EVALUATION OF FLUBENDIAMIDE AS AN IPM COMPONENT FOR THE MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER, *LEUCINODES ORBONALIS* GUENEE

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ABSTRACT: A field experiment was conducted to evaluate the efficacy of flubendiamide as an IPM component for the management of brinjal shoot and fruit borer and eight IPM packages were evaluated. Among the different IPM packages, package 6 (mechanical control + potash @100 kg/ha + field sanitation in combination with flubendiamide 24WG applied at 5% level of shoot and fruit infestation) showed the better performance by reducing 80.63% fruit infestation over control and produced the highest number of healthy and total fruits/plant (25.0 and 27.20, respectively). The same package also increased 108.83% healthy fruit yield and decreased 74.13% infested fruit yield over control. The highest benefit cost ratio (5.53) was recorded in IPM package 2 (Potash @100 kg/ha + flubendiamide 24WG applied at 5% level of fruit infestation), where 9 sprays were required. The BCR of 4.12 and 4.00 was obtained in IPM package 6 and package 5 with 8 and 5 sprays, respectively. The results of this study suggested that application of flubendiamide at 5% level of fruit infestation in combination with mechanical control + potash @ 100 kg/ha + field sanitation may be used for the management of brinjal shoot and fruit borer.

KEY WORDS: Benefit cost ratio, Field sanitation, Infestation, Mechanical control, Potash.

Brinjal shoot and fruit borer is the most destructive pest of brinjal, which caused 31-86% fruit damage in Bangladesh (Alam et al., 2003) reaching up to 90% (Raman, 1997), 37-63% in India (Dhankar, 1988) and 50-70% in Pakistan (Saeed & Khan, 1997). Farmers of Bangladesh as well as of other Asian countries in most cases solely depend on insecticides for the management of the pest. Such reliance on insecticides has created many problems such as very frequent application of insecticides (up to 140 times in a season), excessive residues on market vegetables that concerns general consumer health and the environment, pesticide resistance, trade implications, poisoning, hazards to non-target organisms, increased production costs etc. (Alam et al., 2003; Pedigo, 2002; Debach & Rosen, 1991). In the context of damage for ensuring food safety and minimization of severity, environmental hazards, appropriate management practice for BSFB incorporating different methods as needed and ought to be devised consistent with modern pest management. The researchers have been trying combination of various components of the IPM package such as cultural, mechanical, pheromone, chemical etc. for the control of brinjal shoot and fruit borer (FAO, 2003; Sasikala et al., 1999; Islam et al., 1999; Maleque et al., 1998).

Mechanical control such as collection and destruction of infested shoots and fruits in combination with insecticide treatments reduced BSFB infestation, increased yield of fruit and ensured the highest benefit cost ratio (Alam et al., 2003; FAO, 2003; Rahman et al., 2002). Use of balanced fertilizer and application of insecticides decreased fruit damage both in quantity and quality (Patnaik et al. 1998). Combination of higher dose of potash along with insecticides treatment also reduced the percentage of fruit infestation (Sudhakar et al., 1998). Mechanical control in combination with insecticides spraying at 5% fruit infestation provided the best protection against brinjal shoot and fruit borer (Islam et al., 1999). Field sanitation, through the removal of plant debris and refuges and cleaning reduced the BSFB infestation significantly (Sasikala et al., 1999). However, none of the individual method alone provides satisfactory protection of the crop against this obnoxious pest. Nevertheless, their combination in a best compatible manner is expected to render desirable protection of the crop.

Flubendiamide, having a new biochemical mode of action, showed excellent effectiveness against a broad spectrum of lepidopterous insect pests including resistance strains (Tohnishi et al., 2005). Thus flubendiamide is expected to provide the necessary protection against brinjal shoot and fruit borer, if needed to supplement the actions of other control components such as cultural, mechanical and field sanitation. Accordingly, the present experiment was undertaken to evaluate the effectiveness of flubendiamide as an IPM component for the management of the brinjal shoot and fruit borer in the field.

