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AN INTEGRATED APPROACH TO MANAGE THE RHIZOME ROT DISEASE OF GINGER

M. M. ISLAM[1], F. KHATUN[2], M. I. FARUK[3], M. M. RAHMAN[4] AND M. A. HOSSAIN[5]

Abstract

An experiment was conducted at Gazipur, Bogura and Ramgarh to observe the effect of eight different treatments packages on rhizome rot of ginger. The package comprising of seed treated with Chlorox (10%) + Soil treatment with Stable Bleaching Powder (20 kg/ha) + Soil drenching with Chlorox (10%) and Ridomil (0.2%) alternately for 5 times each gave superior or better results in respect of germination(80-97%), disease reduction(50-62%) and crop yield (24 t/ha) of ginger in all locations. The same package showed disease reduction ranging from 53 to 57.33% at Nilphamari, Rangpur, Bogura, Madhupur and Ramgarh in the validation trials and thereby produced higher yield of ginger 24.8 t/ha at Bogura, 23.6 t/ha at Rangpur, 23.2 t/ha at Nilphamari and 22.6 t/ha at Ramgarh. The same package also gave higher benefit cost ratio (BCR) of 4.85 in case of experiment and 4.58 in case of validation trials. This package was therefore seemed to be cost effective in reducing rhizome rot disease of ginger and accelerate the yield if applied properly.

Keywords: Ginger, Rhizome rot, Integrated management.

Introduction

Ginger (*Zingiber officinale* Rosc.) is important because its aromatic rhizomes are being used as spice and medicine. Major producing countries of ginger in the world are India, Jamaica, Sierra Leone, Nigeria, Southern China, Japan, Taiwan and Australia. Though the crop is affected by many diseases rhizome rot is prevalent in most of the ginger growing areas and may cause losses to the extent of 50% or more (Joshi and Sharma, 1982). The disease was first reported in 1907 by Butler from Bengal and Gujrat and thereafter reported from almost all the ginger growing countries of the world (Chauhan and Patel, 1990; Dohroo *et al.*, 1987; Iyer, 1987).

Ginger is one of the most essential spices in Bangladesh and is cultivated more or less all over the country. Bangladesh produces only 77,000 metric tons of ginger from an area of 9000 hectares as against the requirement of 3,10,000 metric tons per annum (Anon., 2018). The yield of ginger in Bangladesh is very low

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compared to other ginger growing countries in the world. Every year a good quantity of ginger is imported from abroad in exchange of foreign currency. Dseases are to be considered the major limiting factor for ginger cultivation in Bangladesh caused by *Pythium aphanidermatum*, *Fusarium oxysporum*, *Sclerotium rolfsii* and *Ralstonia solanacearum.*

The causal organisms/agents perpetuate through infected soil and seeds (rhizomes). Diseased rhizomes are considered to be the main factor in the disease dissemination. To reduce disease infection, best method is to use disease free rhizomes for planting (Anon., 2015). Since the disease is internally seed borne also, seed treatments can reduce the infection to a limited extent. Various types of seed treatment have been tried by many workers prior to storage and also prior to planting including chemicals and hot water. Many chemicals have been tried by different workers for seed steeping such as Mercuric chloride 0.1%, Bavistin 0.3%, Dithane M-45 0.3% and Terrazole 0.2% (Iyer *et al.,* 1984). Two varying duration of seed steeping in the chemical solution *viz*., 30 minutes and 60minutes were found to be equally effective (Iyer *et al.*, 1985; Razu *et al.*, 1985). The other important source of infection is the infected soil. In most of the growing areas, crop rotation of 3-5 years is suggested to be practiced as routine. Proper drainage of excess water in the fields is recommended to reduce the disease spread. Early sowing of the crop during May and June has been found to suffer less from soft rot disease (Iyer *et al.,* 1984). Application of soil amendments is another method of reducing soil inoculum of the pathogen. Among the various amendments, application of neem cake has been found to reduce the soft rot incidence (Sadanandan and Iyer, 1986). Biological control of the pathogen by using well established antagonists has been attempted by several workers. Antagonistic activity of *Trichoderma* species in dual cultures against causal fungi of rhizome rot of ginger was demonstrated by Bhardwaj and Gupta (1987). Steeping inoculated rhizome in a spore suspension of *T. viridae* was quite effective against *P. aphanidermatum* and *Fusarium equisetti* on seed ginger. Another method of controlling the disease in the field is through fungicides. Soil and seed treatment with Ridomil 5G and Apron 35 WS gave the best control of the disease in infected plots (Ramchandra *et al.,* 1989). Available literatures indicate that the rhizome rot disease of ginger is difficult to control through single option in the field (Anon., 2015). Therefore, there is an urgent need to address this problem and to develop a combined management options for effective control of the disease. So the present study was undertaken to develop an integrated management package for controlling rhizome rot disease of ginger.

