et al*., 2007).

Eggplants bear flowers with abundant pollen that can only be dispersed through small orifices in the anthers. Eggplant flowers are hermaphroditic and are capable of some self-pollination (Free, 1993), but the process of expelling pollen from these flowers onto female flower parts requires shaking either by wind or by the action of insect visitors.

Honeybee *Apis mellifera* visitation has been shown to significantly increase fruit weight in eggplant (Levin, 1989). Some bee species can expel and efficiently harvest pollen from flowers with poricidal anthers by vibrating their bodies while in contact with the stamen, effecting a process termed ‘‘buzz pollination’’ (Buchmann, 1983). Honeybees are not able to effectively buzz pollinate, so it is likely that wild insect visitors that are capable of handling flowers in this way could be even more effective in accessing pollen from poricidal anthers and effectuating pollination (Kearns and Inouye, 1997). Moreover, eggplant flowers produce no floral nectar and bees that pollinate eggplant may be expected to depend on other sources of nectar nearby (Free, 1993).

Many horticultural crops are dependent on insect pollinators for optimal yields (Klein *et al.,* 2007). Anthropogenic disturbances including habitat modification and fragmentation cause declines in pollinator abundance and diversity. To operate the concept of ecosystem services in a practical sense, it is important to link research findings to the land-use decisions of the farming community. Therefore, this study was undertaken to identify the insect pollinators associated with eggplant using variety BARI Begun-8 and their impacts on yield and seed quality.

Materials and Method

The study was conducted during March to August, 2016 in the Field Laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, Bangladesh. The soil of the study site is silt clay in texture belonging to Salna series. The area represents the agro-ecological zone of Madhupur tract (AEZ-28) with pH 5.8-6.5, cation exchange capacity of 25.6 and C:N ratio of 3:1 (Haider *et al.,* 1991).

Study location and climatic conditions: The study site (BSMRAU, Gazipur) is located at 25°25′ North latitude and 89°5′ East longitude, which is in the middle of Bangladesh.The study area has a subtropical *climate having* mean maximum and minimum temperaturesof 36.0 ºC and 12.7 ºC, respectively, and relative humidity and average annual rainfall were 65.8% and 237.6 cm, respectively.

Collection of eggplant seeds and cultivation of crop: Seeds of eggplant varietyBARI Begun 8 were collected from the Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh. Seeds of eggplant were sown on 2March, 2016 in polythene bags. For transplanting seedlings, plots having 3.0 m ×3.0 mfollowed by randomized complete block design were used. Eggplant seedlings were transplanted 60 cm apart on 21March2016, in rows. The distance fromrow to row was1.0 m. Each plot has three rows and each row contained 5 plants.Fertilizers were applied according to Fertilizer Recommendation Guide (FRG, 2012) (N- 80 kg, P- 24 kg, K- 60 kg, S- 10 kg per hectare). Intercultural operations such as irrigation and weeding were done whenever necessary.

Effect of pollinators on fruit set: To determine the effect of wind and insect pollinators on fruit set, three types of treatments were adopted on the experimental plots. The adopted treatments were (i) open plot (wind and wild insect pollination), (ii) enclosed plot (covered with mosquito net)having25supplemented insect pollinators (black ant, honeybee and house fly) per week, and (iii) covered plot (covered with mosquito net) without supplemented pollinators. Each treatment was replicated three times.

Collection of insect and identification of pollinators: Free-living insects were collected from flower initiation to fruit maturation stage using a 30 cm diameter sweep net having 1.5 mm mesh, and attached with a 2 m long rod. Every week sweeping was done in between 09:00 to 11:00 h of the day, and each sample was consisted of 30 sweeps. The collected insects werebrought to the Entomology Laboratory of BSMRAU for identification and counting. They were killed by storage in a freezer for a few hours, mounted on points, dried and morphotyped. Insect pollinators were identified to species following morphological characters and comparing with museum specimens.