MATERIALS AND METHODS

The experiment was conducted in the field at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) during October 2006 to May 2007 (winter season). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 3 m × 3 m having 2 m space between the blocks and 1.5 m between the plots. The distance between rows was 1 m and that between plants was 60 cm. The crop was grown following the recommended practices as described by Rashid (1993). Weeding, mulching and irrigation were done as and when necessary. The experiment comprised 8 combinations of IPM components each such combination termed as an IPM package and an untreated control.

Package 1: Mechanical control + application of flubendiamide 24WG at 5% level of fruit infestation: Twenty days after transplanting, clipping of infested shoots by scissors was carried out and destroyed them by burring at a 7 days interval. At fruiting stage, removal and destruction of both infested shoots and fruits were carried out at 7 days interval and continued till the last harvest. Field application of flubendiamide 24WG (0.012%) was made at 5% level of fruit infestation at 7 days interval and continued till the last harvest.

Package 2: Use of potash @ 100 kg/ha + application flubendiamide 24WG at 5% level of fruit infestation: Application of 100 kg potash per hectare as muriate of potash (MP) fertilizer. One third of the MP was applied in the pit one week before transplanting and the rest of MP was applied in two equal installments as top dressing at 20 days after transplanting and at the flower initiation stage and flubendiamide 24WG was applied as IPM package 1.

Package 3: Field sanitation and application of flubendiamide 24WG at 5% level of fruit infestation: Dead and fallen leaves were collected from the field and destroyed by burring in soil to remove the pupae from soil at 7 days interval and flubendiamide 24WG was applied as IPM package 1.

Package 4: Use of potash @ 100 kg/ha + mechanical control + application of flubendiamide 24WG at 5% level of fruit infestation: Potash was applied as IPM package 2. Mechanical control and application of flubendiamide were done as IPM package 1.

Package 5: Use of potash @ 100 kg/ha + mechanical control + field sanitation + application of flubendiamide 24WG at 5% level of fruit infestation: Potash was applied as IPM package 2 and field sanitation was done according to IPM package 3. Mechanical control and application of flubendiamide were done as IPM package 1.

Package 6: Use of potash @ 100 kg/ha + mechanical control + field sanitation + flubendiamide 24WG applied at 5% level of shoot and fruit infestation: Potash was applied as IPM package 2 and field sanitation was done as IPM package 3. Mechanical control was also made as IPM package 1 but flubendiamide 24WG (0.012%) was applied at 5% level of both shoots and fruits infestation.

Package 7: Use of potash @ 100 kg/ha + mechanical control + field sanitation: Potash was applied as IPM package 2 and field sanitation was done as IPM package 3. Mechanical control was also made as IPM package 1.

Package 8: Schedule spray of flubendiamide 24WG at 7 days interval: After 20 days of transplanting, field application of flubendiamide 24WG (0.012%) was made at 7 days interval and continued till the last harvest.

Untreated control: No pest control technique was applied in control plots. However, an equal volume of water, which was used for other plots, was sprayed at 7 days intervals.

Insecticide application: Brinjal fields were visited regularly and the number of total and infested shoots was counted to determine the level of shoot infestation. The level of fruit infestation was determined by random observation and selection of 50 fruits/ plot everyday. Flubendiamide 24WG was applied by mixing 2.5 g of insecticide with 5 liter of water (0.5 g of flubendiamide 24WG per liter of water i.e., 0.012% flubendiamide) and sprayed covering the whole plants. Five liters of spray material was required to spray three plots. The spraying was done in the afternoon to avoid bright sunlight and drift caused by strong wind and adverse effect on pollinating bees and other pollinators.

Data collection: The total number of shoots as well as the number of infested shoots was recorded from 10 plants of each plot at weekly intervals and the percent shoot infestation was calculated. Fruits were harvested at 7 days interval and the number of healthy and infested fruits was recorded for calculating the percent fruit infestation. The weight of healthy and infested fruits was noted separately per plot per treatment. The cumulative plot yield of healthy and infested fruits of 10 harvests were transformed into healthy, infested and total yield per hectare in tons respectively.