Materials and Methods

a) On-station

The experiments were conducted at Gazipur, Bogura and Ramgarh (Khagrachari) to develop a sustainable management package for controlling the rhizome rot

disease of ginger through an integrated approach during 2015-16 and 2016-17 cropping seasons. Recommended fertilizer doses and proper intercultural operations were applied in all the experiments. Cowdung @ 5 t/ha, N @ 140 kg/ha, P @ 54 kg/ha and K @ 117 kg/ha were applied. The experiments were carried out following Randomized Complete Block Design with three replications. Size of the unit plot was 3.0m x 2.0 m and plant spacing was maintained 50 cm x 25 cm. Variety 'BARI Ada -1' was used in the experiment. There were 8 treatments in the experiment *viz*., T_1= Mustard oil cake (300 kg/ha), T_2= Poultry refuge (5t/ha), T_3= Stable Bleaching Powder (SBP) @ 20kg/ha, T_4= Seed treatment with Chlorox (10.0%), T_5= Bavistin (0.2%) seed treatment + 2 times soil drenching with Bavistin (0.2%) , T_6= Ridomil (0.2%) seed treatment + 2 times soil drenching with Ridomil (0.2%), T_7= Seed treatment with Chlorox (10%) + Soil treatment with SBP (20kg/ha) + Soil drenching with Chlorox (10.0%) & Ridomil (0.2%) alternately for 5 times each and T_8= Control.

Rhizomes were planted on April 15, 2015. Intercultural operations were done to maintain the normal hygienic condition of the crop in the field. Data were recorded on germination, percent infected plants and yield. The recorded data were analyzed statistically to find out the level of significance and the variance was analyzed following Duncan's New Multiple Range Test (DMRT).

b) Validation Ttrial

Based on the results of trials obtained from first year, a validation trial was conducted in farmer's fields of five different districts with the best treatment package and control treatment during 2016-17 cropping season. The locations of validation trial were Nilphamari, Rangpur, Bogura, Madhupur (Tangail) and Ramgarh (Khagrachari). The trials were replicated thrice. The design of the trials was paired plot. 'BARI Ada-1' was sown at all locations. The two selected treatments of validation trials were: T_1= Seed treatment with Clorox (10%) + Soil treatment with SBP (20 kg/ha) + Soil drenching with Clorox(10.0%) and Ridomil(0.2%) alternately for 5 times and T_2= Control. Data on germination, disease incidence and yield were collected from the validation trials. The data were analyzed statistically and the means were separated by Duncan's New Multiple Range Test (DMRT) for interpretation of the results.

Economics of the Research

Cost Benefit ratio for application of package treatment for management of rhizome rot disease of ginger was done based on the current market price of input, rate of hiring labour and agricultural machineries. Estimation of Benefit Cost Ratio (BCR) was calculated according to Gitting (1982) using the following formula:

Benefit Cost Ratio (BCR) = Gross return (Tk./ha)/Total cost of production (Tk./ha).

Results and Discussion

a) On-station experiment

The germination of rhizome ranged 80.0-97.0% under different treatments at various locations. The highest germination was observed (97.0%) at Bogura in T_4 treatment (Table 1) and the lowest germination 86.0% was found in control treatment (T_7). Similar result was also obtained from Gazipur. However, the germination was lowest at Ramgarh.