Observation of insect abundance and foraging behavior of pollinators: Landing duration (length of foraging time on a flower) of the insect pollinators on eggplantflowerswere measured using a stop watch. Observations were donein between 10:00 to 13:00 h of the day and data were recorded 7 times for each pollinator species.

Observation of plant and fruit infestation: During the study, plants were regularly monitored to record their infestation level by different chewing and sucking insects. Infested plants were recorded by observing the symptoms on shoot and leaves and then percent infested plant was calculated. During fruiting, field inspection was done daily to observe the infestation of the fruits by shoot and fruit borer. The damaged and undamaged fruits were counted and percentage of fruit infestation was calculated on number basis.

Observation of the number of fruit per plant and quantifying yield: Systematic sampling was done to count the number of fruit per plant. In this strategy, the plants in the third row of each plot were marked to collect data of the number of fruits produced per plant. Every harvesting date, number of fruits collected from the respective plants was recorded. Marketable and infested fruits of each plot were harvested and weighed using a digital balance (CANRY, China). The yield (kgunit area^{-1}) of each plot was converted to tha^{-1}.

Germination test: For this purpose, 5 mature fruits were randomly collected from each treatment and the seeds of the fruit were separated. Sixty seeds from each treatment were randomly selected and these were kept for germination test. Trays, each 30 cm × 30 cm × 5 cm (L × W × D), was used for this purpose. A single sheet of paper was placed in the bottom of each tray to cover drainage holes. Each tray was filled with clean and moist sandmixed soil and 20 seeds were sown in 5 rows of 4 seeds. Seeds were sown at the normal seeding depth of 3 cm and werewatered every alternate day. Only healthy seedlings were counted after 7 days when the majority of seedlings were emerged. Diseased, discolored, or malformed seedlings were excluded from counts. The total number of healthy seedlings for each treatment was used to determine germination percentage.

Statistical analysis: One way analysis of variance (ANOVA) followed by Tukey posthoc statisticwas employed for analyzing the data. All the analyses were performed using IBM SPSS 21.0. (IBM SPSS statistics 21, Georgia, USA).

Results and Discussion

The present study showed that8 species of insects belonged to 6 families under 3 orders (Hymenoptera,Lepidoptera and Diptera) were found as pollinators andtheir abundance varied from 0.6±0.1 to 1.6±0.3/30 sweeps (Table 1) and the results differed significantly ($F_{5,\ 160}$ = 4.2, p < 0.005). Theblack ant showed the highest abundance (1.6±0.3)and syrphid fly, sulphur butterfly and wasp showed the lowest abundance (0.6±0.3 and 0.7±0.1, respectively) and they were statistically similar.

Vergara and Badano (2009) reported 12 species of insect pollinators in eggplant field and Sung *et al.* (2006) reported that the honey bees (*Apiscerana* and *A. mellifera*) were the major pollinators in the eggplant field followed by allodapine bee (*Braunsapishewitti*) and sweat bees (*Halictus*sp. and *Lassioglossumspp*.). The present findings differed with Sung *et al.* (2008) due to geographical location, climatic condition and surrounding cropping pattern.

Foraging duration of the major abundant pollinators, presented in Fig. 1, ranged from 10.7 ± 0.9 to 22.4 ± 1.7 seconds per flower and the results differed significantly ($F_{5,\ 42}$=5.1, p< 0.05). Ant spent the longest time per flower followed by wasp, honeybee, sulphur butter fly and house fly.The syrphid fly foraged for shortest duration. This study indicated that syrphid fly and ant are the most rapid and sluggish fliers,respectively. Saeed *et al*. (2008) observed the syrphid fly as a rapid visitor of loquat flowers. Amin *et al.* (2015) observed that the syrphid fly and house fly were rapid fliers on mango flower compared to sulphur butterfly and wasp.

