PERFORMANCE OF SOME COUNTRY BEAN VARIETIES AGAINST POD BORER, *MARUCA VITRATA* FAB. IN SUMMER

S. M. SHAFIUL ALAM

DEPARTMENT OF ENTOMOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
SHER-E-BANGLA NAGAR
DHAKA-1207, BANGLADESH

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BY

S. M. SHAFIUL ALAM

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Approved by

Prof. Dr. Md. Mizanur Rahman **Research Supervisor**	**Assist. Prof. Ayesha Akter** **Co-supervisor**

Prof. Dr. Md. Razzab Ali
Chairman
Examination Committee

DEPARTMENT OF ENTOMOLOGY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka

CERTIFICATE

This is to certify that thesis entitled, **"PERFORMANCE OF SOME COUNTRY BEAN VARIETIES AGAINST POD BORER, *MARUCA VITRATA* FAB. IN SUMMER"** submitted to the Faculty of **Agriculture,** 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 bona field research work carried out by **S. M. SHAFIUL ALAM, Registration no. 09-03747** under my supervision and 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.

Date: June, 2011
Place: Dhaka, Bangladesh

Prof. Dr. Md. Mizanur Rahman
Research Supervisor

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ABSTRACT

The experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during April 2011 to November 2011 to evaluate the performance of some country bean varieties against the attack of pod borer in summer. The study was comprised of five varieties; IPSA seam-1, IPSA seam-2, IPSA seam-3, BARI seem-3 and Goalgada. From the present study it was observed that the BARI seem-3 variety of country bean gave the highest result. The variety BARI seem-3 showed highest (14.67 ton ha^{-1}) total yield among the different varieties of country bean used in the present study. This variety (BARI seem-3) performed best results in increasing number of healthy flower for 5 inflorescences (11.00), lowest number of infested flower for 5 inflorescences (0.6667), lowest flower drops (4.333), highest total number of pods (127.3 pods $plot^{-1}$), increasing number of healthy pods (119.0 pods $plot^{-1}$), increased rate of length (14.83 cm) and girth (6.867 cm) of 5 healthy pods, highest total weight of healthy pods (758.3 g), lowest number of infested pods (8.333 pods $plot^{-1}$),increased rate of length (10.90 cm) and girth (6.033 cm) of 5 infested pods, highest total weight of infested pods (93.67 g) over the other varieties. The variety IPSA seam-1 showed the least performance regarding all the parameters. Whereas, IPSA seam-3 variety gave the second best performance regarding the above parameters including the second highest yield (10.67 ton ha^{-1}).

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CHAPTER I

INTRODUCTION

The country bean, *Lablab purpureus* Lin. (Leguminosae: Papilionaceae), is an important vegetable-cum-pulse crop grown everywhere in Bangladesh. This bean frequently known as Seem, Hyacinth bean, Indian bean, Egyptian kidney bean and Bovanist bean (Rashid, 1999). The crop is very popular for its tender pods, which are consumed mostly as vegetables, sometimes as pickles. Its tender seeds are also used as vegetables; however, the matured and dried seeds are used as pulses. In Bangladesh, the crop is usually grown in winter. But recently, a number of photo-insensitive and summer varieties are developed, which helped to promote the cultivation of country beans year-round including summer. About 40,992 metric tons of country beans are produced from 88,581 hectares of land per year in Bangladesh, (BBS 2010).

The crop cultivation faces various problems including the pest management (Rashid, 1999). These include the availability of quality seeds, irrigation water and technical information, supply of fertilizers, incidence of pest and diseases, transportation, storage and marketing. Among these problems, occurrence of frequent insect pest attacks has been most important, requiring the pests to be managed twice or thrice in a season. Insect pests, which cause colossal losses to bean crops, are serious problems. Reports reveal that in Bangladesh, over 30 different species of arthropods have been reported in country bean crop, although only a few occur regularly and cause economic damage (Alam, 1969; Begum, 1993; Karim, 1993, 1995; Das, 1998; Islam, 1999). Among the insect pests, the pod borer, *Maruca vitrata* (Fabricius), is considered as one of the major pests of country beans in Bangladesh.

Bean pod borer population has been found to reduce up to 100 percent of crop yields in pigeon pea in Bangladesh (Rahman *et al.*, 1981). Farmers in Bangladesh frequently require application of control measures to suppress the population of the pest, thereby to protect their crops (Rahman and Rahman, 1988; Begum, 1993).

But the fact is that still now the farmers mostly dependent solely on chemical insecticides to control the pest infesting country beans. Such an over reliance on insecticides for controlling insect pests in crop fields has developed over generations (Islam, 1999). Insecticides commonly used, however, are not specific and they frequently kill natural enemy populations and may cause upset and resurgence of other pest populations (Debach and Rosen, 1991; Pedigo, 1999).

In addition, development of insect biotypes resistant to the commonly used insecticides is not uncommon (Debach and Rosen, 1991; Pedigo, 1999). Thus as an alternative to sole reliance on insecticide, the use of resistant cultivars and other non-chemical methods would provide avenues towards safer pest control practices.

Considering the above facts view in mind, the experiment has been undertaken with the following objectives:

- To study the performance of some varieties of country bean on incidence of pod borer in summer.
- To identify the best variety for cultivation which can withstand against the infestation of the insect pests of country bean.

CHAPTER II

REVIEW OF LITERATURE

Although country bean is an important vegetable-cum-pulse crop of the tropics, the crop cultivation faces various problems including the pest management. Among the insect pests, the pod borer is considered as one of the major pests of country beans. But considerable literature dealing with reducing infestation of pod borer, performances and effectiveness of chemical and non-chemical treatments are very limited. An attempt has been taken in this chapter to review the pertinent research work related to the present study. The information is given below under the following headings:

2.1 General review of bean pod borer

2.1.1 Nomenclature

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Pyralidae

Genus: *Maruca*

Species: *Maruca vitrata* Fab.

2.1.2 Biology of pod borer

The pod borer is a holometabolous insect. So, it has four stages to complete its life cycle viz. egg, larva, pupa and adult.

Egg

Maruca vitrata females normally lay eggs on floral buds and flowers, although oviposition on leaves, leaf axils, terminal shoots, and pods has also been recorded (Bruner, 1931; Wolcott, 1933; Krishnamurthy, 1963; Taylor, 1963, 1967, 1978; Vishakantaiah and Babu, 1980; Rai, 1983). The eggs are normal1y deposited on the under surface of plant parts (Vishakantaiah and Babu, 1980; Rai, 1983). A female may lay up to 400 eggs in batches of 2-16 (Okeyo-Owuor and Ochieng, 1981; Jackai et al., 1990). The effect of temperature on oviposition and adult longevity of *Maruca vitrata* was examined by Chi et al. (2005). Female adult longevity and pre-ovipositional period were shortened with increasing temperature. The egg laying period lasts an average of 3 days at 24-27ºC (Ramasubramanian and SundaraBabu, 1989). Eggs are light yellow, translucent, and have faint reticulate sculpturing on the delicate chorion, and measure 0.65 x 0.45 mm (Taylor, 1967).

Larva

The mean incubation period is around 3 days under at around 25-28°C and over 80% relative humidity (vishakantaiah and Babu, 1980; okeyo-owuor and ochieng, 1981; Rai, 1983). Mature larvae are 17-20 mm long. The head capsule is light to dark brown, and the prothoracic plate is dark brown and divided dorsally. The body is whitish to pale green or pale brown, with irregular brownish black spots; the spots become indistinct immediately before pupation. There are five instars that a larva has to pass through before molting into a pupa (Odebiyi, 1981). The total length of the larval period on cowpea was about 11 days in lndia (Singh1983), which was 8-13 days in Southern Nigeria (Taylor, 1967), and10-14 days in Kenya (okeyo-owour and ochieng, 1981). Early instars are dull white, but the later instars are black-headed, with irregularly shaped brown or black spots on the dorsal, lateral and ventral surfaces of each body segment.

Pupa

Once matured and the food materials required to consume and preserve for supporting the pupal stage, the fifth instar larva stops feeding and the body shrunk before entering in to the pupal stage. To pupate, the larva spins silken threads around it in a net fashion and molt into a pupa within the silken cocoon covered under dried leaves on soil. The color of the pre-pupa is light green and measures 13 mm in length and 2.59 mm in width (Rai, 1983). The pre-pupal period lasts for 2 to 3 days (Rai, 1983) at around 25-28°C. A pupa measures 11.59 mm in length and 2.83 mm in width (Rai, 1983). The pupa is reddish brown in color. Being a tropical and subtropical insect, *M. vitrata* does not require entering into diapause (Taylor, 1967). The lower developmental threshold temperature for pupae is 15.6 - 17.8°C and the upper threshold is 28 -34°C (Sharma, 1998).

Adult

About 8 or 9 days after pupation, an adult emerges from the pupa, (Rai, 1983). The adult moths of bean pod borers usually emerge in the night, most of them emerge between 20:00 hr. and 23:00 hr., although some may emerge late in the night or early in the morning (Jackai et al., 1990). Generally, adults of the emerged insect population comprise the male: female ratio of 1:1 (Rai, 1983). The moths are small, dark gray in color with white brown patterns of the wings. The adult moth has light brown forewings with white patches, and white hind wings with an irregular brown border. It often rests with the wings outspread measuring up to 25 mm. They are inactive during the day and can be found at rest with outspread wings under the lower leaves of the host plants.

Adults live, on average, 6-10 days. The female moths have been found to live 11 or 12 days, whereas the males live 9 or 10 days at around 2BoC (Singh 1983). Djamin (1961) reported that the female moths lived up to 22 days and male moths up to 12 days elsewhere. Taylor (1978) found that in Nigeria female moths could live for 4 to 8 days.

Okeyo-Owour and Ochieng (1981) reported that adults lived for 12 to 26 days in Kenya. The variations of the duration in the adult longevity were presumably due to the variations in ambient temperature and humidity in different regions. The life cycle is completed in 18-35 days depending upon temperature.

2.1.3 Host range of legume pod borers

The legume pod borer, *(Maruca vitrata* F.), is a polyphagous insect, lwhich has been reported to feed on various types of plants, both cultivated and wild. Akinfenwa (1975) and Atachi and Djihou (1994) reported that the insect has been observed to feed on 39 host plants; most of these plants were leguminous. Among the host plants, the most frequent ones are *Cajanus cajan*, *Vigna unguiculata*, *Phaseolus lunatus*, and *Pueraria phaseoloids*. The insect has been reported to consume and survive well on pigeonpea, cowpea and hyacinth beans (Ramasubramanian and Babu, 1988; Ramasubramanian and Babu, 1989a). On the basis of number of eggs laid, percentage of egg hatch, growth index, and adult emergence are considered, despite several species of host plants are avatlable, hyacinth bean has been found to be the most suitable host for culturing *M. vitrata* (Sharma, 1998). In absenceof the preferred hosts, the insect would perpetuate on alternate and wild hosts such as *Vigna triloba, Crotularia sp., Phaseolus sp*. and pigeonpeas (Taylor, 1967). Sharma (1998) reviewed the host plants of the pest and compiled a list of about 40 plant species used by legume pod borers as their hosts.