Table 1. Effect of treatments on germination, diseases incidence and yield of ginger at different locations during 2015-16

Treatments	Bogura			Gazipur			Ramgarh	
	Germination (%)	Disease incidence (%)	Yield (t/h)	Germination (%)	Disease incidence (%)	Yield (t/h)	Germination (%)	Disease incidence (%)
T_1= Mustard oil cake (300kg/ha)	87.0	50a	8.5f	83.0	45.66b	10.0g	80.0	51.66b
T_2= Poultry refuge (5t/ha)	88.0	48c	11.6e	87.0	44.66b	12.9f	81.0	50.00b
T_3= Stable bleaching powder (20kg/ha)	89.0	11f	12.0e	90.0	9.00de	13.9e	87.0	12.00d
T_4= Seed treatment with Chlorox (10.0%)	97.0	13e	22.8b	97.0	11.00d	22.5b	86.0	14.00d
T_5= Bavistin seed treatment + 2 times soil drenching with Bavistin	88.0	17.66d	12.53d	89.0	15.00c	16.96d	83.0	20.000c
T_6= Ridomil seed treatment + 2 times soil drenching with Ridomil Gold	92.0	8.00g	14.7c	93.0	7.33ef	19.06a	84.0	8.33e
T_7= Seed treatment with Chlorox (10.0%) + Soil treatment with Stable Bleaching Powder (20kg/ha) + Soil drenching with Chlorox & Ridomil Gold alternately for 5 times	96.0	7.00g	24.7a	97.0	6.00f	24.00a	86.0	6.67e
T_8= Control	86.0	55.00a	6.53g	82.0	50.00a	5.93h	80.0	62.00a
LSD value	-	1.991	0.4107	-	2.228	0.4325	-	3.77
CV (%)	-	4.33	1.65	-	5.40	1.52	-	2.215

The disease incidence was significantly reduced in all treatments over control (Table 1). The disease incidence ranged from 50.0-62.0 % in control (T_8) plots whereas the lower incidence ranged from 6-7% was observed in T_7 treatment where seed treatment with Chlorox (10.0) % + Soil treatment with stable bleaching powder, 20kg/ha + Soil drenching with Chlorox and Ridomil alternately for 5 times were applied. The higher yield ranging from 24.0-24.70 t/ha was obtained from T_7 at Gazipur and Bogura followed by 22.80 t/ha and 22.50 t/ha at Bogura and Gazipur in the treatment T_4. The lowest yield 5.93 t/ha was obtained in Gazipur and 6.53 t/ha in Bogura from untreated control (Table 1).

The result of the present study indicated that combined application of seed treatment with Chlorox (10.0%) + Soil treatment with Stable Bleaching Powder (20kg/ha) + Soil drenching with Chlorox and Ridomil alternately for 5 times gave good control of rhizome rot disease as well as increased yield of ginger. Rathaiah (1987) also reported that soft rot of ginger was controlled by using Ridomil in combination of Captofal/Mancozeb as wetting of seed (rhizome) pieces before planting and soil drenching of Ridomil and Captofal significantly increased yield of ginger.

b) Validation trials

The validation trials to control the rhizome rot were conducted at five locations viz. Nilphamari, Rangpur, Bogra, Madhupur and Ramgarh in farmer's field for confirming the treatment-effect obtained as promising in the first year results with some modifications. The package treatment (T_1= Seed treatment with Chlorox (10%) + Soil treatment with SBP (20 kg/ha) + Soil drenching with Chlorox(10%) and Ridomil Gold (0.2%) alternately each for 5 times gave better performance both in relation to germination of ginger and reduction of rhizome rot, irrespective of locations. The germination ranged from 82-97% over the locations of Nilphamari, Rangpur, Bogura, Madhupur and Ramgarh in the package treatment, whereas it was 78-89% in the same locations in the control plot (Table 2).

Table 2. Effect of package treatment on the germination of ginger at 5 locations during 2016-17

Treatment	Germination (%)				
	Nilphamari	Rangpur	Bogura	Madhupur	Ramgarh
T_1= Seed treatment with Chlorox (10.0%) + Soil treatment with SBP (20kg/ha) + Soil drenching with Chlorox & Ridomil Gold alternately for 5 times application	96	94	95	97	82
T_2= Untreated control	88	86	85	89	78
Increased germination over control (%)	9.09	9.30	12.0	9.0	5.12

Similarly, 53-60.33% reduction of disease incidence was observed in the package treatment compared to control plot at Nilphamari, Rangpur, Bogra, Madhupur and Ramgarh (Table 3). Considering the yield, the highest yield 24.8 t/ha was obtained at Bogura followed by 23.6 t/ha at Rangpur, 23.2 t/ha Nilphamari, 22.6 t/ha at Madhupur and 21.24a t/ha in Ramgarh in the package treatment. The control treatment gave the lowest yield at all locations (Table 4).

