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DEVELOPMENT OF EFFECTIVE MANAGEMENT PRACTICE(S) AGAINST POD BORER (*HELICOVERPA ARMIGERA* HUBNER) INFESTING CHICKPEA

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ABSTRACT

There are many constraints in chickpea production, of which pod borer, *Helicoverpa armigera* Hubner is the most notorious pest which causes both quantitative and qualitative loss. Therefore, the study was conducted at the research field of Plant Pathology and Seed Science Department, Faculty of Agriculture, Sylhet Agricultural University (SAU), Sylhet, Bangladesh to evaluate the effectiveness of different synthetic insecticides and natural botanicals against the pod borer attacking chickpea during 25 November, 2018 to15 April, 2019. The six treatments *viz*., spraying of lamda-cyhalothrin @ 1.5 ml L^{-1} of water, chloropyrifos + cypermethrin @ 2 ml L^{-1} of water, chlorantranilprole @ 0.15g L^{-1} of water, neem leaf extract (1:4), bishkatali leaf extract (1:4), marigold leaf extract (1:4), and untreated control (water sprayed only) were evaluated in this experiment. The parameter viz., pod damage (%), number of pod $plant^{-1}$, number of bored pod per 10 infested pods, plant height (cm), number of branch $plant^{-1}$, weight of 1000 seeds (g), yield of chickpea (t ha^{-1}) were investigated to evaluate the treatments against the pod borer. Results indicated that lamda-cyhalothrin was found as most effective insecticide because it caused the highest pod damage reduction over the untreated control (72.53%) and provided the highest yield (1.6 t ha^{-1}) and highest marginal benefit cost ratio (MBCR) (4.60). Thus, it may be concluded that spraying of lamda-cyhalothrin may be an effective management practice against the chickpea pod borer.

Keywords: Chickpea, pod borer, control, MBCR, economics.

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INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an important legume crop belonging to the family Fabaceae. It is also known as gram or Bengal gram, garbanzo, or garbanzo bean, and is sometimes known as Egyptian pea. It is one of the most important food grain legumes in the world with the production of 14.78 million tons from 14.56 million hectares with 1014.60 kg ha^{-1} in 2017 (FAOSTAT 2019). Asia contributes 90% of chickpea production in the world (Ahmed and Awan 2013). The average yield of chickpea is 0.80 t ha^{-1} in Bangladesh which is lower compared to the potential yield of this crop and average yield of other pulse-growing countries (BBS 2011). It contributes 3.87% of the total pulse production in Bangladesh (BBS 2013). The major chickpea-producing countries are India (67.41%), Australia (6.21%), Pakistan (5.73%), Turkey (3.86%), and Myanmar (3.74%) (FAOSTAT 2015).

Chickpea is an important source of energy, protein and soluble and insoluble fiber. It provides the highest level of protein (>20%) as an alternative to meat for poor people (Hefnawy *et al.* 2012). Along with vegetable protein, it is also a source of carbohydrate, cholesterol lowering fiber, oil, ash, phosphorus, calcium, magnesium, iron and zinc, unsaturated fatty acids and β-carotene (Muehlbauer and Rajesh 2008, Jukanti *et al*. 2012, Patil *et al.* 2017). Mature chickpea grains contain 60-65% carbohydrates, 6% fat and 12 to 31% proteins, which is higher than any other pulse crops (Kerketta *et al*. 2015). Chickpea is used for human consumption as well as feed for animals. Its seeds are eaten as green vegetable, fried, roasted, as snack food and ground to obtain flour and *dhal* (Pachundkar *et al*. 2013). Its straw has also good forage value (Shrestha *et al.* 2011). It also contains essential amino acids like isoleucine, leucine, lysine, phenylalanine, and valine (Karim and Fattah 2006). Additionally, it has the ability to fix atmospheric nitrogen and can also tolerate high temperatures during and after flowering (Cumming and Jenkins 2011). It is one of the earliest cultivated legumes (Bell 2014).