2.1.4 Seasonal distribution of legume pod borer

Legume pod borer population build-up is related to cumulative rainfall and the number of rainy days between crop emergences to flowering (Sharma, 1998). The insect is multivoltine; having at least two over lapping generations a year in most places of its distribution (Sharma, 1998). Being a multivoltine insect with polyphagous nature of feeding activities, and with preference for some particular parts of a particular host plant

(Karel, 1985; Sharma 1998; Singh and Taylor, 1978). Legume pod borer is likely to differ in its seasonal distribution spatially even within a host plant and temporally within the growling season of a particular host plant. Again, the weather pattern varies across continents, and therefore, the seasonal distribution of the insect is likely to vary regionally as well.

In Nigeria, the insect reaches to its peak infestation levels during June and July (Tayior, 1967). The first generation adults developing from the initial stock-generation in cowpea fields appears in July and the second generation between July and September. When host plants become scarce, or the prevailing environment becomes less favorable, the insects possibly migrate from South to North guided by air-movements of the inter-tropical convergence zone, and again head toward South in November-December (Taylor, 1967). Within a 24-hour timeframe, adults of the insects are more active from dusk to midnight, with a peak occurrence between 20:00 and 21:00 h (Akinfenwa, 1975). In Kenya, pod borer populations are low during the short rainy season, although infestation continues unless flower and pod production ceases (Okeyo-Owuor *et al.*, 1983). At ICRISAT Headquarters, moth catches were greatest between early November to mid December in the light traps (Srivastava *et al.,* 1992) with peak catches occurring during November. In Sri Lanka, Saxena *et al.* (1992) observed a high larval density in host crops planted in mid-October. In Bihar of India, Akhauri *et al.* (1994) observed that on early pigeon pea the larval density increased from mid-October to the end of November, with the occurrence of peak larval density in the last week of November. Sharma (1998) reported that the presence of significant relationships between the peak occurrence of pod borers and cumulative rainfall and number of rainy days between crop emergences to flowering.

In Bangladesh, Alam *et al.* (1969) studied the infestation levels of *M. vitrata* on different plant parts of country beans in Gazipur and Jessore. They found that the patterns of seasonal occurrence varied in flowers and pods in both localities. However, the authors did not provide any information regarding the seasonal distribution of the pest in either locality. But, they reported that pods experienced the more infestation than did flowers. Rahman and Rahman (1988) in a study found that the insect attacked the rabi-season pigeon peas from mid December until the crop was harvested in early February in Gazipur. The authors found in the same study that legume pod borer larvae occurred with their peaks during the second week of January to the beginning of February. However, according to them, the insect population may vary depending on the plant parts present; they found larval peak population in flowers around the middle of January, after which the population declined in flowers. On the other hand, the insect tended to occur increasingly in pigeon pea pods until the end of January. Such difference in the seasonal distribution of the pest infestation in different plant parts of the same host plant is presumably because of the preference of one part to the other, a phenomenon very common in insects. The suitability of a particular plant part as a feeding unit may also change over time (Wold and Marquis, 1997). This may also be the case with pigeon peas causing a decline in frequency of infestation on flowers, while increasing the frequency of infestation on pods, as found in the study of Rahman and Rahman (1988).

2.1.5 Nature of damage of legume pod borers

Maruca vitrata (Fabricius) is a tropical insect that attacks several species of plants, primarily the legume plants, although pod borers in the genus *Maruca* are polyphagous in nature (Taylor, 1978; Singh and Jackai, 1988; Rahman, 1989; Babu, 1989). Babu (1989) reported that hyacinth bean, which is also known as the country bean, is the most favorable food plant for *M. vitrata (testulalis).* Generally the insect infestation begins at the terminal plant parts (Jackai, 1981). At the early stage of plant growth, the insect attacks plant leaves, fastens the leaves together to clusters and feed while living inside the tunnels of clusters (Singh, 1983; Das and Islam, 1985; Rahman, 1989; Karim, 1993). However, the insect prefers ovipositing at the flower bud stage, suggesting that at earlier stages of plant growth, infestations of legume pod borer may not be conspicuous. Pod borer infestation is more frequent from flowering stage of plants. As soon as buds and flowers appear on plants, many of the insect larvae can be present moving from buds/flowers to buds/flowers and bore into them. A single larva can consume 4-6 flowers before the larval development is completed (Sharma, 1998). The attacked buds and flowers subsequently wither and may fall down. Later the insects move into pods and bore into the pods; the insect would occasionally bore into peduncle and stems of host plants (Taylor, 1967). Generally, one larva bores into a single pod, although there have been instances where two or more larvae entered into a single pod (Das and Islam, 1985). In such a case, when more than one larvae enter into a single Pod, cannibalism might be occurring, a phenomenon very common in most leaf miners. However, there has been little research in this regard for legume pod borers.

The first and second instars larvae feed mostly on the inner walls of the young pods and scrap inside the bored pods/flowers. The larvae of later instars, in most cases, enter into the pods, bore into the seeds and feed these parts by making circular holes. The entry holes are often difficult to visualize, as the holes are often plugged with the faecal excretion of the pest. In instances where the extruded frass can be seen from the outside, it is rather an obvious indicator of pod borer infestation (van Emden, 1980). The infesting larva can consume the entire seeds within a pod. After entering into a pod, the larva usually does not leave it until the food is totally exhausted. The infested pod often becomes unfit for human consumption.

Although the insect has been found to feed on different plant parts as explained above, Karel (1985) in a study observed that more than 52% of the larval populations were feeding on flowers, and about 38% larvae were feeding on pods. In contrast, she found only about 10% of the larvae to be feeding on leaves. The result is consistent with Sharma (1998), who concluded that the order on preference of different plant parts is flowers > flower buds > terminal shoot > pods and seeds. As a result of the insect infestations, crop yields can often be severely affected (Singh and Taylor, 1978).

2.2 Yield loss caused by pod borer

M. vitrata (testulalis) is a very important pest causing profound damages to legume crops including the country beans in Bangladesh. Singh and Taylor (1978), Rahman (1987) and Rahman and Rahman (1988) reported that pod borer infestation may cause great reduction of yields of the infested crops. However, these authors did not provide any information with respect to the amount of percentage of yield reduction caused by the pest attack. Nevertheless, there have been several reports on quantified effects of the pest infestation on various crops. Singh and Allen (1980) reviewed the infestation of pod borers in field and horticultural corps across Africa, Asia, south Central America and Australia, and concluded that the insect can cause 20 – 60% damage to host crops. Karel (1985) in Tanzania found that the pod borer infestation could reduce seed yields of local French bean cultivars by 20%-50%. In Kenya, the insect was found to cause 80% reduction of cowpea production (Okeyo-Owuor and Ochieng, 1981). Rahman et.al., (1981) found the insect to cause as high as 100% infestation of black gram leaves, the effect of infestation at such high levels are likely to be profound on yield of the crop. Rahman et al. (1981) reported that bean pod borers could cause as high as 38% reduction of the yields of pigeon peas in Bangladesh. Ohno and Alam (1989) found that pod borer damage in cowpea was 54.4% at harvest, although the reduction of seed yield of cowpeas was estimated only 2o%. Sarder and Kundu (1987) studied pod borer infestation in four bean cultivars and reported that the borers caused up to 7% reduction of country bean yield in Bangladesh. Kabir *et al.* (1983) studied pod borer infestations on 32 different genotypes of country beans in Jamalpur, Bangladesh and found that the insect caused up to 17% damage to country bean pods. But for country beans the magnitude of infestation would be more severe, as infested pods are likely to be unfit and unacceptable for human consumption.

2.3 Pest complex of country bean

The pest spectrum of a crop can vary geographically and temporally (Pedigo, 1999). It appears that there have been variations of country bean pest complex in different countries and parts of the season. In east Africa, more than 50 arthropod pests are reported and the pestiferous effects of these insects vary across the continent (Singh, 1983). He also noted that in addition to the 50 insects known so far, there might have been some other insect pests and mites causing damage to the crop but they have been ignored because of the inconspicuous presence and activities of those pests. However, he noted that despite the occurrence of a large number of arthropod pests, only a few occur more frequently and can cause significant damage to the crop. These include mainly the bean flies, black bean aphids and pod borers in many east African countries.

Many pestiferous arthropods occur in America and some of them inflict severe damage to several legume crops including beans. In Hawaii, legume pod borer have been ubiquitous causing severe damage to beans including lima beans (Holdaway and Look, 1942).

In India, country bean has been reported to be attacked by more than 57 species of pestiferous arlhropods (Govindan, 1974).In nofihern India, country beans have been reported to be frequently attacked by the galerucid beetle, *Madurasia obscurella* Jacob (Coleoptera: Chrysomelidae), which may cause economic damage to the crop (Gupta and Singh, 1978). Naresh and Nene (1968), and Saxena (1973 and 1976) have also reported that galerucid beetles and some other insect pests including various aphid species; hooded hopper, *Leptocentrus taurus* Fb. (Homoptera: Membracidae); leaf beetle, *Sagra carbunculus* Hope (Coleoptera: Chrysomelidae); leaf-eating caterpillars, *Plusia oricalchea* Fb. (Lepidoptera: Pyralidae); leaf miner, *Cosmopterix* sp. (Lepidoptera: Pyralidae); leaf weevil, *Blosyron oniscus* Ol. and *Alcides collaris* P. (Coleoptera: Curculionidae); pod borer, *Maruca* sp. (Lepidoptera: Pyralidae); and mites, *Tetracychas* sp. (Acarina), attack country beans in different parts of India and the subcontinent. Singh (1983) also stated that there might have been 30 more species of arthropods associated with bean crops, but their inconspicuous nature probably caused them to be ignored. In Burma, country beans have been reported to be attacked by 14 arthropods pests (Shroff, 1920), although it is not clear which ones are of major importance in terms of damage.

In Bangladesh, country bean has been frequently reported to be infested with various species of aphids including *A. craccivora and A. medicagenis* Koch (Homoptera: Aphididae); bean bug, *Coptosoma cribrarium* Fb. (Hemiptera: Plataspidae); green semi-looper, *Plusia oricalchea* Fb. (Lepidoptera: Pyralidae); hooded hopper, *Leptocentrus tarus* Fb. (Homoptera: Membracidae); leaf miner, *Cosmopterix spp.* (Diptera: Agromyzidae); leaf weevil, *Blosyrus onisctts Ol.* (Coleoptera: Curculionidae); pod borer, *Maruca sp.* (Lepidoptera: Pyralidae); shoot borer, *Sagra carbunchulus H.* and, *S. femorata D.* (Lepidoptera: Pyralidae); shoot weevil, *Alcides collaris P.* (Coleoptera: Curculionidae) and the mite, *Tetranychar spp.* (Acarina) (Alam, 1969; Begum, 1993; Karim, 1993, 1995; Das, 1998; Islam, 1999). Among these insect pests, only a few species occur in most places of the country, and may often cause economic damages. Alam (1969) stated that there had been nine species of arthropod pests regularly occur in country bean fields, although only three species of insects including aphid, bean bug, leaf miner and one species of mites caused economic damages to the crop during 1970s in Bangladesh. It appears that with the progress of time there has been a shift in the assemblages of arthropod pest species in fields of the crop, particularly in Central Bangladesh. In 1990s, the major arthropod pests of country beans in Bangladesh were the aphid, *A. craccivora*, the pod borers, *M. vitrata* (*testulalis*) and *Helicoverpa armigera*, and the red mite, *Tetranychus sp.* Das (1998) reporled that there were five species of arthropods causing major damages to country bean; these included the aphid, *A. craccivora*; leafminer, *Cosmopteris sp*.; leaf paster, *H. indica*; pod borer, *M. vitrata* and the mite, *Tetranychlrs* sp. in different places of Bangladesh. It appears that the black bean aphid, *Aphis craccivor*, and the pod borer, *M. vitrata*, are common everywhere in Bangladesh (Karim, 1995; Das, 1998; Islam, 1999) and the infestation of the pest can often be so severe that the economy of the bean growers can be heavily affected in this country.