Table 1.Insect pollinators along with their relative abundance in eggplant field

Pollinator	Taxonomic profile	Abundance
Honey bee	*Apis mellifera* (Hymenoptera: Apidae)	0.9±0.2 ab
Wasp	*Vespa vulgaris* (Hymenoptera: Vespidae)	0.7±0.1 b
Sulphur butterfly	*Colias eurytheme* (Lepidoptera: Pieridae)	0.6±0.3 b
Black ant	*Formica rubra* (Hymenoptera: Formicidae)	1.6±0.3 a
	Camponotus compressus (Hymenoptera: Formicidae)	-
	Solenopsis geminate (Hymenoptera: Formicidae)	-
Syrphid fly	*Syrphus*sp. (Diptera : Syrphidae)	0.6±0.1 b
House fly	*Musca domestica* (Diptera: Muscidae)	1.0±0.2 ab

Data expressed as mean ± SE. Mean of each pest was taken from 30 sweeps per total collection. Means in the column followed by same letter(s) are not significantly different by Tukey HSD posthoc statistic at < 0.05.

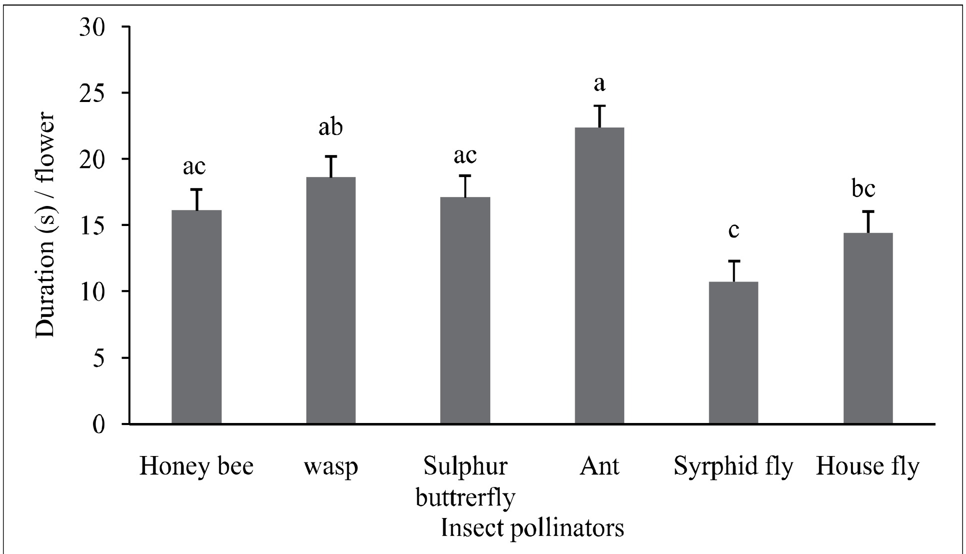

Fig. 1. Foraging duration (mean ± SE) of different insect pollinators visited eggplant flowers. Bars with common letter(s) are not significantly different by Tukey posthoc statistic at P < 0.05.

Significant differences were found in the level of plant infestation by insect pests when cultivated in enclosed and open conditions ($F_{2, 6} = 6.9$, $P < 0.05$, Fig. 2). Plant infestation level varied from 2.6±2.6 to 12.8±1.6% and the highest and the lowest levels were observed in open condition and enclosed condition, respectively. Percent fruit infestation ranged from 11.3±1.6 to 43.7±3.0 and the results differed significantly ($F_{2, 42}$ = 66.0, P < 0.001, Fig. 3). Percent fruit infestation was the highest in natural pollination condition. In enclosed condition, net hindered the entrance of shoot and fruit borer moth, red pumpkin beetle, epilachna beetle and other small to medium size insects thus resulted lowest level of plant and fruit infestation. In this condition, only minute insects like aphid, jassid and thrips entered and caused infestation. In insect pollination condition, pollinator insects (black ant, honeybee and house fly) were released 7 times when the minute insects as well as some medium size insects entered accidently and they caused infestation. In natural pollination condition, plants received benefit from insect pollinatiors but all the pests in the field were free to cause infestation in the suitable parts of the plant. El-Shafie (2001) recorded 28 species of insects were associated with damage on the reproductive parts (flower buds and fruits), 3 species were responsible for the damage of stem and roots, while 18 species were notorious for their occurrence as foliage pests of brinjal.