Chronological data regarding chickpea production shows an irregular trend due to abiotic factors like weather conditions, intensity of rains and different biotic factors such as diseases and insect pests (MINFAL 2016). Among insect pests, chickpea pod borer (*Helicoverpa armigera* Hubner) (Lepidoptera: Noctuidae), is the most common and critical challenge for successful chickpea production around the world (Ujjan *et al*. 2019, Kumar *et al.* 2019, Jai *et al*. 2020). In case of outbreaks, yield

losses caused by chickpea pod borer range from 10-90% and 50-60% pod damage in the crop depending upon the insect population and susceptibility of genotypes (Sharma *et al*. 2012, Kambrekar 2012, Iqbal *et al*. 2014, Ahmed and Awan 2013). Single larva can damage 40 pods and it feeds on floral buds, flowers and young pods of the growing crop (Khan *et al.* 2009, Bajia and Bairwa 2015). *H. armigera* is widely dispersed throughout the African, Asian, European and Mediterranean regions (EPPO 2006, Zohary *et al*. 2012).

The wider host range, multiple generation, migratory behavior and high fecundity of gram pod borer made it difficult to manage. The chemical control options are still regarded as the last resort for its management due to their quick known effects (Sreekanth 2014). In Bangladesh, synthetic insecticides are generally used to control the pest. However, continuous and indiscriminate use of synthetic pesticides has resulted in residues, development of insecticide resistance, adverse effects on non-target organisms, humans and the environment (Boulamtat *et al*. 2020, Patil 2017, Hossain *et al.* 2010, Kumar and Sarada 2015). Based on the above negative consequences, many medicinal plants, botanicals and spice crops have been evaluated as alternative pest control agents (Yankanchi and Gonugade 2009). Botanicals can be characterized as environmentally non-persistent and therefore they are unlikely to result in environmental contamination. It has been reported that certain plant preparations and traditional methods are much safer than chemical insecticides (Yankanchi and Patil 2009). Considering the severe attack of gram pod borer, the present study attempted to develop environmentally safe and economically viable management practices against the pod borer infesting chickpea crop under field conditions in the northeastern part of Bangladesh.

MATERIALS AND METHODS

Field/Plot details: With a view to developing the most effective management practice(s) against pod borer of chickpea, the experiment was carried out in the research field of Plant Pathology and Seed Science Department, Faculty of Agriculture, Sylhet Agricultural University (SAU), Sylhet, Bangladesh during *Rabi* 2018-19. The experimental site was located at the northeastern corner of Bangladesh lying between $23^{0}57'$ and $25^{0}13'$ North latitude, $90^{0}56'$ and $92^{0}21'$ East longitude. The site falls under the Agro-ecological Zone-20**:** Eastern Surma-Kusiyara Flood

Plain (UNDP and FAO 1988). The chickpea genotype BARI Chola-9 was raised as per standard agronomic practices during *Rabi* 2018-19. Seeds were collected from farmers' fields as per the International Rules for Seed Testing (ISTA 2001) at 15 days before sowing the chickpea seed. The soil of experimental site is grey, sandy loams in texture and belongs to the 'Non-calcareous Grey' soils. Organic matter content of the soil is moderate with pH 4.8. The individual plot size was 1 m × 2 m. Blocks were 1.0 m apart and rows were 0.5 m apart. Plant spacing was 10 cm and line spacing was 40 cm.

Experimental design: The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were six treatments and untreated control. Description of each treatment is shown in Table 1.

All the treatments were applied in field as foliar application manually with hydraulic knapsack sprayer machine. The land of the experimental plots was prepared as per standard agronomic practices and fertilizers were applied as per the recommendation of Bangladesh Agricultural Research Council, Dhaka (FRG 2012) (Table 2). The seeds were sown in the treatment plots about 2.0 cm depth in 4 lines per plot in the afternoon.