Benefit Cost Ratio (BCR): For benefit cost analysis, records of the costs incurred for labour, fertilizer, insecticide, application in each IPM package were maintained. It is to be noted here that expenses incurred referred to those only on pest control. The price of the harvested marketable healthy fruits of each treatment and that of control were calculated at market rate. The result of Benefit-Cost analysis was expressed in terms of Benefit Cost Ratio.

Data analysis: Data were analyzed by using MSTAT software for analysis of variance after square root transformation. ANOVA was made by F variance test and the pair comparisons were performed by Duncan's Multiple Range Test (DMRT) (Gomez & Gomez, 1984).

RESULTS

Effect of different IPM packages on shoot infestation

Shoot infestation of brinjal was significantly influenced by the different IPM packages. The lowest percent of shoot infestation was observed in schedule spray plot (package 8), which was significantly lower than that of all packages (Figure 1). However, the highest percent of shoot infestation was observed in untreated control, which was statistically identical with IPM package 3 (field sanitation + flubendiamide applied at 5% level of fruit infestation) and package 2 (potash @ 100k/ha + flubendiamide at 5% level of fruit infestation). Accordingly, Figure 2 illustrated that IPM package 8 (schedule spray plot) provided maximum reduction of shoot infestation over control, which was significantly higher than that of all other IPM packages. No significant difference was observed among the percent reduction of shoot infestation over control in IPM package 1 (mechanical control + flubendiamide 24WG applied at 5% level of fruit infestation), package 4 (mechanical control + potash @100 kg/ha + flubendiamide 24WG at 5% level of fruit infestation), package 5 (mechanical control + potash @100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of fruit infestation), package 6 (mechanical control + potash @100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of infestation) and package 7 (mechanical control + potash @100 kg/ha +field sanitation).

Effect of different IPM packages on fruit infestation

IPM packages significantly reduced the borer infestation on brinjal, increased the number of healthy and total fruits/plant, and decreased the number infested fruits/plant of brinjal. Data (Table 1) revealed that IPM package 6 (mechanical control + potash @ 100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of infestation) produced the highest number of healthy fruits/plant (25.00) and statistically similar results were obtained in package 8 (schedule spray of flubendiamide 24WG at 7 days interval) regarding this parameter. However, the number of healthy fruits/plant was statistically identical in IPM package 5 (mechanical control + potash @100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of fruit infestation), package 4 (mechanical control + potash @100 kg /ha + flubendiamide 24WG applied at 5% level of fruit infestation) and package 1 (mechanical control + flubendiamide 24WG applied at 5% level of fruit infestation). In contrast, the lowest number of healthy fruits/plant (11.98) was obtained from the untreated control, which was significantly lower than all other IPM packages except package 7 (mechanical control + fertilizer +field sanitation). Moreover, the data regarding the number of infested fruits/plant (Table 1) showed that the highest value (8.53) was obtained from untreated control as against the lowest (2.20) in IPM package 6 (mechanical control + potash @100 kg /ha + field sanitation + flubendiamide 24WG applied at 5% level of infestation). However, the number of total fruits/plant was statistically identical in IPM package 1, 2, 4, 5, 6 and 8 (Table 1).

Table 1 further revealed that the lowest level of fruit infestation (8.04%) was found in IPM package 6 and statistically no significant difference was observed between IPM package 8 (8.85%), package 5 (10.23%). IPM package 7 (mechanical control + potash @100 kg /ha + field sanitation) had comparatively higher level of fruit infestation (34.94%) than all other IPM packages. The rest of the packages (package 1, package 2 and package 3) had intermediate levels of fruit infestation having no significant difference among them. Significantly the highest percent fruit infestation (41.60%) was obtained in untreated control.

The data (Table 2) showed that IPM package 6 (mechanical control + potash @ 100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of fruit infestation) provided the highest reduction of fruit infestation (80.63%) over the control having no significant difference with package 8, package 5 and package 4. Therefore, the results indicated that none of the package was able to exceed the standard level of 80% reduction in fruit infestation over control except the package 6. Mechanical control in combination with potash @100 kg/ha and field sanitation (package 7) showed very low effectiveness and flubendiamide alone and in combination with mechanical control or potash fertilizer showed significantly higher level of effectiveness against the brinjal shoot and fruit borer.