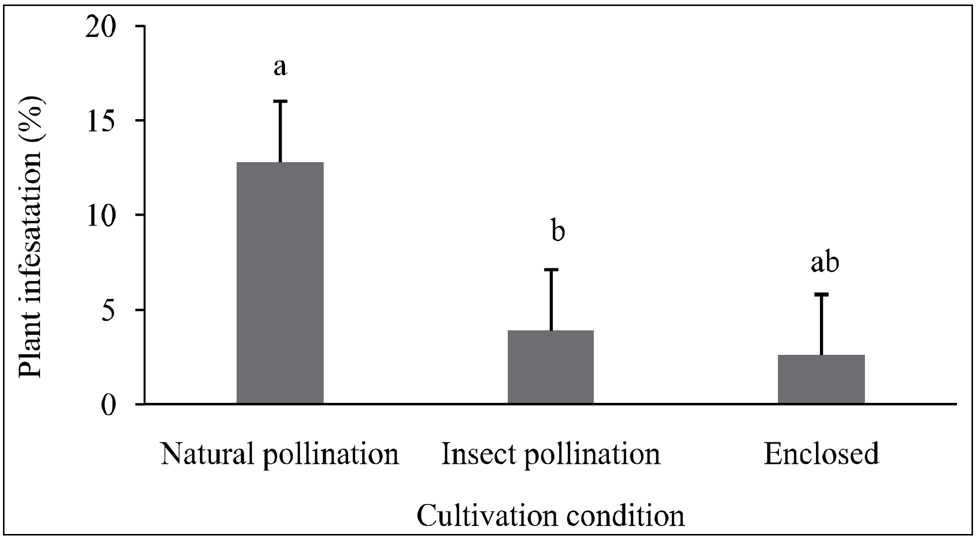

Fig. 2. Percent plant infestation by different chewing and sucking insects in different cultivation condition. Data expressed as % mean ± SE. Bars with common letter(s) are not significantly different by Tukey posthoc statistic at P < 0.05.

Insects, the biotic components of the environment are very potential interacting factors in the crop field. Their activity directly affects plant growth, productivity, and quality of the yields. Present study showed that pollination condition had significant effect on the number of fruit production of eggplant ($F_{2, 42}$ = 64.9, P < 0.001, Fig. 4). Fruit production in different pollination conditions varied from 7.2±0.4 to 14.4±0.4fruits plant^{-1}.Plants which were cultivated under enclosed with supplemented insect pollinators produced significantly the higher number of fruit compared to other two conditions (Fig. 4).