Table 1. Description of all the treatments used in this experiment

Treatments	Active ingredients	Mode of action	Dose (ml L^{-1} of water)
Karate 2.5EC	lamda-chyhalothrin	Nerve poison (cholinesterase inhibitor)	1.5 ml
Nitro 505EC	Chloropyrifos + cypermethrin	Nerve poison, contact and stomach poison	2 ml
Virtako 40WG	Chlorantraniliprole	Systemic (Ryanodine receptor Modulator)	0.15 g
Neem leaf extract	Azadirachtin	Antifeedants, growth regulators and sterilants	1:4 (extracts and water)
Bishkatali leaf extract	Monoterpenoids	Antibacterial, antiviral, anti-stomach complaint	1:4 (extracts and water)
Marigold leaf extract	Pyrethrin	Antibacterial, antifungal, larvicidal, activity	1:4 (extracts and water)
Untreated control (water sprayed only)			

Table 2. Fertilizer for chickpea as per Bangladesh Agricultural Research Council (FRG 2012)

Name of the fertilizer	Dose (kg ha^{-1})
Urea	45 kg ha^{-1}
TSP	85 kg ha^{-1}
MOP	35 kg ha^{-1}
Boric acid	10 kg ha^{-1}

Preparation of insecticidal solution: The insecticidal spray solution of desired concentration as per treatment was freshly prepared every time at the time just before the start of spraying operations. To prepare botanical insecticides i.e., fresh leaves of neem (*Azadirachta indica*), bishkathali (*Polygonum hydropiper*) and marigold (*Tagetes patula*) were collected from the surrounding areas of Sylhet Agricultural University, Sylhet, Bangladesh. The collected plant parts were chopped after cleaning under running tap water. The extracts were prepared by crushing the plant parts in a blender with distilled water at 1:1 (100g crushed plant materials in 100 ml water). The extracts were filtered through cheese cloth and poured in the bottle. The extracts thus obtained were kept in a refrigerator at 4 ± 1^{0}C until use in the plots.

Application of synthetic insecticides and botanicals: First spray of each insecticide was applied when 50% plants attained flowering stage. Second and third spray was applied after 10 days interval from the first spray. Insecticides were sprayed as solution into the experimental plot as per treatment. Each spray solution was prepared by mixing desired quantity of insecticides with tap water. The whole surface of the plant was sprayed with the solution of the insecticides. In case of control plot water was sprayed only. Special attention was given to complete coverage of the growing plants with the spray volume. The spraying was done in the afternoon to avoid bright sunlight and drift caused by strong wind and adverse effect on pollinating bees. Chickpea was harvested when 90% of the pods turned into dark brown in color and then dried separately in bright sunshine.

Data collection: Observations were started 30 days after sowing (DAS) in one meter length from each plot at vegetative stage to determine the economic threshold level (one larva per meter per row) of chickpea pod borers for timely application of chemicals. Ten plants were selected at random from each treatment. The plant height was measured from ground level to the tip of the plant. Total number of branch, total

number of healthy and bored pods were counted and mean was calculated. Weight of 1000 seeds was also measured by electronic balance.

Pod damage (%): On maturity of crop, the pod damage (%) was determined by counting total number of pod and number of damaged pods from randomly selected ten plants from each treatment, using the following formula:

$$\text{Percent pod damage} = \frac{\text{No. of damaged pods}}{\text{No. of total pods}} \times 100$$

Pod damage reduction over control was measured using following formula:

$$\text{Pod damage reduction over control} = \frac{T_0 - T_r}{T_0} \times 100$$

Where,

T_0 - Mean value of the control (untreated) plot

T_r – Mean value of treated plots

Grain yield: The grain yield per plot was recorded at harvest including untreated control and it was converted into t ha^{-1}.

Economic analysis: Marginal Benefit Cost Ratio (MBCR) was calculated considering the total expenditure of management cost and the total return from that particular treatment as described by Hossain *et al.* (2016) as follows:

$$\text{Marginal Benefit Cost Ratio (MBCR)} = \frac{\text{Adjusted net return}}{\text{Total management cost}}$$

Adjusted net return = Net return from the treated plant – Net return from the control plant.