Among the major insect pests, aphids occur frequently. Because of their high reproductive capacity and sedentary habits, population of aphids can often be too high to make concerns to farmers. In addition, aphids can transmit diseases to plants, which make them a potential pest of crops, particularly at favorable environmental conditions of the pest. Aphid, *Aphis craccivora* is cosmopolitan in distribution and the insects damage different crops in the temperate, tropic and subtropics continents (Hill, 1983; Butani and Jotwani, 1984). In general, colonies of aphids start from a few individuals arriving from an infested area. Upon arrival, the insects reproduce rapidly and build up the colony. On country beans, aphids suck plant sap from underside of young leaves, tender twigs and shoots (Hill, 1983; Singh, 1983; Butani and Jotwani, 1984; York, 1992). When plants are heavily infested, leaf distortion and stunting frequently occur, which often result in poor fruit setting (Hill 1983; Butani and Jotwani, 1984; York, 1992). In addition to the damage caused by feeding, aphids also damage the crop by acting as a vector of diseases (Butani and Jotwani, 1984). Although aphids can cause damages by sucking plant sap and transmitting diseases, unless their population goes extremely high, aphids usually cause little damage through direct feeding activities. In addition, aphid populations are often suppressed naturally by a complex of predators including ladybird beetles (Coleoptera: Coccinellidae), lacewings (Neuroptera: Chrysopidae), syrphid flies (Dipetra: syrphidae), various species of insect parasitoids and other natural enemies. As a result, in most crop fields, aphid populations do not require to be suppressed by artificial pest management practices (Pedigo, 1999).

On the other hand, the legume pod borer, (*M. vitrata* F.) has been considered as a serious pest of grain legumes in the tropics and sub- tropics because of its extensive host range, destructiveness and wider distribution (Taylor, 1967; Raheja, 1974). In most places of its distribution, population of *M. vitrata* frequently reaches economic threshold levels causing enormous economic losses; to prevent rises to such damaging populations of the pest farmers frequently require application of control measures, particularly insecticides (Taylor, 1967). In Bangladesh, pod borers have been frequently attacking various crops including country beans and causing enormous amount of damages to the crop (Alam, 1969; Rahman and Rahman, 1988; Karim 1993). Therefore, interests in the present study have been concentrated on the legume pod borer. From hereon, discussion will be dedicated mostly to the legume pod borers and further discussed in detail in the following sections.

2.4 Control of pod borer in field crops

As summarized in the previous section, being one of the most frequently occurring and damaging insect pest of different legume crops including country beans, pod borers received interests from people involved in both research and business across continents (Singh and Allen, 1980) There have been growing interests in controlling the pest, country bean pod borer, in this country. Several methods including cultural, mechanical, biological and chemical methods ate available for controlling the pest in field crops. Despite the availability of various pest control methods, application of synthetic chemical insecticides appears to be the most common means of controlling legume pod borers, a trend consistent with most pests in field crops (Debach and Rosen 1991; Pedigo 1999). The management practices that have been commonly used for controlling insect pests including pod borers are reviewed and discussed below. For convenience, the methods have been discussed in two major categories, non-chemical and chemical control methods. Within each category, sub-categories have been described.

2.4.1 Non-chemical control

Farmers believe that insecticides are the only method to control insect pest. This mental make up has been created from their practice of using insecticides to control the insect pests attacking their crops over many years (Islam, 1999). More over, the government's policy of giving 100% subsidy on pesticides i.e., giving the pesticides free of cost to the farmers had helped encourage and develop the habit of indiscriminate use of pesticides among the farmers. This is serious basic problem in achieving success in IPM programs.

Cultural control

The populations of legume pod borers are frequently suppressed naturally by environmental factors including temperature, humidity and photoperiod (Karim, 1995).

Among the environmental factors, rainfall appeared to be one of the important key factors; the distribution of rainfall over time is more critical than the total amount in determining pod borer populations. Thus, the adjustment of planting dates in such a way that the crop receives rainfall for a considerable period from flowering to harvest has been suggested as a component of a pest management system that is structured in an Integrated Pest Management (IPM) set up. Again, pod borer population tends to build up over the season (Ekesi *et. al.*, 1996), the pod borer infestation increases on the late sown crop (Alghali, 1993a). In such a case, yield may be affected, as is the case with cowpea, grain yield of which decreases in late planted crops (Ezueh and Taylor, 1984). In such a case, early planting might help reduce legume pod borer infestation.

Cropping system has profound effect on pod borer infestation. As a cultural practice of controlling pod borer infestation, intercropping has been successfully used. It has been reported that pod borer damage in a monocrop is greater than the maize-cowpea-sorghum crop grown as intercrops (Amoako-Atta and Omolo, 1982; Amoako-Atta *et. al.*, 1983; Fisher *et. al.*, 1987; Omolo *et. al.*, 1993). Karel (1984 and 1993) also reported that pod borer incidence was significantly lower in intercropped than in pure stands. In contrast, Alghali (1993b), Ofuya (1991), Natarajan *et. al.* (1991), Patnaik *et. al.* (1989) and Saxena *et. al.* (1992) reported no effect of intercropping on the incidence of *Maruca vitrata*. This suggests that the success of the adjustment of cropping time and system in reducing the pod borer infestation may vary depending upon the crop and time of the season.

As a cultural mean of controlling pod borers, adjustment of plant density can be another option. Plant density has been found to affect pod borer activities. Karel (1984 and 1993) found that at higher plant densities of common bean, *Phaseolus vulgaris*, pod borer infestation was reduced compared with a lower plant population. In the context of country bean production in Bangladesh, there has been little information regarding pod borer control by using cultural methods of pest control. Research in this regard may be helpful to come by some cultural tools that could be integrated with other methods of pest control.

Biological control

Biological control agents including predators, parasitoids and pathogens greatly reduce pest populations in various crop fields. There have been researches on predaceous fauna of legume pod borers across continents (Usua and Singh, 1977; Barrion *et. al.*, 1987; Vishakantaiah and Babu, 1980; Okeyo-Owuor *et. al.*, 1991). In general, the role of predators in pest population reduction is difficult to determine in field conditions (Debach and Rosen, 1991; Pedigo, 1999). This is simply because predators usually devour the prey immediately leaving no trace or signs of the predation. As a result, there has been little information on control of pod borers by predators.

There have been researches on parasitic fauna of legume pod borers across continents (Usua and Singh, 1977; Barrion et. al., 1987; Vishakantaiah and Babu, 1980; Okeyo-Owuor *et. al.*, 1991). It has been noted that, parasitoids, both by their stinging and direct feeding activity during the process of host selection for oviposition and by killing the parasitized larvae and pupae, inflict significant mortality to most insect pests (Debach and Rosen, 1991). Okeyo-Owuor *et. al.*, (1991) conducted extensive research on biological control of pod borers in Kenya and conducted that a plethora of parasitic fauna attacks bean pod borers and greatly suppress the pest infestation in several places. Okeyo-Owuor *et. al.*, (1991) that more than 98% of the eggs oviposited by pod borer females do not reach adulthood in Kenya. One of the key factors causing such a high level of mortality was the parasitoid, which included seven parasitoid species. It is believed that a plethora of parasitoids are active and they probably kill significant portions of legume pod borer population in Bangladesh. However, there is little investigation in this regard.

Pheromonal control

The use of pheromone has also been reported against legume pod borer. In Kenya, pheromone traps were used against the bean pod borer *Maruca vitrata* (Okeyo-Owuor and Agwaro, 1982). The pheromone used has been a female sex pheromone. Generally, the sex pheromones could be successfully used as mating disruptors and prevent pod borers from rising to population levels damaging the crop (Alghali, 1993). However, pheromone trap is a tool that has been used frequently for monitoring the population of a particular pest rather than controlling the pest (Pedigo, 1999). In addition, pheromones are frequently sensitive to time; last for a relatively short period have the potential to influence natural enemy populations (Pedigo, 1999). Construction and placement of the traps also important. As a result, pheromones have been rarely used for the control of bean pod borers in Bangladesh.

2.4.2 Host plant resistance

Genetic control of pod borer mostly reflects the use of resistant plant genotypes against the pest. Searches for plant materials resistant to legume pod borers have been frequently made across continents. Screening techniques for plant materials resistant to the pest have been reported from field, greenhouse and laboratory conditions (Jackai, 1981 and 1991; Valdez, 1989; Echendu and Akingbohungbe, 1990). Sharma (1998) reviewed and concluded that significant progress in developing resistant varieties in this regard have been made using cowpeas and pigeonpeas as plant materials from Africa. Mechanisms associated with resistance of those plant materials have been explored and determined (Sharma, 1998). Ramasubramanian and Babu (1989b) studied country beans, cowpeas and pigeonpeas and concluded antixenosis, antibiosis and tolerance have been the mechanisms through which these plant materials resisted pod borers activities. They also reported that country beans exhibited less antixenosis for oviposition of the pest compared with the other legumes they tested. In contrast, Valdez (1989) did not find such events in cowpeas. Non-preference of larval feeding has been reported to be associated with pod borer resistance in cowpeas (Echeden and Akingbohungbe, 1990). Valdez (1989) and Sharma (1998) found prevalence of larval antibiosis on some cowpeas genotypes. Okech and Saxena (1990) also attributed antibiosis to be a mechanism of some legumes pod borer resistant cowpea and pigeonpea genotypes. Saxena *et al.* (1996), on the other hand, observed some materials to be tolerant to the pod borers.

Factors associated with plant resistance to legume pod borers have been studied, which indicate that morphological, anatomical and biochemical factors greatly determine the capability of a plant material to be resistant to legume pod borers. Plant morphological characteristics include open plant canopy, long peduncles, and pod characteristics including size, growth, erectness and angle (Singh, 1978; Usua and Singh, 1979; Oghiakhe *et al.*, 1992b; 1993b). Lateef and Reed (1981) and Saxena *et al.* (1996) reported that indeterminate type of plants was more resistant to pod borers that the determinate type of cowpea plants. Singh (1978) and Oghiakhe *et al.*(1992b) reported that cowpea cultivars that had long pod peduncles and pod held at wider angles than the normal ones were more resistant to pod borers. Usua and Singh (1979) found that cowpea genotypes producing bunched pods suffer more damages by pod borers. Taylor (1986) observed that pod infestation was least in flower opened in eight days after anthesis in cowpeas. The author also noted pods maturing earlier provide some resistance to the pest. The author concluded that open plant canopy, long peduncles, erect pods with

wide angles, profuse flowerings, pod size and rate of pod growth can be used to select resistant genotypes against pod borers. Jackai and Oghiakhe (1989) found that the presence of trichomes affects larval feeding and development of legume genotypes.
Plant anatomy has also contribution to plant resistance against the insect. Oghiakhe *et al.* (1992b) noted that types and structures of stem's epidermal cells influence larval movement and feeding of stem's tissues. The author also noted that thinner stems were less attractive than the thicker ones. Oghiakhe *et al.* (1992b) stated that although epidermal cells mainly the collenchymatious cell of plants have been reported to be providing resistance against the pest, there has been no such effect consistent in their study, suggesting that some other factors are also needed for manifesting the effect.