Table 3. Effect of package treatment on rhizome rot disease incidence of ginger at various locations during 2016 -17

Treatment	Rhizome rot incidence (%)				
	Nilphamari	Rangpur	Bogura	Madhupur	Ramgarh
T_1= Seed treatment with Chlorox (10.0%) + Soil treatment with SBP (20kg/ha) + Soil drenching with Chlorox & Ridomil Gold alternately for 5 times.	6.00 b	6.33 b	8.00 b	7.0 b	8.0 b
T_2= Control	63.33 a	60.00 a	61.00 a	67.33 a	65.00 a
Reduction of rhizome rot (%)	57.33	53.77	53.00	60.33	57.00
CV (%)	2.36	1.23	19.55	3.86	1.94

Table 4. Average yield of ginger from various locations under package treatment during 2016-17

Treatment	Yield (t/ha)				
	Nilphamari	Rangpur	Bogura	Madhupur	Ramgarh
T_1= Seed treatment with Chlorox (10.0%) + Soil treatment with SBP (20kg/ha) + Soil drenching with Chlorox & Ridomil Gold alternately for 5 times.	23.20a	23.60a	24.80a	22.60a	21.24a
T_2= Control	6.10b	6.40b	6.60b	5.80b	5.65b
Yield increased over control (%)	73.70	72.88	73.39	74.34	70.49
CV (%)	2.10	2.16	1.35	1.49	1.32

It is clear from the results that 78.0-96.0% germination observed in the validation trials where the rhizome rot disease incidence was comparatively less in treated plot. The present findings is supported by Anon. (2006) who showed that, minimum disease incidence (16.40 %) was recorded by one hour seed treatment with Ridomil MZ (3g/l of water) followed by Indofil M-45 (25.30 %). Integration of different components had a significant influence compared to single component on the incidence of rhizome rot disease and yield of ginger (Anon., 2013, Anon., 2014 and Anon., 2015). In addition Stable Bleaching

Powder (12 kg/ha) mixed in furrows at the time of planting could reduce the bacterial wilt of potato by 80 per cent (Shekhawat *et al*., 1988).

Table 5. Benefit Cost Ratio (BCR) of developed technology for controlling rhizome rot disease of ginger in field experiment.

Treatment	Average yield (t/ha)	Gross return (Tk.)	Total cost (Tk.)	BCR
T_1= Mustard oil cake (300kg/ha)	9.25	1110000	545400	2.03
T_2= Poultry liter (5t/ha)	12.25	1470000	548403	2.68
T_3= SBP (20kg/ha)	12.95	1554000	589275	2.63
T_4= Seed treatment with Chlorox (10.0%)	22.65	2718000	589275	4.61
T_5= Bavistin seed treatment + 2 times soil drenching with Bavistin	14.74	1768800	539403	3.27
T_6= Ridomil seed treatment + 2 times soil drenching with Ridomil Gold	16.88	2025600	597900	3.38
T_7= Seed treatment with Chlorox (10.0%) + Soil treatment with SBP (20kg/ha) + Soil drenching with Chlorox & Ridomil alternately for 5 times.	24.35	2922000	602475	4.85
T_8= Control	6.23	747600	505000	1.48

Table 6. Benefit Cost Ratio (BCR) of a package technology for controlling rhizome rot disease of ginger in validation.