Statistical analysis: The collected data on different parameters were statistically analyzed by using the MSTAT-C computer software package program (Russell 1986) to find out the level of significant differences resulting from experimental treatments. The difference between the treatment means were evaluated for significance using Duncan's Multiple Range Test (DMRT) following the procedure as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of different treatments on percent pod infestation by chickpea pod borer: The results showed that each individual treatment was significantly efficient than the untreated control (Table 3). The best result in terms of lowest pod infestation (4.73%) was obtained from lamda-cyhalothrin treated plot followed by 5.14% in chlorantranilprole treated ones. 5.57% in chloropyrifos + cypermethrin, 6.50% in neem leaf extract, 6.96% in bishkatali leaf extract and 7.77% in marigold leaf extract treated plots were found. However, comparing all the treated plots with that of untreated control plot, the treated plots were significantly effective since the pod damage percentage in case of untreated control plot was 17.21%. The pod infestation reduction over untreated control, the highest percent reduction of pod infestation (72.53%) was calculated in lamda-cyhalothrin treated plots followed by 70.15% in chlorantranilprole, 67.65% in chloropyrifos + cypermethrin, 62.25% in neem leaf extract, 59.58% in bishkatali leaf extract, 54.88% in marigold leaf extract treated plots. From these results, it was found that lamda-cyhalothrin was more effective to reduce pod infestation. The present results are in agreement with Hossain *et al.* (2010), where lambda-cyhalothrin (Karate 2.5EC) exhibited better results (only 2.55% pod damage) for suppressing chickpea pod borer.

Table 3. Effect of different treatments on percent pod infestation by chickpea pod borer

Treatments	Pod infestation (%)	Reduction over control (%)
Lamda-cyhalothrin	4.73e (2.170)	72.53
Chloropyrifos + cypermethrin	5.57c-e (2.357)	67.65
Chlorantranilprole	5.14de (2.267)	70.15
Neem leaf extract	6.50b-d (2.547)	62.25
Bishkatali leaf extract	6.96bc (2.613)	59.58
Marigold leaf extract	7.77b (2.787)	54.88
Untreated control (water sprayed only)	17.21a (4.15)	-
$LSD_{(0.01)}$	0.294	-
CV (%)	4.34	-

Common letters in a column denote no significant difference between treatments (DMRT, P>0.01). All the values in parentheses are square root transformed value.

Effect of different treatments on the number of bore on pods due to chickpea pod borer: The number of bore on pods 10^{-1} infested pods significantly differed among the treatments (Table 4). The highest number of bore on pods (12.17 10^{-1} infested pods) was found in untreated control plot and the lowest number (10.73 10^{-1} infested pods) was obtained from lamda-cyhalothrin treated plots. The intermediate number of bore followed by 11.50 10^{-1} in pods of bishkathali leaf extract treated plot, 11.40 10^{-1} bore pods in neem leaf extract, 11.37 10^{-1} in marigold leaf extract, which was followed by 11.10 10^{-1} bore pods in chloropyrifos + cypermethrin, 11.20 10^{-1} bore pods in chlorantranilprole treated plot which were not significantly different from that of untreated control plot.

In terms of percent reduction over untreated control, the highest reduction of number of bored pods (11.83%) though very poor was recorded in lamda-cyhalothrin and lowest (5.51%) was recorded in bishkathali leaf extract treated plots.

Effect of different treatments on number of pod per chickpea plant: The effectiveness of various treatments on number of pod per plant has been shown in Table 5. The highest number of pod per plant (49.20) was observed in chlorantranilprole treated plot and the second highest was recorded in lamda-cyhalothrin (46.00 pod plant^{-1}). Significantly the lowest number of pod per plant (32.77) was harvested in untreated control plot. The best result in terms of percent increase of number of pod (50.14%)

Table 4. Effect of different treatments on number of bore on pods

Treatments	No. of bore on pods 10^{-1} infested pods	Reduction over untreated control (%)
Lamda-cyhalothrin	10.73 b	11.83
Chloropyrifos + cypermethrin	11.10 b	8.79
Chlorantranilprole	11.20 b	7.97
Neem leaf extract	11.40 ab	6.33
Bishkathali leaf extract	11.50 ab	5.51
Marigold leaf extract	11.37 ab	6.57
Untreated control (water sprayed only)	12.17 a	-
$LSD_{(0.01)}$	0.75	-
CV (%)	2.64	-

Note: Common letters in a column denote no significant difference between treatments (DMRT, $P>0.01$).