Effect of different IPM packages on yield performance of brinjal

The effect of different IPM packages on yield of brinjal was evaluated in terms of healthy fruit yield, infested fruit yield and total fruit yield. IPM package 6 (mechanical control + potash @100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of infestation) produced the highest healthy fruit yield (17.71 t/ha). Although statistically no significant difference was observed in IPM package 8 (schedule spray of flubendiamide 24WG at 7 days interval) and package 5 (mechanical control + potash @100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of fruit infestation) regarding healthy fruit yield (Table 3). In contrast, healthy fruit yield was the lowest (8.48 t/ha) in untreated control plots, which was identical with that of the IPM package 7 (mechanical control + potash @100 kg/ha + field sanitation). Accordingly, infested fruit yield was the highest in untreated control plots (4.33 t/ha) having no statistical significant with IPM package 7 (mechanical control + potash @100 kg/ha + field sanitation). Thus, the highest total fruit yield was obtained in IPM package 6 with no significant difference among the IPM packages 1, 2, 4, 5, 6 and 8 treated plots. A further analysis of the yield to assess the impact of each treatment on yield over control as shown in the same Table, suggested that IPM package 6 ensured maximum increase (108.84%) of healthy fruit yield over control. However, maximum reduction (74.13%) of infested fruit yield was found in that package and as a cumulative impact, maximum increase of total fruit yield (46.99%) was obtained in the same package (mechanical control + potash @100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of infestation).

Economic analysis of different IPM packages

The benefit-cost ratio (BCR) as worked out based on the expenses incurred and value of crops obtained against the treatment used in the present study for the control of brinjal shoot and fruit borer has been presented in Table 4. It is revealed from Table that the highest BCR (5.53) was found in IPM package 2 (potash @100 kg/ha + flubendiamide 24WG applied at 5% level of fruit infestation) where 9 applications were required. Although almost equal BCR (5.48) was obtained in package 4 (mechanical control + potash @ 100 kg/ha + flubendiamide 24WG applied at 5% level of fruit infestation) with only 5 sprays of flubendiamide. In contrast, the lowest BCR (0.53) was obtained from IPM package 7 (mechanical control + potash @100 kg/ha + field sanitation) with no application of insecticide. In the schedule spray plots, the BCR was 4.03 but the number of spray was 16. Although the IPM package 6 (mechanical control + potash @100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of infestation) had the higher BCR (4.12) than IPM package 5 (mechanical control + potash @100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of fruit infestation) however, the number of spray was lower in package 5 (5) compared to package 6 (8). IPM package 3 (field sanitation + flubendiamide 24WG applied at 5% level of fruit infestation) required 7 sprays but the BCR was only 1.70.

DISCUSSION

The results demonstrated that the scheduled spray of flubendiamide at weekly intervals was found to be the most effective in reducing shoot infestation of brinjal by shoot and fruit borer. There is no information on the efficacy of flubendiamide against the pest in the field or laboratory; however, findings of other researchers with different insecticides supported these results. Raman et al. (2002) stated that schedule spray of cypermethrin at weekly interval showed the best efficacy in reducing shoot infestation of brinjal. Moreover, Kabir et al. (2003) found the similar efficacy against this pest by spraying of carbosulfan at weekly intervals.

The performance of the different IPM packages against brinjal shoot and fruit borer in different aspects such as percent fruit infestation, reduction of infestation over control, healthy fruit yield and total yield as found in the present study was more or less in conformity with the findings of several other similar studies. Mannan & Begum (1999) found that hand picking damaged shoots and fruit and spraying of cypermethrin at 15 days interval caused 25.78% fruit infestation and 63.93% fruit infestation reduction over control. Gapud et al. (1999) reported that the removal of damaged shoots and fruit at every week produced higher yield than plants sprayed every three weeks. Moreover, mechanical control in combination with spraying of cypermethrin and monocrotophos alternatively at 5% fruit infestation provided effective control of the brinjal shoot and fruit borer (Islam & Karim, 1994). Combination of 4 cultural practices such as irrigation, pruning of older leaves and use of wide spacing, sanitation and proper disposal of BSFB-infested plant material and fertilizer use as per recommended rate controlled 70% of BSFB population in brinjal (FAO, 2003). These findings also agree with that of the Sudhakar et al. (1998), who reported that a higher dose of potash along with insecticide treatment reduced the percentage of fruit infestation.