The chemistry of plants has been found to be associated with plants' resistant to legumes pod borers (Oteino *et al*. 1985; Oghiakhe *et al*. 1993a). Oteino *et al*. (1985) indicated that ethyl acetate soluble fraction of methyl alcohol extracts showed significant feeding inhibition of legume pod borer on resistance cowpea genotypes. In contrast, Oghiakhe *et al*. (1993c and d) did not find any relationships between suger or phenol concentrations and resistance of cowpea cultivars against legume pod borers. This suggests that there might be some other factors involved, presence or absence of which may modify the type of response that a plant would exhibit when exposed to legume pod borer attacks. Rainfall, temperature and photoperiod of some of this factors influencing legume pod borer infestation.

It appears that most of the information regarding the use of plant resistant against legume pod borers is from cowpea and pigeonpeas. There has been little information about country bean genotypes that are resistant to legume pod borer. This aspect need to be thoroughly studied, as concerns regarding the use of chemical insecticides has been increasing greatly, and control method that are relatively safer are solicited for controlling insect pest on crops. For vegetables crops, safety issue are more critical, as vegetables are sometimes raw or within a few days after pesticides applications.

2.4.3 Chemical control

Despite the fact that there has been a plethora of natural enemies and that there have been many non-insecticidal means for controlling legume pod borers on legume crops including beans, farmers often apply insecticides for controlling the pests. Insecticides of both botanical and synthetic origins have been used. Karim (1995) successfully controlled legume pod borer by applying aqueous extracts of neem seed kernel powder at 25-50 g neem kernel powder/L of water at the beginning of flowering. Neem extracts may act as direct toxicants to larvae or they many affect feeding activities, growth and development of the insect pest (Jackai and Oyediran, 1991). These authors have documented in laboratory conditions that different formulations of neem oil affected survival of legume pod borers. Botanical insecticides have been successfully used in controlling many insect pests attacking different field crops (Pedigo, 1999). However, the use of botanicals is less popular, primarily because botanical compounds do not last long, as they are sensitive to light and heat; they often dissociate and loose insecticidal properties soon at higher light, temperature and moisture conditions.

Despite the availability of different pest control methods, it appears that synthetic chemical insecticides dominate the other means of controlling the insect pests on legumes including country beans. In Bangladesh, Karim (1993 and 1995) recommended application of synthetic pyrethroid insecticides including Deltamethrin, Cypermethrin or Fenvalerate or Cyfluthrin at the rate of 1.0 ml /1 of water for control of the legume pod borer. Dandale *et al.* (1981) reported the superiority of Cypermethrin, Fenvalerate and Endosalfan in reducing pod borer infestation in red gram elsewhere. Rahman and

Rahman (1988) sprayed 0.008% Cypermethrin at initial, 50% and 100% flowering and at l00% pod setting stages of plants and obtained complete protection of pigeon pea from legume pod borers in the winter season of 1987 - 88 in Bangladesh. They also tried Dimethoate, which however did not appear to be as much effective as the Cypermethrins were.

It is a general belief that application of insecticides is the only effective and economically viable method of controlling insect pests in field crops. The philosophy of such an over reliance on insecticides for controlling insect pests in crop fields has developed over generations (Islam, 1999). As a result, it appears very difficult in achieving success in popularizing alternative methods that could be more economic and sustainable in the long run (Debach and Rosen 1991; Pedigo 1999). Insecticides commonly used, however, are not specific and they frequently kill natural enemy populations and may cause upset and resurgence of other pest populations (Debach and Rosen, l991; Pedigo, 1999). In addition, development of resistant genotypes of the pest to the commonly used insecticides is not uncommon (Debach and Rosen, 1991; Pedigo, 1999). As an alternative mean to insecticide use, demand for the use of integrated Pest Management (IPM) has been increasing. However, successful IPM and economic pest management are based on some pest control decision making criteria, most frequently the economic threshold levels (ETL) (Pedigo, 1999). In the context of country bean crops in Bangladesh, such ETLs need to be established and popularized. The use of resistant cultivars and other non-chemical methods would direct us toward safer pest management practices.

CHAPTER III

MATERIALS AND METHODS

The study was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207 during the period from April 2011 to November 2011 to know the performance of some country bean varieties against the infestation of pod borer in summer. The materials and methods that were adopted for conducting the experiment are discussed under the following heading and sub-headings:

3.1 Experimental site

The experimental field was located at 90º 33.5´ E longitude and 23º 77.4´ N latitude at an altitude of 9 meter above the sea level. The field experiment was set up on the medium high land of the experimental farm.

3.2 Soil

The soil of the experiment site was a medium high land, clay loam in texture and having p^H 5.47-5.63. The land was located in Agro-ecological Zone of ‘Madhupur Tract’ (AEZ No. 28).

3.3 Climate

The climate of the experimental site is sub-tropical characterized by heavy rainfall during April to July and sporadic during the rest of the year.

3.4 Design of the experiment and layout

The experiment was conducted with 5 varieties. The experiment was laid out in a Randomized Complete Block Design (RCBD). The entire experimental field was divided into three blocks. Each block was divided into five plots. Two adjacent unit plots were separated by 1.0 m apart and blocks were separated by 1.0 m apart. Each experimental plot comprised of 3m x 2m area and the total area covered 13m x 16m. Each treatment combinations were allocated randomly within the block and replicated three times (Plate 1).

3.5 Land preparation and fertilization

The main land was ploughed thoroughly by a tractor drawn disc plough followed by harrowing. The stubbles of the crops and uprooted weeds were removed from the field and the land was then labeled prior to transplanting. The field layout was done on accordance to the design, immediately after land preparation. The plots were raised by 10 cm from the soil surface keeping the drain around the plots. During land preparation, cow dung was incorporated into the soil at the rate of 10 t/ha. Recommended doses of fertilizer comprising Urea, TSP and MP at the rate of 30, 90 and 65 kg/ha respectively were applied. Entire amount of cow dung was applied during the final land preparation. Entire dose of TSP and half amount of Urea and MP were applied to the soil of the pit 4-5 days before the transplanting. The rest amount of Urea and MP were top dressed 30 days after transplanting (BARC, 1997).

3.6 Experimental materials

Five varieties of country bean, namely IPSA seam-1, IPSA seam-2, IPSA seam-3, BARI seem-3 and Goalgada were selected as experimental materials for the experiment.

Plate 1. The experimental plot at SAU, Dhaka

3.7 Treatments

This experiment is consists of five varieties. Each variety of country beans was designated as individual treatment. The treatments of the present study were given as follows:

Treatment	Variety	Source
V_1	IPSA seam-1	Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur
V_2	IPSA seam-2	Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur
V_3	IPSA seam-3	Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur
V_4	BARI seem-3	Bangladesh Agricultural Research Institute (BARI), Gazipur
V_5	Goalgada	Siddiquebazar seed market, Dhaka

3.8 Collection of seeds

The seeds of among five country bean varieties IPSA seam-1, IPSA seam-2, IPSA seam-3 were collected from Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur; BARI seem-3 variety was collected from Bangladesh Agricultural Research Institute (BARI), Gazipur and Goalgada variety was collected from Siddiquebazar seed market, Dhaka.

3.9 Sowing of seeds

For rapid growth and germination the seeds of country bean varieties were soaked for 12 hours in water. Two seeds of each variety were then sown per polyethylene bags (12cm x 18 cm) containing a mixture of equal proportion of well-decomposed cow dung and loamy soil. Irrigation was given by watering can as per requirement. After germination, the seedlings were placed to partly sunny place for hardening. Finally, 15 days old seedlings were transplanted to the experimental plots as three seedlings per pit on last week of April. At the time of transplanting the polybags were cut and removed carefully in order to keep the soil intact with the root of the seedlings. The seedlings were transplanted in the pits with the entire soil ball. The seedlings were watered until they got established. Out of three seedlings per pit, one was removed two weeks after transplanting.

3.10 Intercultural operation

After transplanting the plants were initially irrigated by watering can and later on surface irrigation was given. After 7 days of transplanting, propping of each plant by bamboo sticks (1.75m) was provided on about 1.5m high from ground level for additional support to allow normal creeping. All the bamboo sticks in each row were fastened strongly by a galvanized wire to allow the vines to creep along. Weeding and mulching in the plots were done, whenever necessary.

3.11 Data collection

Data were recorded on the following parameters:

- Number of inflorescence plant^{-1}
- Number of flower for 5 inflorescences
- Number of infested flower for 5 inflorescences
- Number of healthy flower for 5 inflorescences
- Total number of pods plant^{-1}
- Number of healthy pods plant^{-1}
- Number of infested pods plant^{-1}
- Length & girth of 5 healthy pods (cm)
- Length & girth of 5 infested pods (cm)
- Weight of 5 healthy pods (g)
- Weight of 5 infested pods (g)

- Total weight of healthy pods (g)
- Total weight of infested pods (g)
- Total yield (kg)

3.12 Procedure of data collection

1. **Number of inflorescence**

   During the reproductive stage of the plant total numbers of inflorescences from each individual plant were recorded at 7 days interval in each treatment.

2. **Flower infestation**

   Five inflorescences from each individual plant were selected randomly and the data on number of healthy and infested flowers were recorded by regular observation at 7 days interval.

3. **Pod infestation**

   Harvestable mature pods were collected and sorted into infested and non-infested ones at weekly interval after careful examination on the presence of hole and excreta.

4. **Length, girth & weight of pods**

   Five healthy and five infested pods were randomly selected and the data on length, girth & weight were recorded from each plot in each treatment.

5. **Total yield**

   Total yield/plant was measured and then averaged to kg/plant. Total yield/plot was also taken and then total yield per hectare for each treatment was calculated in tons from cumulative pod production in a plot.

3.13 Data calculation

I. Percent of flower infestation

From the collected data on total number of flower and number of infested flower by bean pod borer the percent flower infestation was calculated using the following formula:

$$\%\text{ Flower infestation} = \frac{\text{Number of infested flower}}{\text{Total Number of flower}} \times 100$$

II. Percent of pod infestation

From the collected data on total number of pods and number of infested pods by bean pod borer the percent pod infestation was calculated using the following formula:

$$\%\text{ Pod infestation} = \frac{\text{Number of infested pod}}{\text{Total Number of pod}} \times 100$$

3.14 Statistical analysis of data

Analysis of variance was done with the help of computer package MSTAT program (Gomez and Gomez 1976). The data recorded on different parameters were subjected to analysis of variance (ANOVA) and the means were compared according to Least Significant Difference Test (LSD) at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to evaluate performance of some country bean varieties against the infestation of pod borer in summer. The data were calculated on the basis of number of inflorescence, flower infestation, pod infestation, length of healthy and infested pods, girth of healthy and infested pods, weight of total yield varied significantly with different treatments. The results of the present study have been discussed and possible interpretations are furnished and presented in this chapter under the following headings and plates (2-5):

4.1 Varietal performance of country bean on number of inflorescence

There were significant differences in number of inflorescences plant^{-1} among different varieties of country bean. Goalgada variety of country bean did not show any reproductive stage. The variety BARI seem-3 showed highest result (83.33 inflorescence plant^{-1}) which was closely followed (65.33 inflorescence plant^{-1}) by IPSA seam-3 and they were statistically identical. On the other hand, the lowest (34.00 inflorescence plant^{-1}) number was recorded from the variety IPSA seam-1 which was closely followed (44.33 inflorescence plant^{-1}) by the variety IPSA seam-2 and they were also statistically identical (Figure 1).