Table 5. Effect of different treatments on number of pod per plant of chickpea

Treatments	No. of pod plant^{-1}	Increase over control (%)
Lamda-cyhalothrin	46.00 ab	40.37
Chloropyrifos + cypermethrin	42.00 abc	28.17
Chlorantranilprole	49.20 a	50.14
Neem leaf extract	44.00 ab	34.27
Bishkathali leaf extract	36.87 bc	12.51
Marigold leaf extract	38.00 bc	15.96
Untreated control (water sprayed only)	32.77 c	
LSD $_{(0.05)}$	9.41	-
CV (%)	12.82	-

Common letters in a column denote no significant difference between treatments (DMRT, P>0.05).

over control was recorded in chlorantranilprole treated plots followed by 40.37% in lamda-cyhalothrin treated plot.

Effect of different treatments on plant height, number of branch per plant, weight of 1000 seeds and grain yield of chickpea: The range of plant height in every plot was 39.60 cm to 43.43 cm (Table 6). The plot treated with chlorantranilprole had the highest plant height (43.43 cm), followed by the plot treated with lamda cyhalothrin (42.87 cm), and the plot under untreated control had the lowest plant height (39.60 cm).

The number of branches plant^{-1} was not significantly affected by different treatments (Table 6). The plot treated with marigold leaf extract (1:4) showed a statistically larger number of branches plant^{-1} (15.20). The plots treated with neem leaf extract (1:4) showed the fewest branches 12.47 plant^{-1}.

The effects of various treatments on thousand grain weight (g) were significant (Table 6). The results showed that the lamda-cyhalothrin treated plot had the maximum weight of 1000 seeds (232g), whereas the untreated control plots had the lowest weight (198.3g). The intermediate weight 226.7g was in chloropyrifos + cypermethrin treated plot, 222.7g in chlorantranilprole, 216g in neem leaf extract, 209g in bishkatali leaf extract treated plots and 201g in marigold leaf extract treated plots were obtained.

All treatments were superior to the untreated control in terms of higher grains yield. The highest yield (1.6 t ha^{-1}) was recorded in lamda-cyhalothrin treated plot and the lowest yield (1.05 t ha^{-1}) was obtained from untreated control plot (Table 6). The yields of chloropyrifos + cypermethrin treated plot was 1.4 t ha^{-1}, neem leaf extract treated plot was 1.31 t ha^{-1}, chlorantranilprole used plot had 1.3 t ha^{-1}, bishkathali leaf extract treated plot resulted 1.28 t ha^{-1} and marigold leaf extract sprayed plot had 1.25 t ha^{-1}.

Mathirajan *et al*. (2000) observed that the highest yield (1506 kg ha^{-1}) was obtained from the lambda-cyhalothrin treated plot. Hossain *et al*. (2010) also conducted a study for the management of chickpea pod borer (Helicoverpa armigera) and found that the highest yield (1338 kg ha^{-1}) was obtained from lambda-cyhalothrin treated plot. The data of yield increase over untreated control indicated that highest yield increase over control was recorded in lamda-cyhalothrin treated plot (53.38%) and lowest in marigold leaf extract treated plot (19.05%). The yield increase over untreated control from chloropyrifos + cypermethrin plot had 33.33%, neem leaf extract plot provided 24.76%, chlorantranilprole plot gave 23.81% and bishkathali leaf extract plot resulted 21.91%.

Table 6. Effect of different treatments on plant height, number of branch per plant, weight of 1000 seeds and grain yield of chickpea

Treatments	Plant height (cm)	No. of branch $plant^{-1}$	Weight of 1000-seeds (g)	Grain yield (t ha^{-1})	Yield increase over untreated control (%)
Lamda-cyhalothrin	42.87	15.00	232 a	1.6 a	53.38
Chloropyrifos + cypermethrin	40.57	14.73	226.7 ab	1.4 b	33.33
Chlorantranilprole	43.43	13.73	222.7 a-c	1.3 bc	23.81
Neem leaf extract	40.30	12.47	216.0 bc	1.31 bc	24.76
Biskatali leaf extract	41.97	13.80	209.3 cd	1.28 bc	21.91
Marigold leaf extract	40.37	15.20	201 d	1.25 c	19.05
Untreated control (water sprayed only)	39.60	12.73	198.3 d	1.05 d	-
CV (%)	5.21	20.70	2.62	3.83	-
Significance/LSD (0.01)	NS	NS	14.05	0.14	-

Common letters in a column denote no significant difference between treatments (DMRT, P>0.01).