Treatment	Average yield (t/ha)	Gross return (Tk.)	Total cost (Tk.)	BCR
T_1= Seed treatment with Chlorox (10.0%) + Soil treatment with SBP (20kg/ha) + Soil drenching with Chlorox and Ridomil Gold alternately for 5 times application	23	27 60000	602475	4.58
T_2= Control	6	720000	505000	1.43

Economic analysis

Benefit Cost Ratio (BCR) of the field experiment as well as validation trial were estimated according to Gitting (1982). It was found that the teatment T_7 i.e. Seed treatment with Chlorox (10%) + Soil treatment with SBP (20 kg/ha) + Soil drenching with Chlorox (10%) and Ridomil Gold (0.2%) alternately for 5 times yielded the highest return showing benefit cost ratio (BCR) 4.85 followed by treatment T_4= Seed treatment with Chlorox (10.0%) with BCR 4.61. Benefit cost ratio were 3.38 and 3.27, respectively for the other promising treatment T_6=

Ridomil seed treatment + 2 times soil drenching with Ridomil Gold and T_5= Bavistin seed treatment + 2 times soil drenching with Bavistin in compared to control (Table 5). In validation trial the benefit cost ratio was more than four times (4.58) higher than control treatment (T_2).

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BIO-RATIONAL MANAGEMENT APPROACHES OF FRUIT BORER, *HELICOVERPA ARMIGERA* (HÜBNER) INFESTING TOMATO

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Abstract

The present study was conducted during November 2014 to June, 2015 with bio-rational approaches for combating tomato borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) using Vertimec 1.8EC (Abamectin), Tracer 45SC (Spinosad), mechanical control (hand picking), 3 Neem products and an untreated control following Randomized Complete Block Design with 3 replications. The lowest level of fruit borer infestation (11.05% by number) at entire fruiting seasons and at early (11.05%), mid (10.88%) and late (11.28%) fruiting season was obtained from Tracer 45EC treated plot. The highest marketable yield (46.00 t/ha) was produced in the plot treated with Tracer 45SC sprayed @ 0.4 ml/L of water at 15 days interval. The marketable yield in plots treated with Vertimec 1.8EC @ 1.2 ml/L of water at 15 days interval was 37.67 t/ha and the plot sprayed with neem seed kernel extract @ 50 g/L of water at 15 days interval yielded 36.17 t/ha. The highest benefit cost ratio of 6.84 was obtained from the plot applied with Tracer 45SC followed by 6.39 obtained in the plots using Vertimec 1.8EC and this was followed by 6.18 found in neem seed kernel extract treated plot. Tracer 45SC was the most effective against tomato fruit borer.

Keywords: Bio-rational pesticides, neem, *Helicoverpa armigera*, mechanical control

Introduction

Tomato (*Solanum lycopersicum*) is one of the most popular and important vegetable grown in Bangladesh during *rabi* season and round in many countries globally. In Bangladesh, Tomato yield is not satisfactory enough compared to other tomato growing countries of the world (Aditya *et al.,* 1999). Different limiting factors are responsible for the low yield of tomato in Bangladesh. Among them the attack of insect pest from seeding to fruiting stage is the important factor for low yield of tomato because all the plant parts including leaves, stems, flowers and fruits are subjected to attack.

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The tomato plant is attacked by different species of insect pests such as fruit borer, white fly, aphid and leaf miner in Bangladesh. Among them tomato fruit borer, *Helicoverpa armigera* (Hübner) is one of the serious pests. It has been reported to cause damage to an extent of 50-60 % fruits (Singh and Singh, 1977). Fruit damage by this pest might be up to 85-93%. Due to severe infestation, fruit as well as seed maturation hampered greatly and the viability of the seeds reduced (Tewari, 1985).

Though the tomato fruit borer (*H. armigera*) is a major pest in status, the management of this pest through non-chemical tactics including cultural, mechanical, biological and host plant resistance undertaken by the researcher throughout the world is limited. Generally the farmers of Bangladesh combat this pest by the application of chemical insecticides. In Bangladesh, it was reported that cypermethrin, deltamethrin, fenvalerate and quinalphos @ 1.5 ml/L of water gave the better result in controlling tomato fruit borer (Alam *et al.,* 2003). However, indiscriminate and non-judicious use of insecticides may result in a serious problem related to both loss of their effectiveness and in the long run, it develops insect resistance, pollution and health hazards (FAO, 2003). Moreover, continuous use of chemical insecticides develops cross and multiple resistant strains in many important insect species (Geiger *et al*., 2010) including this fruit borer. Indiscriminate and haphazard use of these chemicals, particularly at fruiting stage, leads to its accumulation in the vegetables which consequently cause hazards to human health through food chain (Nafees *et al.,* 2009). As the tomato is mostly consume in raw, so the problems is more serious than any other vegetables. Again the question of residual toxicity of pesticides is another big threat to our vegetable exports in the foreign markets (Islam *et al.,* 1999). Therefore, eco-friendly management approach is must to reduce the environment and health hazards. Various non-chemical approaches like use of environment friendly biopesticides, botanicals, clean cultivation, mechanical control like hand picking and destroying of infested plant parts are common practices used for suppressing the insect pests (Hassan, 1994). Appropriate knowledge and availability of botanical pest management approaches and their integration with selective chemicals may give better results against tomato fruit borer. Considering the circumstances, the present study was conducted to evaluate the effectiveness of some bio-rational management approaches against *H. armigera* in tomato field.