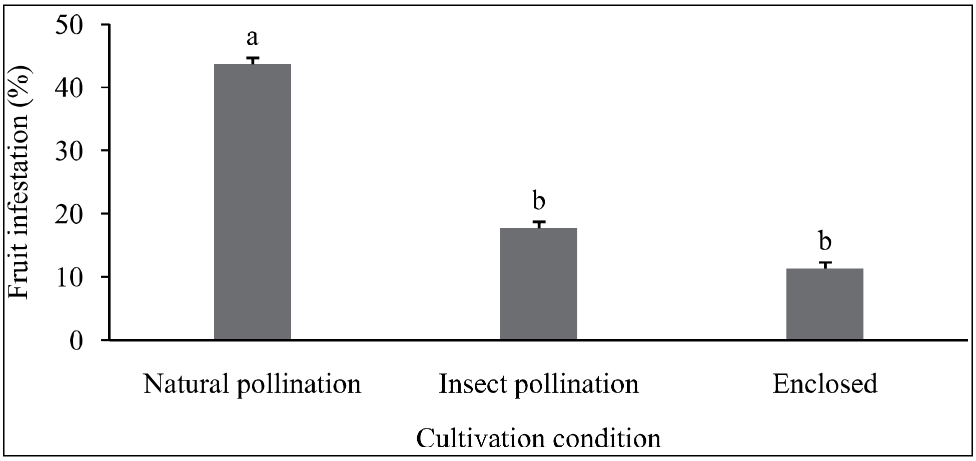

Fig. 3. Percent fruit infestation by different chewing and sucking insects in different cultivation condition. Data expressed as % mean ± SE. Bars with common letter(s) are not significantly different by Tukey posthoc statistic at P < 0.05.

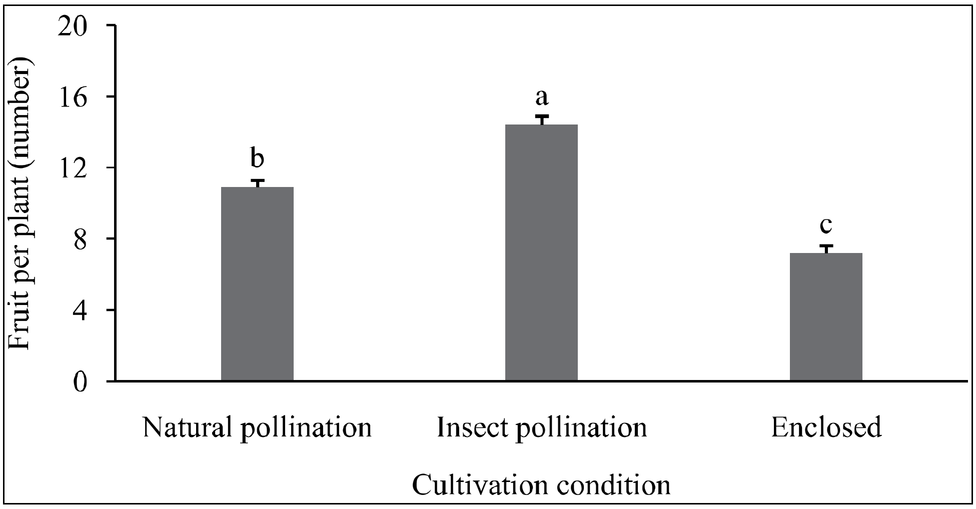

Fig. 4. Effect of pollination on the number of fruit production of eggplant. Data expressed as mean ± SE. Bars with common letter(s) are not significantly different by Tukey posthoc statistic at P < 0.05.

Significant different length and breadth of eggplant fruits were produced when cultivated natural pollination, insect pollination in enclosed condition (length: $F_{2, 27} = 9.3$, $P < 0.01$; breadth: $F_{2, 27} = 4.6$, $P < 0.05$; Fig. 5). Results showed that the fruit length and breadth ranged from 23.5±0.8 to 27.6±0.7 cm and 11.0±0.1 to 11.6± 0.2 cm, respectively.Fruit length and breadth were recorded the highest in insect pollinated condition. In enclosed with supplemented condition, there were sufficient insect pollinators and wind flew across the plot thus flowers received sufficient pollination. At the same time plants were protected from the attack of insect infestation. In this condition, plants were healthy and vigorous and they produced higher number of fruits per plant as well as larger and heavier fruits. On the contrary, plants did not receive proper pollination in the enclosed condition devoid of insect pollinators and produced significantly lower number as well as smaller fruits. Farjado *et al.* (2008) reported that introduction of bee colonies in eggplant field significantly increase fruit setting and yield.