Marginal Benefit Cost Ratio (MBCR): The data of economics of different insecticides presented in Table 7 indicated that the highest net return was recorded from lamda-cyhalothrin (Karate 2.5EC) treated plot (Tk. 82600) followed by chloropyrifos + cypermethrin (Nitro 505EC) sprayed plot (Tk. 70637) and the lowest net return was recorded from marigold leaf extract (1:4) applied plot (Tk. 65250). The highest gross return (88000 Tk. ha^{-1}) was found in lamda-cyhalothrin treated plot and lowest gross return (57750Tk. ha^{-1}) was found in untreated control. The highest Marginal Benefit Cost Ratio (MBCR) was found in lamda-cyhalothrin plot (4.60:1) followed by neem leaf extract plot (3.77:1). On the other hand, the lowest Marginal Benefit Cost Ratio was recorded from chlorantranilprole treated plot (1.78:1). The present results are in agreement with the results of Hossain *et al.* (2010) who reported that the highest MBCR was found from lambda-cyhalothrin application. Among the botanical insecticides evaluated, neem leaf extract treated plots produced the highest yield and MBCR. Although lower yield was obtained from botanicals treated plots, they gave higher MBCR than some synthetic insecticides due to less cost involvement with those treatments.

Table 7. Economic analysis of different treatments for the control of chickpea pod borer

Treatments	No. of spray	Yield (t ha^{-1})	Gross return (Tk ha^{-1})	Cost of treatment (Tk ha^{-1})	Net return (Tk ha^{-1})	Adjusted net return ((Tk ha^{-1})	MBCR (TkTk^{-1})
Lamda-cyhalothrin	3	1.6	88000	5400	82600	24850	4.60
Chloropyrifos + cypermethrin	3	1.4	77000	6363	70637	12887	2.03
Chlorantranilprole	3	1.3	71500	4950	66550	8800	1.78
Neem leaf extract (1:4)	3	1.31	72050	3000	69050	11300	3.77
Bishkathali leaf extract (1:4)	3	1.28	70400	3000	67000	9250	3.08
Marigold leaf extract (1:4)	3	1.25	68750	3500	65250	7500	2.14
Untreated control	-	1.05	57750	-	57750	-	-

Cost of synthetic insecticides and botanicals: Lamda-cyhalothrin @ Tk. 68 per 50 ml bottle, chloropyrifos + cypermethrin @ Tk. 80 per 50 ml bottle, chlorantranilprole @ Tk. 140 per 10g packet, Collection and processing cost of neem leaf extract @ Tk. 400/spray, Collection and processing cost of bishkathali leaf extract @ Tk. 400/spray, Collection and processing cost of marigold leaf extract @ Tk. 550/spray. Market price of chickpea = Tk.55/kg, Labour cost = Tk.300/day/labour. Labor requirement: For insecticide preparation and application @ 2 labor ha^{-1} $spray^{-1}$.

CONCLUSION

Based on the results of the study it can be concluded that in respect of protection level and economic return from spraying of lamda-cyhalothrin @ 1.5ml L^{-1} of water is effective treatment for the management of chickpea pod borer, *Helicoverpa armigera* (Hubner). Although application of neem leaf extract is less effective against the chickpea pod borer but it is environmentally safe, readily available, and cost effective and thus may be recommended for the management of chickpea pod borer.

REFERENCES

AHMED, K. & AWAN, M. S. 2013. Integrated management of insect pests of chickpea *Cicer arietinum* (L. Walp) in South Asian Countries: Present status and future *strategies–A review. Pak. J. Zool.* **45**(4): 1125-1145.

BAJIA, R. & BAIRWA, B. 2015. Eco-friendly Integrated Pest Management of Gram Pod Borer (*Helicoverpa armigera*) (Hubner) in Chickpea Ecosystem. *Popular Kheti.* **3**(1): 70-72.

BAKR, M. A., AFZAL, M. A., HAMID, A., HAQUE, M. M. & AKTAR, M. S. 2004. Blackgram in Bangladesh. Lentil, Blackgram and Mungbean Development Pilot Project, Pulses Research Centre, BARI, Gazipur.