The findings regarding BCR and number of spray agree with Alam et al. (2006), who obtained the benefit cost ratio (BCR) 3.4 in IPM treated field during winter trial. However, the findings also coincide with those of Maleque et al. (1998), who found a benefit cost ratio (BCR) of 3.4 and 3.3 by using mechanical control + application of cypermethrin at 5% level of fruit infestation and schedule spray of cypermethrin at 7 days intervals, respectively where the weekly spray involved applying 8 times more insecticides. These results contradict the findings of Islam et al. (1999), who observed the BCR of 37.77 in plots treated with shobicron (mixture of cypermethrin and profenofos) at 10% fruit with only 3 applications. The difference in results might be due to the cost of insecticides, the price of product and socio-economic conditions.

The overall results suggested that use of IPM package 5 (mechanical control + potash @100 kg/ha + field sanitation + flubendiamide 24WG applied at 5% level of fruit infestation) against the brinjal shoot and fruit borer reduced fruit infestation, increased marketable yield and benefits cost ratio. This had ultimately reduced the number of insecticide applications. This would have a positive impact on the environment, reduce toxic residue load on brinjal fruits and finally the cost of control measure would be minimized significantly.

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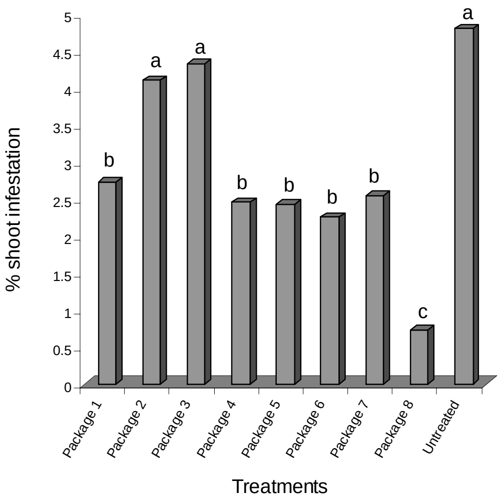

Fig. 1 Percent shoot infestation under different treatments caused by brinjal shoot and fruit borer. Bars having the same letter are not significantly different according to DMRT at $P\leq$ 0.05

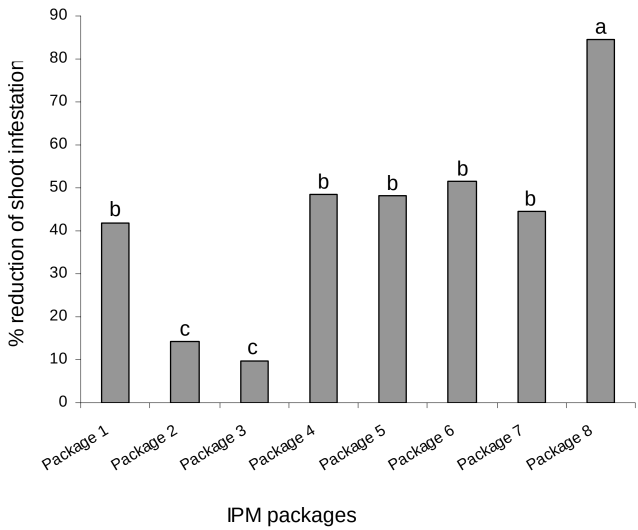

Fig. 2 Effect of different IPM packages on percent reduction of shoot infestation over control against brinjal shoot and fruit borer. Bars having the same letter are not significantly different according to DMRT at $P\leq$ 0.05

Table 1. Effect of different IPM packages on number of fruits per plant and percent fruit infestation caused by brinjal shoot and fruit borer