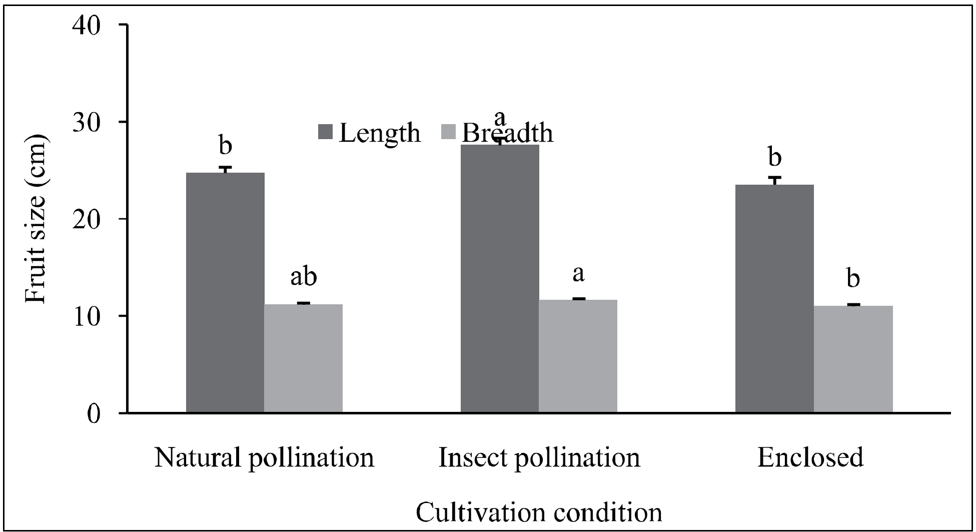

Fig. 5. Effect of pollination on the fruit size (length and breadth) of eggplant. Data expressed as mean ± SE. Bars with common letter(s) are not significantly different by Tukey posthoc statistic at P < 0.05

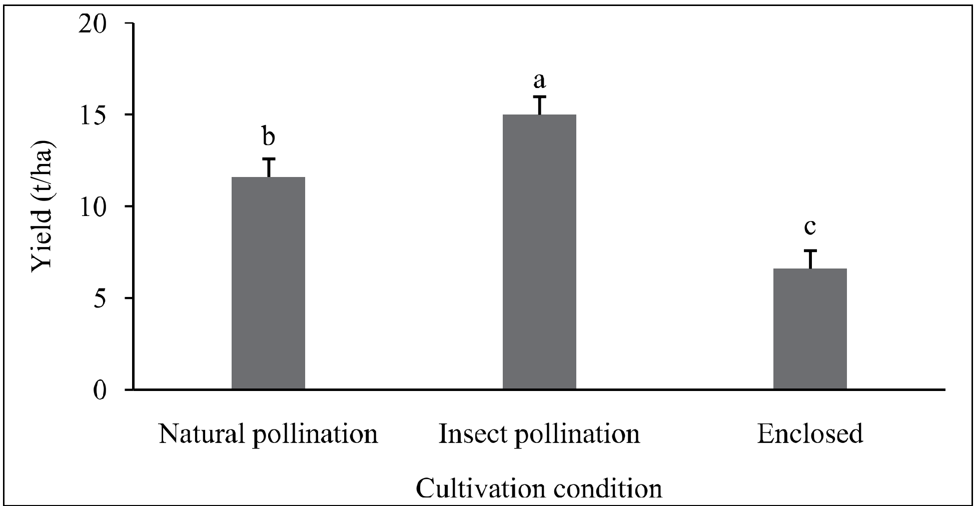

Fig. 6. Effect of pollination on the yield of eggplant. Data expressed as mean ± SE. Bars with common letter(s) are not significantly different by Tukey posthoc statistic at P < 0.05.