BBS (Bangladesh Bureau of Statistics). 2011. Yearbook of Agricultural Statistics of Bangladesh, 23rd Edition Bangladesh Bureau of Statistic, Ministry of Planning, Govt. of the People's Republic of Bangladesh, Dhaka. Pp. 96.

BBS (Bangladesh Bureau of Statistics). 2013. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka. Bangladesh.

BELL, S. 2014. The small but mighty chickpea. Phys.org. Retrieved 8 October 2015.

BOULAMTAT, R., LHALOUI, S., SABRAOUI, A., EL-FAKHOURI, K., OUBAYOUCEF, A., MESFIOUI, A. & EL-BOUHSSINI, M. 2020. Antifeedant and larvicidal activities of *Mentha pulegium* on chickpea pod borer *Helicoverpa armigera* (Lepidoptera: Noctuidae). *Int. J. Trop. Insect Sci.* **40**:151-156.

CUMMING, G. & JENKINS, L. 2011. Chickpea: Effective crop establishment, sowing window, row spacing, seeding depth and rate. Northern Pulse Bull. **7**: 6.

EPPO. 2006. Distribution maps of quarantine pests, Helicoverpa armigera. On-line available at www.eppo.org/QUARANTINE/insects/ Helicoverpa_armigera/HELIAR_map.html.

FAOSTAT. 2015. http://faostat.fao.org/site/567/default.aspx#ancor. Accessed 4 June 2015.

FRG. 2012. Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka 1215. 274 P.

GOMEZ, K. A. & GOMEZ, A. A. 1984. Statistical Procedures for Agricultural Research. International Rice Research Institute. 2nd edition. Wiley-Inter Science Publication, New York. 680 P.

HOSSAIN, A., HAQUE, A., AHMAD, M. & PRODHAN, M. Z. H. 2010. Development of an Integrated Management Approach for Pod Borer, *Helicoverpa armigera* (Hubner) On Chickpea. *Bangladesh J. Agril. Res.* **35**(2): 201-206.

HEFNAWY, T. M. H., EL-SHOURBAGY, G. A. & RAMADAN, M. F. 2012. Impact of adding chickpea (*Cicer arietinum* L.) flour to wheat flour on the rheological properties of toast bread. *Int. Food Res. J.* **19**(2): 521-525.

ISTA. 2001, International Rules for Seed Testing. Rules Amendments. *Seed Sci. Technol.* **29**: 1-127.

IQBAL, J. S., FAROOQ, U., JAMIL, M., KHAN, H. A. A. & YOUNIS, M. 2014. Relative efficacy of selective insecticides against gram pod borer (*Helicoverpa armigera*) of chickpea. *Mycopath*. **12**(2): 119-122.

JAI, B. K., SONI, V. K. & Chandraker, H. K. 2020. Surveillance of pod borer, *Helicoverpa armigera* (Hubner) and its natural enemies on chickpea at Sahaspur Lohara blocks. *J. Pharm. Phytochem.* **9**: 1995-2000.

JUKANTI, A. K., GAUR, P. M., GOWDA, C. L. L. & CHIBBAR, R. N. 2012. Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.). *Br. J. Nutr*. **108**: 512–526.

KAMBREKAR, D. N. 2012. Management of pod borer in chickpea. The Hindu, http://www.thehindu.com/scitech/agriculture/management-of-pod-borer-inchickpea/article 4143687.ece

KARIM, M. F. & FATTAH, Q. A. 2006. Changes in biocomponents of chickpea (*Cicer arietinum* L.) sprayed with potassium napthenate and napthenic acetic acid. *Bangladesh J. Bot*. **35**(1): 39-43.

KERKETTA, M., AWASTHI, H. K. & SHRIWAS, Y. 2015. Constraints faced by chickpea growers in adoption of integrated pest management practices. Plant Archives. **15**: 1051-1053.

KHAN, S. M., INAYATULLAH, M. Y. & KHAN, M. A. 2009. Varietal screening of chickpea and the efficacy of different insecticides against chickpea pod borer *Helicoverpa armigera* (Hb). *Gomal Univ. J. Res.* **25**: 20-24.