IPM packages	Healthy fruits/ plant	Infested fruits/ plant	Total fruits/ plant	Percent fruit infestation by number	Percent reduction of fruit infestation over control
Package 1	20.09 bc	4.76b	24.85 abc	19.15 cd	53.86 bc
Package 2	19.42 cd	4.24 bc	23.66 abc	17.95 cd	56.85 bc
Package 3	16.38 de	4.80 b	21.18 bc	22.83 c	45.15 c
Package 4	21.47 bc	3.56 bcd	25.03 ab	14.16 de	65.99 ab
Package 5	21.67 bc	2.49 cd	24.16 abc	10.23 e	75.34 a
Package 6	25.00 a	2.20 d	27.20 a	8.04 e	80.63 a
Package 7	14.18 ef	7.69 a	21.87 bc	34.94b	16.32 d
Package 8	23.11 ab	2.27 cd	25.38 ab	8.85 e	78.70 a
Untreated	11.98 f	8.53 a	20.51 c	41.60 a	-
df	8,16	8,16	8,16	8,16	7,14
F	33.60	25.56	5.26	56.07	31.56
P	0.000	0.000	0.002	0.000	0.000

Means followed by the same letter in a column are not significantly different according to DMRT at $P \leq 0.05$.

Table 2. Effect of different IPM packages on fruit yield of brinjal against brinjal shoot and fruit borer infestation

IPM Packages	Healthy fruit yield		Infested fruit yield		Total fruit yield	
	t/ha	Increase over control (%)	t/ha	Decrease over control (%)	t/ha	Increase over control (%)
Package 1	14.60 b	72.17	2.41 b	44.34	17.01 a	32.79
Package 2	14.76 b	74.06	2.31 b	46.65	17.07 a	33.26
Package 3	11.60 c	36.79	2.43 b	43.88	14.03 b	9.52
Package 4	15.21 b	79.36	1.80 bc	58.43	17.01 a	32.79
Package 5	16.02 ab	88.92	1.32 c	69.52	17.34 a	35.36
Package 6	17.71 a	108.84	1.12 c	74.13	18.83 a	46.99
Package 7	10.04 cd	18.40	3.91 a	9.70	13.95 b	8.90
Package 8	16.37 ab	93.04	1.15 c	73.44	17.52 a	36.77
Untreated	8.48 d	-	4.33 a	-	12.81 b	-
df	8,16		8,16		8,16	
F	48.68		26.93		15.24	
P	0.000		0.000		0.000	

Means followed by the same letter in a column are not significantly different according to DMRT at $P \leq 0.05$.

Table 3. Benefit cost ratio of different IPM packages for the management of brinjal shoot and fruit borer

IPM Packages	No. of sprays	Variable cost of pest management (Tk/ha)				Healthy fruit yield (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Adjusted net return (Tk./ha)	Benefit cost ratio (BCR)
		Insecticide	Fertilizer	Labour	Total					
Package 1	6	7500	0	8360	15860	14.60	219000	203140	75940	4.79
Package 2	9	11250	1200	1980	14430	14.76	221400	206970	79770	5.53
Package 3	7	8750	0	8580	17330	11.60	174000	156670	29470	1.70
Package 4	5	6250	1200	8140	15590	15.21	228150	212560	85360	5.48
Package 5	5	6250	1200	15180	22630	16.02	240300	217670	90470	4.00
Package 6	8	10000	1200	15840	27040	17.71	265650	238610	111410	4.12
Package 7	0	0	1200	14080	15280	10.04	150600	135320	8120	0.53
Package 8	16	20000	0	3520	23520	16.37	245550	222030	94830	4.03
Untreated	0	0	0	0	0	8.48	127200	127200	-	-

Cost of insecticides : Flubendiamide 24WG @ Tk 5000.00/kg
Cost of spray : Two labourers/spray/ha @ Tk 110.00/day. Spray volume required: 500 l/ha
Cost of mechanical control : One labour/ha/week before fruiting stage for weeks; four labourers/ha/week starting from fruiting stage for 15 weeks (Islam et al., 1999)
Cost of field sanitation : Four labourers/ha/week starting from fruiting stage for 15 weeks.
Cost of muriate of potash : Tk 16.00/kg
Market price of brinjal : Healthy fruit Tk 15.00/ kg. (1U$= 69.00TK.)