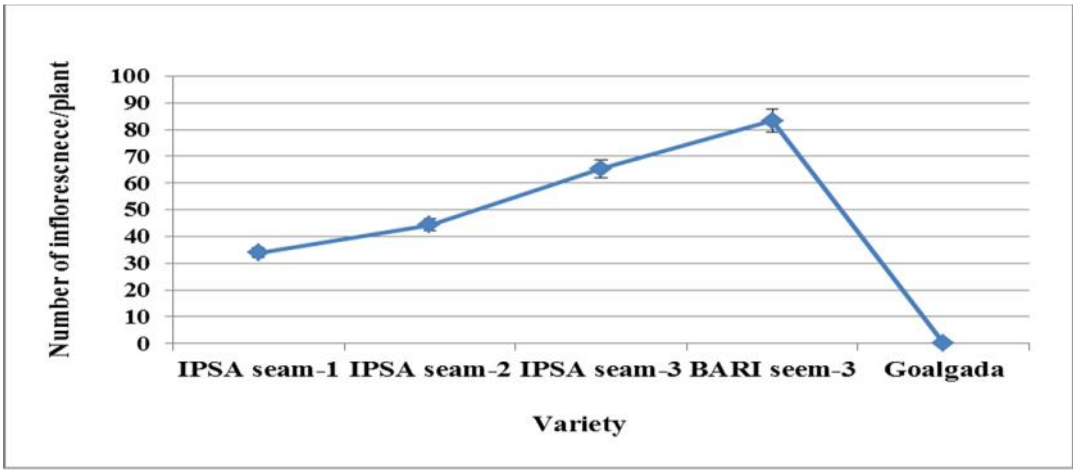
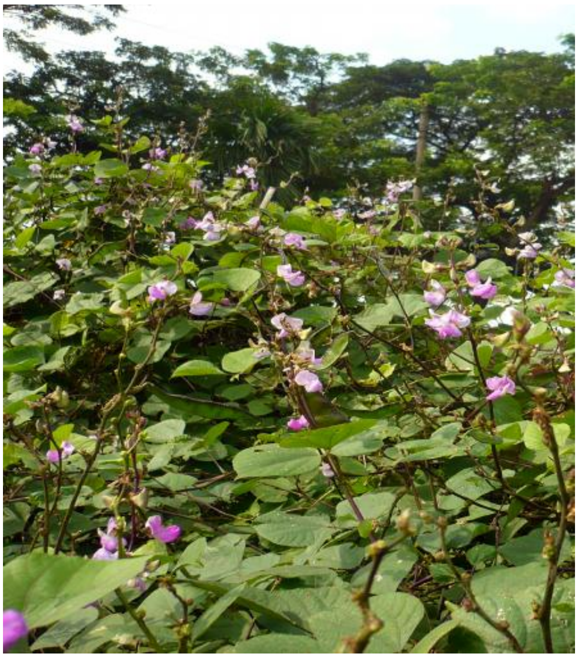


Figure 1: Varietal performance of country bean on number of inflorescences



IPSA seam-1

IPSA seam-2

IPSA seam-3

BARI seem-3

Plate 2. Different varieties of country bean showing the inflorescences

4.2 Varietal performance of country bean on number of flower

Different varieties of country bean used in the present study showed highly significant variation on number of flower for 5 inflorescences. The variety BARI seem-3 showed highest result (11.67 flower inforescence^{-1}) followed by IPSA seam-1 (9.667 flower inforescence^{-1}) and they were statistically identical. Whereas the variety IPSA seam-2 showed lowest (6.333 flower inforescence^{-1}) performance which was statistically identical with IPSA seam-3 (7.333 flower inforescence^{-1}) variety (Table 1).

Table 1: Varietal performance of country bean on number of flower

Variety	Number of flower/ 5 inflorescence
IPSA seam-1	9.667 ab
IPSA seam-2	6.333 c
IPSA seam-3	7.333 bc
BARI seem-3	11.67 a
Goalgada	0.000 d
LSD	**3.026**
CV (%)	**2.96**

In a column, numeric data represents the mean value of 3 replications, each replication is derived from 3 plants in a plot and means followed by different letter are significantly different at 5% level as per Least Significant Difference test (LSD).

4.3 Varietal performance of country bean on number of healthy flower

Different varieties of country bean used in the present study also showed significant variation on number of healthy flower for 5 inflorescences. The variety BARI seem-3 gave highest result (11.00 flower inforescence^{-1}) which was statistically identical with the variety IPSA seam-1 (8.667 flower inforescence^{-1}) in case of healthy flower for 5 inflorescences. Whereas the least performance was recorded for IPSA seam-2 (5.667 flower inforescence^{-1}) which was closely (6.667 flower inforescence^{-1}) followed by IPSA seam-3 (Figure 2). Pedigo (1999) reported that larger inflorescence and more flower buds increase appetency and food security, meaning more attraction of insects with increased inflorescence length and flower bud numbers.

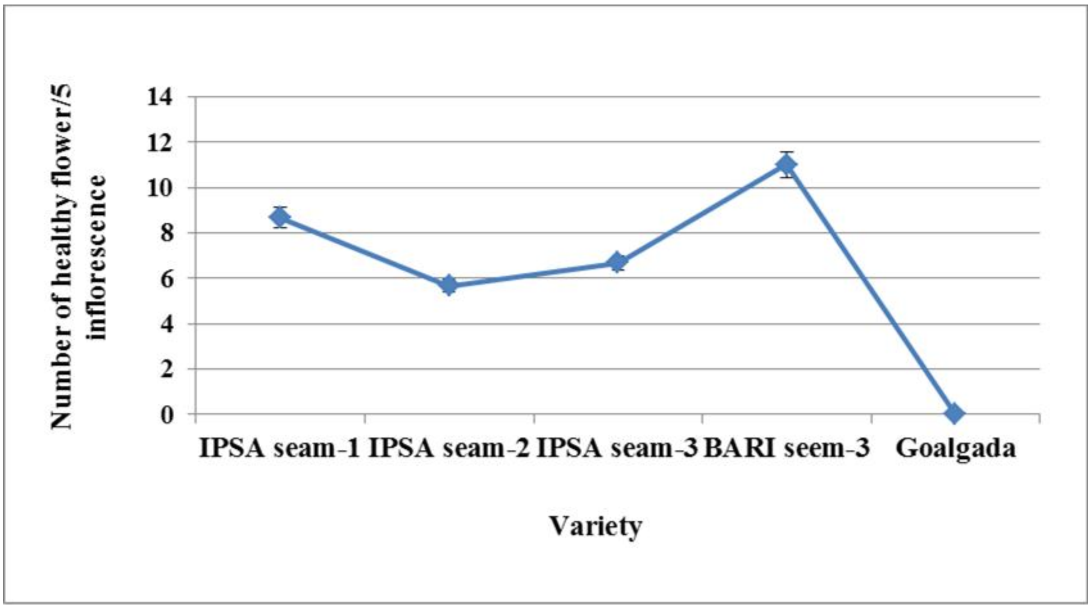


Figure 2: Varietal performance on number of healthy flower of country bean

4.4 Varietal performance of country bean on number of infested flower

Different varieties of country bean used in the present study also showed significant variation on number of infested flower for 5 inflorescences. The lowest (0.6667 flower inforescence^{-1}) flower infestation for 5 inflorescences was recorded for the variety BARI seem-3, IPSA seam-2 and IPSA seam-3 and they were statistically identical. Whereas the highest (1.000 flower inforescence^{-1}) flower infestation was recorded for the variety IPSA seam-1 which was also statistically identical with other varieties (Figure 3). Sharma (1998) observed the similar result where early flowering plants are highly likely to experience elevated levels of pod borer attacks compared with the late flowering ones, as found in the present study.

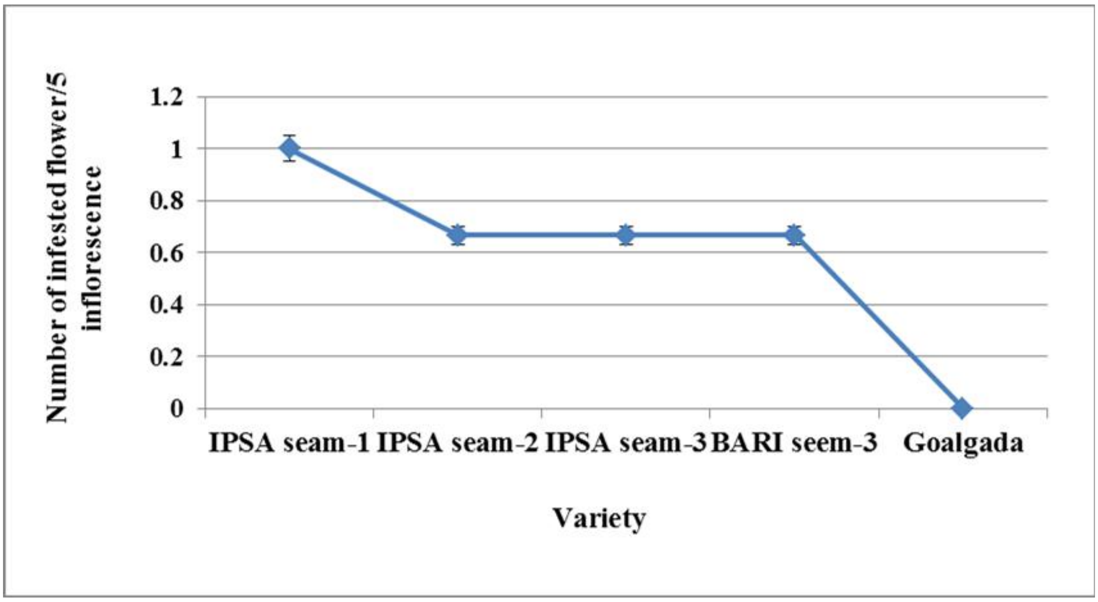


Figure 3: Varietal performance on number of infested flower of country bean

IPSA seam-1

IPSA seam-2

Plate 3a. Infested flower of IPSA seam-1 and IPSA seam-2 varieties of country bean

IPSA seam-3

BARI seem-3

Plate 3b. Infested flower of IPSA seam-3 and BARI seem-3 varieties of country bean

4.5 Varietal performance of country bean on total number of pods

Different varieties of country bean used in the present study also showed significant variation on total number of pods. The variety BARI seem-3 contained highest (127.3 pods plot^{-1}) total number of pods which was significantly different from other varieties and closely followed by IPSA seam-3 (93.33 pods plot-1). The lowest (53.33 pods plot^{-1}) total number of pods was recorded for the variety IPSA seam-2 which was closely followed by IPSA seam-1 (63.67 pods plot^{-1}) and they were statistically identical (Figure 4).