KUMAR, A., TRIPATHI, M. K., CHANDRA, U. & VEER, R. 2019. Seasonal incidence of *Helicoverpa armigera* on chickpea crop in eastern region of Uttar Pradesh. *J Entomol. Zool. Stud.* **7**(1): 03-05.

KUMAR, G. V. S. & SARADA, O. 2015. Field efficacy and economics of some new insecticide molecules against lepidopteran caterpillars in chickpea. *Curr. Biot.* **9**(2): 153-158.

MINFAL. 2016. Economic Survey of Pakistanistan Govt. of Pakistanistan. Economic Advisor Wing, Finance Division, Islamabad. Pp. 24-30.

MUEHLBAUER, F. J. & RAJESH, P. N. 2008. Chickpea, a common source of protein and starch in the semi-arid tropics. *In:* Genomics of Tropical Crop Plants. Springer publishers, New York. Pp. 171-186.

PACHUNDKAR, N., KAMBLE, P., PATIL, P. & GAGARE, P. 2013. Management of gram pod borer *Helicoverpa armigera. In*: Chickpea with Neem Seed Kernel Extract as a Natural Pest Management Practice in Bhojdari Village. *Int. J Curr. Res.* **5**(10): 234-235.

PATIL, S. B., GOYA, A., SATISH, S., SHIV, K. & EL BOUHSSINI, B. 2017. Sustainable management of chickpea pod borer. A review. *Agron. Sustain. Dev.* **37**: 20.

PATIL, S. B., GOYAL, A. & CHITGUPEKAR, S. S. 2017. Sustainable management of chickpea pod borer. A review. *Agron. Sustain. Dev.* **37**(3): 1-18. https://doi.org/10.1007/s13593-017-0428-8

RUSSELL, D. F. 1986. MSTAT-C Package Programme (a computer based data analysis soft ware). Crop and Soil Science Department, Michigan State University, USA.

SHARMA P. K., KUMAR, U., VYAS, S., SHARMA, S. & SHRIVASTAVA, S. 2012. Monitoring of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) through pheromone traps in chickpea *Cicer arietinum* crop and influence of some abiotic factors on insect Population. *J. Environ. Sci*. **1**: 44-46.

SHRESTHA, R., NEUPANE, R. K. & ADHIKARI, N. P. 2011. Status and Future Prospects of Pulses in Nepal. The paper presented at Regional Workshop on Pulse Production held at Nepal Agricultural Research Council (NARC), Kathmandu, Nepal, from 24-25 October, 2011.

SREEKANTH, M., LAKSHMI, M. S. M. & RAO, Y. K. 2014. Bio-Efficacy and economics of certain new insecticides against gram pod borer, *Helicoverpa armigera* (Hubner) infesting Pigeonpea (*Cajanus cajan* L.). *Int. J. Plant Anim. Environ. Sci.* **4**: 11-15.

UJJAN, R. L., AHMED, A. M., ALHILFI, A. Z. A., KHOSO, F. N., RAHOO, A. M., RAJPUT, I. A. & SOOMRO, D. M. 2019. Performance of pheromone traps at different heights for mass trapping of *Helicoverpa armigera* (Noctuidae: Lepidoptera) in chickpea field. *Asian J. Agric. Biol.* **7**: 610-616.

UNDP and FAO. 1988. Land Resource Appraisal of Bangladesh for Agricultural Development Report No. 2. Agro- ecological Regions of Bangladesh. United Nations Development Programme and Food and Agriculture Organization. Pp. 212-221.

YANKANCHI, S. R. & GONUGADE, R. S. 2009. Antifeedant and insecticidal activities of certain plant extract against Red flour beetle, *Tribolium castineum H. J. Life Sci. Bull*. **6**: 331-335.

YANKANCHI, S. R. & PATIL, S. R. 2009. Field efficacy of plant extracts on larval populations of *Plutella xylostella* L. and *Helicoverpa armigera* Hub. and their impact on cabbage infestation. *J. of Biopesti*. **2**: 32-36.

ZOHARY, D., HOPF, M. & WEISS, E. 2012. Domestication of plants in the old world: The origin and spread of domesticated plants in Southwest Asia, Europe, and the Mediterranean Basin. (Oxford University Press, 2012). https://doi.org/10.1093/ acprof:osobl/9780199549061.001.0001.