The yield of eggplant in different treated pollination conditions varied from 6.6±0.3 to 11.6±0.4 tha^{-1} and the results differed significantly (Fig.6, $F_{2, 18} = 109.1$, $P < 0.001$). The highest and the lowest yields were obtained in insect pollination and enclosed condition, respectively. Fruit yield depends on fruit setting, fruit size and protection from pest attack. In this study, eggplants cultivated in insect pollinated condition were safe from pest attack and the flowers got sufficient pollinators due to frequent supplementation of insect as pollinators. In insect pollination condition, plants produced higher number of fruits per plant and the fruits were larger in size thus ensured higher yield. Farjado *et al.* (2008) reported that the eggplants cultivated in insect pollination produced 23.5% fruit setting while that of un-pollinated caged flowers was 1.8%. Amin *et al.* (2015) reported that insect pollination activity increased fruit setting in mango. Vergara and Badana (2009) reported that the pollinator diversity increases fruit production in Mexico.

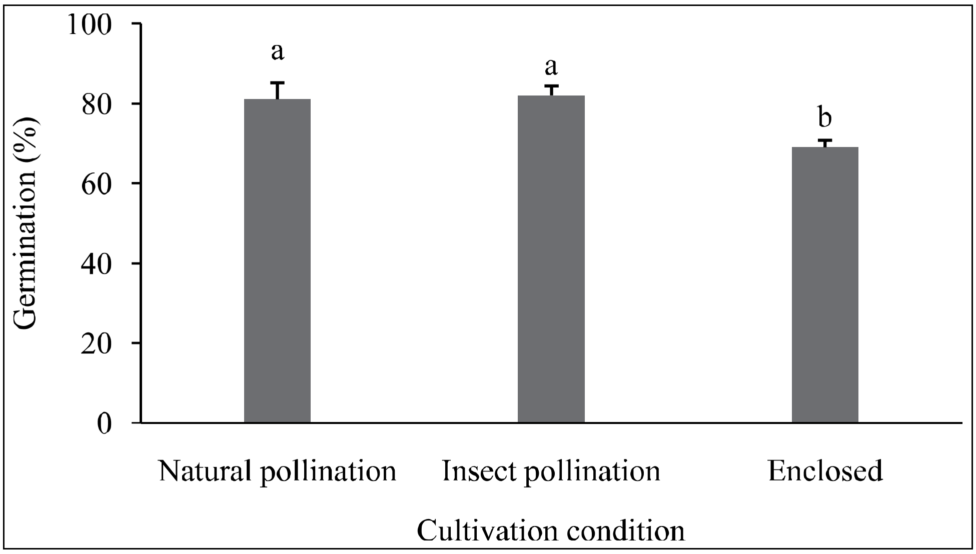

Fig.7. Effect of pollination condition on the germination of eggplant seed. Data expressed as mean ± SE. Bars with common letter(s) are not significantly different by Tukey posthoc statistic at P < 0.05.

Figure 7 shows the germination percentage of seeds in different treatments and the results differed significantly ($F_{2, 12} = 5.5$, $P < 0.05$). The germination percentage varied from 69.0± 1.9 to 82.0 ± 2.5% and the lowest results was found in enclosed condition devoid of insect pollinators. Germination percentage in natural (open) and insect supplemented pollination conditions showed statistically similar results. In natural and insect pollination conditions blooming eggplant flowers were very attractive to different groups of insects for pollination. On the contrary, the abnormal situation in the enclosed condition devoid of insect pollinators determined very weak seed setting.

Koltowski (2005) found that the plants freely visited by the pollinating insects, compared to those kept under gauze cover, were setting a similar number of fruits from 100 flowers and a higher number of seeds per pod. Plants freely available to the pollinating insects increased 16 to 50% yield compared to those under cover (Kamler, 1983; Manning and Boland, 2000). The findings of the present study showed that the foraging insects in eggplants are capable of producing higher yield and seed germination. Insect pest species caused significant level of infestation on plants and fruits, simultaneously pollinator insects contributed in producing higher yield and quality seed. Public awareness is necessary for implementation of IPM to control pest and conservation of native pollinators.

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