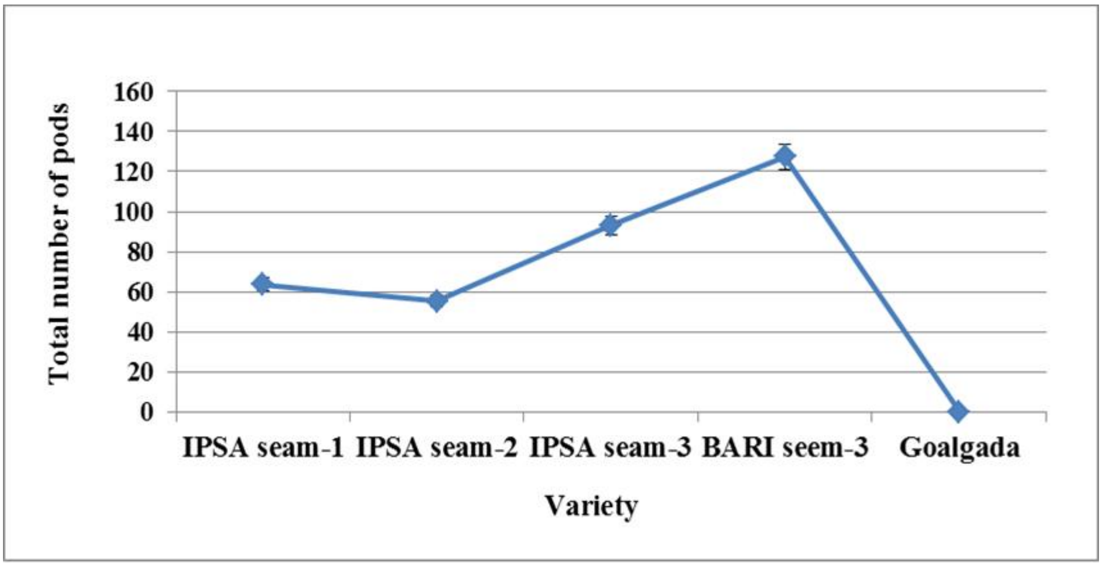


Figure 4: Varietal performance on total number of pods of country bean

4.6 Varietal performance of country bean on number of healthy pods

Different varieties of country bean used in the present study also showed significant variation on number of healthy pods. The variety BARI seem-3 contained highest (119.0 pods plot-1) number of healthy pods which was significantly different from other varieties and followed by IPSA seam-3 (68.67 pods plot-1). Whereas the least (34.33 pods plot-1) performance was recorded for the variety IPSA seam-2 which was followed by IPSA seam-1 (44.67 pods plot-1) and they were statistically identical (Table 2).

Table 2: Varietal performance on number of healthy pods of country bean

Variety	Number of healthy pods $plot^{-1}$
IPSA seam-1	44.67 b
IPSA seam-2	34.33 bc
IPSA seam-3	68.67 b
BARI seem-3	119.0 a
Goalgada	0.000 c
LSD	**40.55**
CV (%)	**4.39**

In a column, numeric data represents the mean value of 3 replications, each replication is derived from 3 plants in a plot and means followed by different letter are significantly different at 5% level as per Least Significant Difference test (LSD).

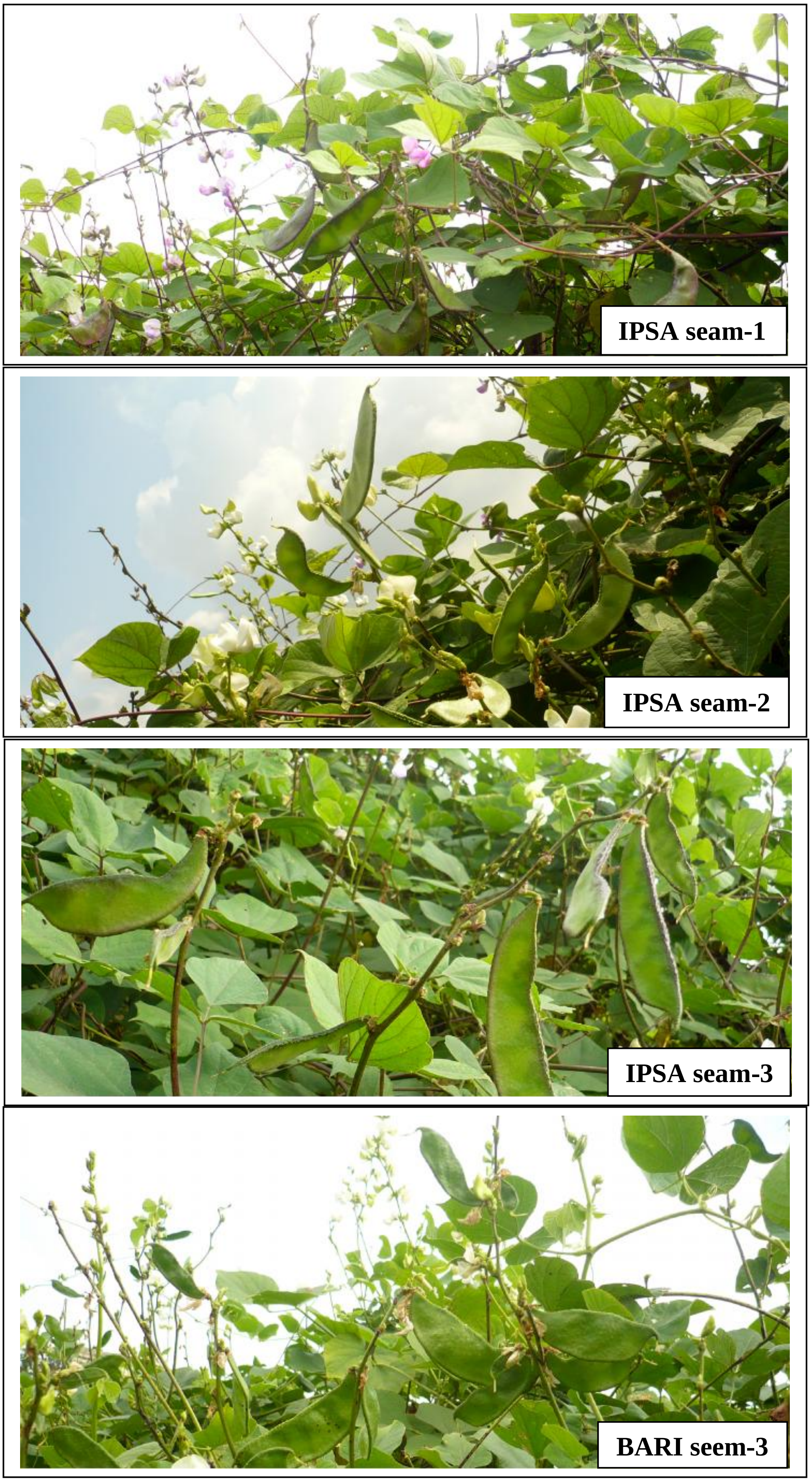


Plate 4. Different varieties of country bean showing pods

4.7 Varietal performance of country bean on number of infested pods

Different varieties of country bean used in the present study also showed significant variation on number of infested pods. The variety BARI seem-3 contained lowest (8.333 pods $plot^{-1}$) number of infested pods which was significantly different from other varieties. While the highest (24.67 pods $plot^{-1}$) number of infested pods was recorded for IPSA seam-3 which was closely followed by IPSA seam-2 (21.00 pods $plot^{-1}$) and IPSA seam-1 (19.00 pods $plot^{-1}$) respectively and they were statistically identical (Table 3). Pod infestation differs among varieties due to differences in the size, shape, color, texture and orientation of bean pods (Singh, 1980; Saxena *et al.*, 1992).

Table 3: Varietal performance of country bean on number of infested pods

Variety	**No. of infested pods $plot^{-1}$**
IPSA seam-1	19.00 a
IPSA seam-2	21.00 a
IPSA seam-3	24.67 a
BARI seem-3	8.333 b
Goalgada	0.000 b
LSD	**10.40**
CV (%)	**4.39**

In a column, numeric data represents the mean value of 3 replications, each replication is derived from 3 plants in a plot and means followed by different letter are significantly different at 5% level as per Least Significant Difference test (LSD).

IPSA seam-1

IPSA seam-2

Plate 5a. Infested flower of IPSA seam-1 and IPSA seam-2 varieties of country bean

IPSA seam-3

BARI seem-3

Plate 5b. Infested flower of IPSA seam-3 and BARI seem-3 varieties of country bean

4.8 Varietal performance of country bean on flower drops

Different varieties of country bean used in the present study showed significant variation on flower drops. The variety BARI seem-3 showed lowest (4.333 flower plot^{-1}) flower drops which was statistically followed by IPSA seam-3 (8.667 flower plot^{-1}). Whereas the highest (18.67 flower plot^{-1}) number of flower drops was recorded for the variety IPSA seam-2 which was closely followed by IPSA seam-1 (12.00 flower plot^{-1}) and they were statistically identical (Table 4).

Table 4: Varietal performance of country bean on flower drops

Variety	Number of flower drops plot^{-1}
IPSA seam-1	12.00 ab
IPSA seam-2	18.67 a
IPSA seam-3	8.667 abc
BARI seem-3	4.333 bc
Goalgada	0.000 c
LSD	**11.22**
CV (%)	**8.26**

In a column, numeric data represents the mean value of 3 replications, each replication is derived from 3 plants in a plot and means followed by different letter are significantly different at 5% level as per Least Significant Difference test (LSD).

4.9 Varietal performance of country bean on length of healthy pods

Statistically significant variation was observed in respect of length of 5 healthy pods at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (14.83 cm) length of 5 healthy pods which was significantly different from other varieties and closely followed by IPSA seam-2 (12.73 cm). Whereas the lowest length of 5 healthy pods was recorded for IPSA seam-1 (9.80 cm) which was closely followed by IPSA SEAM-3 (11.70 cm) and they were statistically similar (Figure 5).

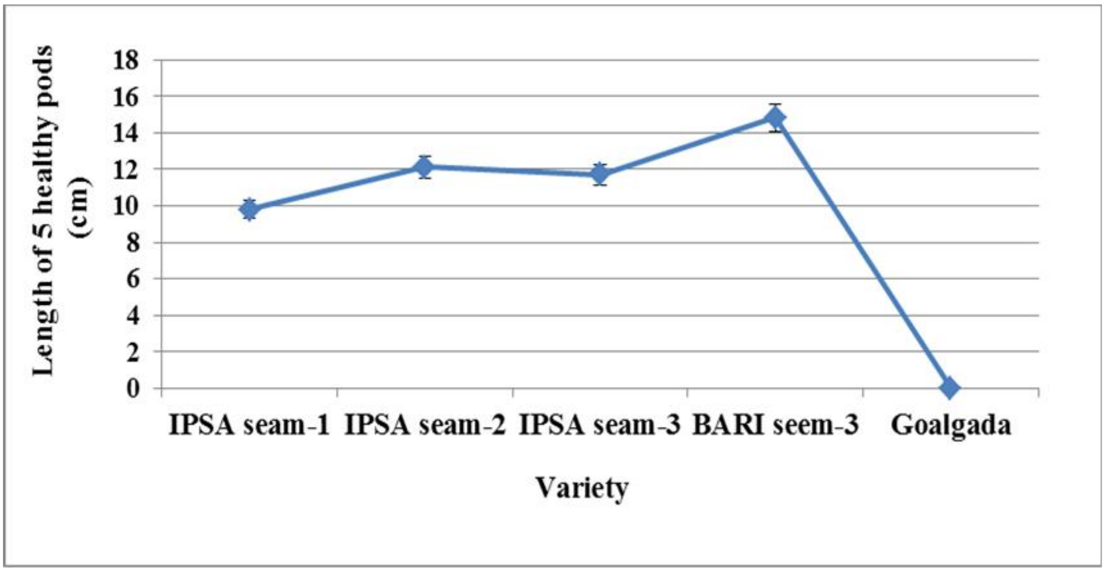


Figure 5: Varietal performance of country bean on length of healthy pods

4.10 Varietal performance of country bean on girth of healthy pods

Different varieties of country bean used in the present experiment showed non significant variation on girth of 5 healthy pods. The variety BARI seem-3 contained highest (6.867 cm) girth of 5 healthy pods which was not significantly differed from IPSA seam-3 (6.067 cm), IPSA seam-2 (6.067 cm) and IPSA seam-1 (6.033 cm) and they were statistically similar (Figure 6).

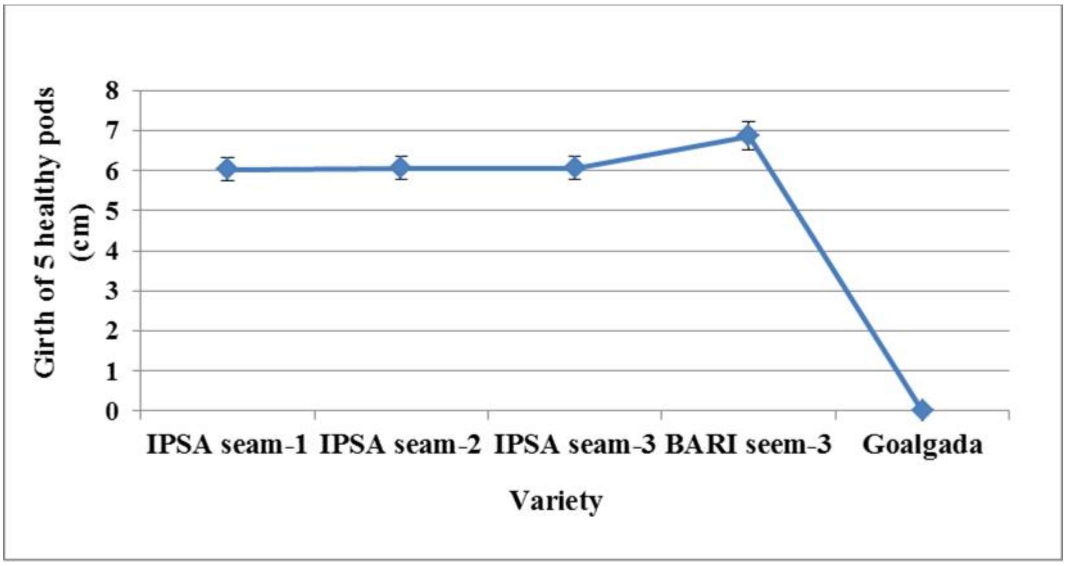


Figure 6: Varietal performance of country bean on girth of healthy pods

4.11 Varietal performance of country bean on weight of healthy pods

Statistically significant variation was observed in respect of weight of 5 healthy pods at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (40.90 g $plot^{-1}$) weight of 5 healthy pods which was closely followed by IPSA seam-3 (39.60 g $plot^{-1}$) and were statistically identical. Whereas lowest (21.93 g $plot^{-1}$) weight of 5 healthy pods was recorded for variety IPSA seam-1 this was followed by IPSA seam-2 (30.77 g $plot^{-1}$) and were not statistically similar (Table 5).

Table 5: Varietal performance of country bean on weight of healthy pods

Variety	Weight of 5 healthy pods (g $plot^{-1}$)
IPSA seam-1	21.93 c
IPSA seam-2	30.77 b
IPSA seam-3	39.60 a
BARI seem-3	40.90 a
Goalgada	0.0000 d
LSD	**5.847**
CV (%)	**11.66**

In a column, numeric data represents the mean value of 3 replications, each replication is derived from 3 plants in a plot and means followed by different letter are significantly different at 5% level as per Least Significant Difference test (LSD).

4.12 Varietal performance of country bean on length of infested pods

Statistically significant variation was observed in respect of length of 5 infested pods at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (10.90 cm) length of 5 infested pods followed by IPSA seam-1 (7.867 cm) and they were statistically identical. The lowest length of 5 infested pods was recorded for the variety IPSA seam-3 (5.60 cm) which was statistically similar (6.20 cm) with IPSA seam-2 (Figure 7). Usa and Singh (1977) reported that different physical and biochemical factors influence the level of pod borer infestation. They did not provide any information regarding the length and girth bean pods.

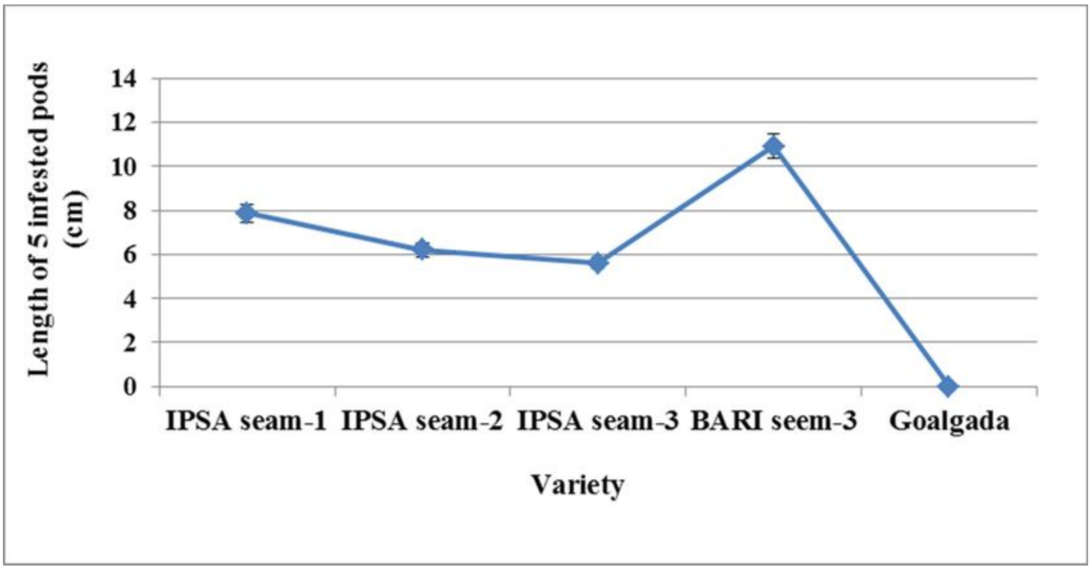


Figure 7: Varietal performance of country bean on length of infested pods

4.13 Varietal performance of country bean on girth of infested pods

Different varieties of country bean used in the present study showed significant variation on girth of 5 infested pods. The variety BARI seem-3 contained highest (6.467 cm) girth of 5 infested pods which was statistically identical with IPSA seam-3 (6.20 cm), IPSA seam-1 (6.033 cm) and IPSA seam-2 (5.50 cm) (Figure 8).

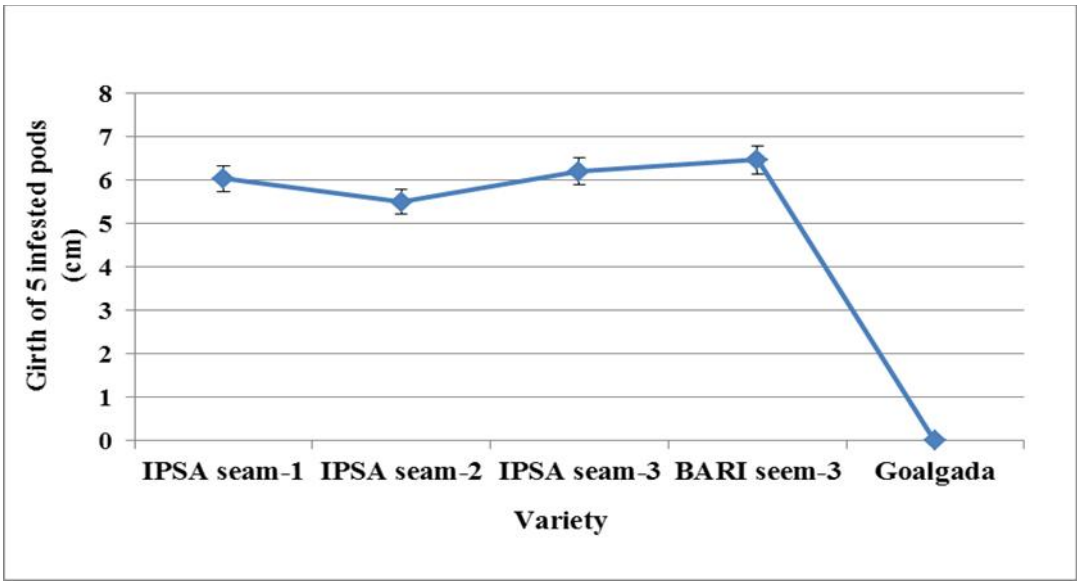


Figure 8: Varietal performance of country bean on girth of infested pods

4.14 Varietal performance of country bean on weight of infested pods

Statistically significant variation was observed in respect of weight of 5 infested pods at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (20.40 g plot-1) weight of 5 infested pods which were followed by IPSA seam-1 (17.33 g plot-1) and were statistically identical. Whereas the least (11.73 g plot^{-1}) weight of 5 infested pods was recorded for IPSA seam-3 which was closely followed by IPSA seam-2 (14.00 g plot^{-1}) and statistically similar (Table 6).

Table 6: Varietal performance of country bean on weight of infested pods

Variety	Weight of 5 infested pods (g plot^{-1})
IPSA seam-1	17.33 ab
IPSA seam-2	14.00 bc
IPSA seam-3	11.73 c
BARI seem-3	20.40 a
Goalgada	0.000 d
LSD	**3.505**
CV (%)	**4.66**

In a column, numeric data represents the mean value of 3 replications, each replication is derived from 3 plants in a plot and means followed by different letter are significantly different at 5% level as per Least Significant Difference test (LSD).

4.15 Varietal performance of country bean on total weight of healthy pods

Statistically significant variation was observed in respect of total weight of healthy pods at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (758.3 g plot^{-1}) total weight of healthy pods which was followed by IPSA seam-3 (703.7 g plot^{-1}), IPSA seam-2 (610.0 g plot^{-1}) and IPSA seam-1 (546.0 g plot^{-1}) and they were statistically identical (Table 7).

Table 7: Varietal performance of country bean on total weight of healthy pods

Variety	Total weight of healthy pods (g $plot^{-1}$)
IPSA seam-1	546.0 a
IPSA seam-2	610.0 a
IPSA seam-3	703.7 a
BARI seem-3	758.3 a
Goalgada	0.000 b
LSD	**426.3**
CV (%)	**3.24**

In a column, numeric data represents the mean value of 3 replications, each replication is derived from 3 plants in a plot and means followed by different letter are significantly different at 5% level as per Least Significant Difference test (LSD).

4.16 Varietal performance of country bean on total weight of infested pods

Statistically significant variation was observed in respect of total weight of infested pods at different varieties used in the present study. The variety BARI seem-3 showed highest (93.67 g $plot^{-1}$) total weight of infested pods which was closely followed by IPSA seam-1 (76.67 g $plot^{-1}$) and they were statistically identical. On the other hand, the least total weight of infested pods was recorded for IPSA seam-3 (39.67 g $plot^{-1}$) which was followed by IPSA seam-2 (66.33 g $plot^{-1}$) and was statistically similar (Table 8).

Table 8: Varietal performance of country bean on total weight of infested pods

Variety	Total weight of infested pods (g $plot^{-1}$)
IPSA seam-1	76.67 a
IPSA seam-2	66.33 ab
IPSA seam-3	39.67 b
BARI seem-3	93.67 a
Goalgada	0.000 c
LSD	**28.02**
CV (%)	**6.93**

In a column, numeric data represents the mean value of 3 replications, each replication is derived from 3 plants in a plot and means followed by different letter are significantly different at 5% level as per Least Significant Difference test (LSD).

4.17 Varietal performance of country bean on total yield

Statistically significant variation was observed in respect of total yield at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (14.67 ton ha^{-1}) total yield which was significantly different from other varieties and followed by IPSA seam-3 (10.67 ton ha^{-1}). Whereas the lowest total yield was recorded for IPSA seam-1 (6.333 ton ha^{-1}) which was closely followed by IPSA seam-2 (9.333 ton ha^{-1}) and they were statistically identical (Table 9).

Table 9: Varietal performance of country bean on total yield

Variety	**Total yield (ton ha^{-1})**
IPSA seam-1	6.333 c
IPSA seam-2	9.333 bc
IPSA seam-3	10.67 b
BARI seem-3	14.67 a
Goalgada	0.000 d
LSD	**3.987**
CV (%)	**5.82**

In a column, numeric data represents the mean value of 3 replications, each replication is derived from 3 plants in a plot and means followed by different letter are significantly different at 5% level as per Least Significant Difference test (LSD).

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY

The experiment was conducted at Sher-e-Bangla Agricultural University Agronomy Farm, Dhaka-1207 during the period of April 2011 to November 2011. The objectives of the study were to find out the performance of some country bean varieties on incidence of pod borer in summer and to identify plant character(s) that influences the rate of infestation of pod borer of country bean. Five varieties of country bean, namely IPSA seam-1, IPSA seam-2, IPSA seam-3, BARI seem-3 and Goalgada were selected as experimental materials for the experiment. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. The mean separation was done by LSD.

There were significant differences in number of inflorescences plant^{-1} among different varieties of country bean. The variety BARI seem-3 showed highest result (83.33 inflorescence plant^{-1}) which was closely followed (65.33 inflorescence plant-1) by IPSA seam-3 and they were statistically identical. On the other hand, the lowest (34.00 inflorescence plant^{-1}) number was recorded from the variety IPSA seam-1 which was closely followed (44.33 inflorescence plant^{-1}) by the variety IPSA seam-2 and they were also statistically identical.

Different varieties of country bean used in the present study showed highly significant variation on number of flower for 5 inflorescences. The variety BARI seem-3 showed highest result (11.67 flower inforescence^{-1}) followed by IPSA seam-1 (9.667 flower inforescence^{-1}) and they were statistically identical. Whereas the variety IPSA seam-2 showed lowest (6.333 flower inforescence^{-1}) performance which was statistically identical with IPSA seam-3 (7.333 flower inforescence^{-1}) variety.

Different varieties of country bean used in the present study also showed significant variation on number of healthy flower for 5 inflorescences. The variety BARI seem-3 gave highest result (11.00 flower inforescence^{-1}) which was statistically identical with the variety IPSA seam-1 (8.667 flower inforescence^{-1}). Whereas the least performance was recorded for IPSA seam-2 (5.667 flower inforescence^{-1}) which was closely (6.667 flower inforescence^{-1}) followed by IPSA seam-3.

Different varieties of country bean used in the present study also showed significant variation on number of infested flower for 5 inflorescences. The lowest (0.6667 flower inforescence^{-1}) was recorded for the variety BARI seem-3, IPSA seam-2 and IPSA seam-3 and they were statistically identical. Whereas the highest (1.000 flower inforescence^{-1}) flower infestation was recorded for the variety IPSA seam-1 which was also statistically identical with other varieties.

Different varieties of country bean used in the present study also showed significant variation on total number of pods. The variety BARI seem-3 contained highest (127.3 pods plot^{-1}) total number of pods which was significantly different from other varieties and closely followed by IPSA seam-3 (93.33 pods plot^{-1}). The lowest (53.33 pods plot^{-1}) total number of pods was recorded for the variety IPSA seam-2 which was closely followed by IPSA seam-1 (63.67 pods plot^{-1}) and they were statistically identical.

Different varieties of country bean used in the present study also showed significant variation on number of healthy pods. The variety BARI seem-3 contained highest (119.0 pods plot^{-1}) number of healthy pods which was significantly different from other varieties and followed by IPSA seam-3 (68.67 pods plot^{-1}). Whereas the least (34.33

pods plot^{-1}) performance was recorded for IPSA seam-2 which was followed by IPSA seam-1 (44.67 pods plot^{-1}) and they were statistically identical.

Different country bean varieties used in the present study also showed significant variation on number of infested pods. The variety BARI seem-3 contained lowest (8.333 pods plot^{-1}) number of infested pods which was significantly different from other varieties. While the highest (24.67 pods plot^{-1}) number of infested pods was recorded for IPSA seam-3 which was closely followed by IPSA seam-2 (21.00 pods plot^{-1}) and IPSA seam-1 (19.00 pods plot^{-1}) respectively and they were statistically identical.

Different varieties of country bean used in the present study showed significant variation on flower drops. The variety BARI seem-3 showed lowest (4.333 flower plot^{-1}) flower drops which was statistically followed by IPSA seam-3 (8.667 flower plot^{-1}). Whereas the highest (18.67 flower plot^{-1}) number of flower drops was recorded for the variety IPSA seam-2 which was closely followed by IPSA seam-1 (12.00 flower plot^{-1}) and they were statistically identical.

Statistically significant variation was observed in respect of length of 5 healthy pods at different varieties of country bean. The variety BARI seem-3 showed highest (14.83 cm) length which was significantly different from other varieties and closely followed by IPSA seam-2 (12.73 cm). Whereas the lowest length of 5 healthy pods was recorded for IPSA seam-1 (9.80 cm) closely followed by IPSA SEAM-3 (11.70 cm) and they were statistically similar.

Different varieties of country bean used in the present experiment showed non significant variation on girth of 5 healthy pods. The variety BARI seem-3 contained highest (6.867 cm) girth of 5 healthy pods which was not significantly differed from

IPSA seam-3 (6.067 cm), IPSA seam-2 (6.067 cm) and IPSA seam-1 (6.033 cm) and they were statistically similar.

Statistically significant variation was observed in respect of weight of 5 healthy pods at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (40.90 g $plot^{-1}$) weight of 5 healthy pods which was closely followed by IPSA seam-3 (39.60 g $plot^{-1}$) and were statistically identical. Whereas lowest (21.93 g $plot^{-1}$) weight of 5 healthy pods was recorded for IPSA seam-1 this was followed by IPSA seam-2 (30.77 g $plot^{-1}$).

Statistically significant variation was observed in respect of length of 5 infested pods at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (10.90 cm) length of 5 infested pods followed by IPSA seam-1 (7.867 cm) and they were statistically identical. The lowest length of 5 infested pods was recorded for the variety IPSA seam-3 (5.60 cm) which was statistically similar (6.20 cm) with IPSA seam-2.

Different varieties of country bean used in the present study showed significant variation on girth of 5 infested pods. The variety BARI seem-3 contained highest (6.467 cm) girth of 5 infested pods which was statistically identical with IPSA seam-3 (6.20 cm), IPSA seam-1 (6.033 cm) and IPSA seam-2 (5.50 cm).

Statistically significant variation was observed in respect of weight of 5 infested pods at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (20.40 g plot-1) weight of 5 infested pods which were followed by IPSA seam-1 (17.33 g plot-1) and were statistically identical. Whereas the least (11.73 g $plot^{-1}$)

weight of 5 infested pods was recorded for IPSA seam-3 which was closely followed by IPSA seam-2 (14.00 g plot^{-1}) and statistically similar.

Statistically significant variation was observed in respect of total weight of healthy pods at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (758.3 g plot^{-1}) total weight of healthy pods which was followed by IPSA seam-3 (703.7 g plot^{-1}), IPSA seam-2 (610.0 g plot^{-1}) and IPSA seam-1 (546.0 g plot^{-1}) and they were statistically identical.

Statistically significant variation was observed in respect of total weight of infested pods at different varieties used in the present study. The variety BARI seem-3 showed highest (93.67 g plot^{-1}) total weight of infested pods which was closely followed by IPSA seam-1 (76.67 g plot^{-1}) and they were statistically identical. On the other hand, the least total weight of infested pods was recorded for IPSA seam-3 (39.67 g plot^{-1}) which was followed by IPSA seam-2 (66.33 g plot^{-1}) and was statistically similar.

Statistically significant variation was observed in respect of total yield at different varieties of country bean used in the present study. The variety BARI seem-3 showed highest (14.67 ton ha^{-1}) total yield which was significantly different from other varieties and followed by IPSA seam-3 (10.67 ton ha^{-1}). Whereas the lowest total yield was recorded for IPSA seam-1 (6.333 ton ha^{-1}) which was closely followed by IPSA seam-2 (9.333 ton ha^{-1}) and they were statistically identical.

From the above results we saw that the BARI-3 variety of country bean always give highest and best results on different parameters against infestation of pod borer.

CONCLUSION

The present study revealed that the increased yield per hectare of country bean with the increase rate of number of inflorescences plant^{-1}, number of flower for 5 inflorescences, number of healthy flower for 5 inflorescences, total number of pods, number of healthy pods and decrease rate of infested flower for 5 inflorescences, number of infested pods, flower drops; increased rate of length and girth (cm) of 5 healthy pods, weight of 5 healthy pods (g), total weight of healthy pods (g) and even the highest length (cm), girth (cm) and weight of 5 infested pods (g), highest total weight of infested pods (g) along with increased total yield (kg) fruits might be obtained by using the BARI seem-3 variety of country bean. Where as, IPSA seam-3 variety of country bean gave better results than the two other varieties like IPSA seam-1 and IPSA seam-2 and was the second best treatment used in this experiment.

From the above description, it can be concluded that, BARI seem-3 variety of country bean significantly deregulates the infestation of pod borer in summer.

RECOMMENDATION

From this study it can be recommended that, BARI seem-3 variety of country bean can be used as a successful variety for country bean cultivation and though IPSA seam-3 variety of country bean didn’t give better result in comparison to BARI seem-3 variety it can be used in consideration of its good performances in reducing infestation of bean pod borer. However, further study of this experiment is needed in different locations of Bangladesh for accuracy of the results obtained from the present experiment.

CHAPTER VI

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