Materials and Methods

Experimental site and design

The study was conducted in the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during November 2014 to June 2015. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The unit plot size was 3m × 3m and separated by 1m and block to block distance was 2m.

Growing of tomato

The seeds of 'BARI tomato-3' were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Seeds were sown in a seed tray. The seedlings were germinated in the seed tray and 10 days after germination, all the seedlings were transplanted into poly bags. From poly bags 30 days old seedlings were transplanted in the experimental plot of each treatment. A total 315 seedlings were transplanted in 21 plots at the rate of 15 seedlings per plot with the distance of 1m between lines and 60 cm between plants. Gap filling was done by transplanting seedlings from the stock. Manures and fertilizers were applied according to Rashid (1999) and intercultural operations such as irrigation, weeding, mulching, and other operations were done throughout the cropping season for proper growth and development of the plants.

Application of treatments

The experimental field was monitored regularly to observe the initiation of infestation. When the pest caused approximately 2% fruit infestation, the application of treatments was started. The experimental treatments were Vertimec 1.8EC (Abamectin) @ 1.2 ml/L, Tracer 45 SC (Spinosad) @ 0.4 ml/L, Neem seed kernel extract (Azadirachtin) @ 50 g/L, Neem leaf extract (Azadirachtin) @ 50 g/L, Neem oil (Azadirachtin) @ 5.0 ml/L of water and Mechanical control (hand picking) with clean cultivation.

For preparing Neem (*Azadirachta indica*) seed karnel extract, mature seeds were collected, sun dried and grounded into powder. The powder was soaked in water @ 50g/300 ml of water for overnight. The mixture was filtered through nylon net and maintained the volume of 1000 ml. For neem leaf extract, fresh leaves were collected one day before application and were cut into small pieces and 500g leaves were blended thoroughly in an electric blender. The blended leaves were mixed with two liters of water and the mixture was kept overnight to enhance extraction. The mixture was then sieved and maintained the volume at 5 liters. All the treatments were applied at 15 days interval by knapsack sprayer and repeated 4 times up to last harvest.

Collection and analysis of data

Data on fruit infestation and fruit yield by number and weight per plot were recorded at early, mid and late fruiting stages on each harvest by number of the harvests sequentially. The infestation of the pest was expressed in percentage based on total number of fruit (n/n) and weight (w/w) of fruit. The cumulative yield (kg) per plot of healthy as well as infested fruits was computed. The final yield was expressed in ton per hectare. For economic analysis, benefit cost ratio (BCR) was calculated on the basis of total expenditure of the respective spray schedule along with the total return from that particular spray schedule. The data

were analyzed statistically by analysis of variance (ANOVA) and the means were separated by using Duncan's Multiple Range Test (DMRT).

Results and discussion

Rate of fruit infestation by number at different fruiting stages

All the bio-rational management approaches significantly reduced percent fruit infestation (n/n) in early, mid and late fruiting stages compared to untreated control plot (Table 1). Significantly the lowest fruit infestation by number (11.05%) was found in Tracer 45 SC treated plot. At early fruiting stage, significantly the highest fruit infestation was found in untreated control plot (31.71%) followed by neem leaf extract (23.76%), neem oil (23.66%) and Vertimec 1.8EC (22.62%) sprayed plots and these were statistically similar to each other. Percent infested fruit by number recorded from neem seed kernel extract treated plot and mechanical control (hand picking) with clean cultivation were 18.17% and 17.37%, respectively and these were statistically similar with each other (Table 1).

At mid fruiting stage, significantly the highest fruit infestation was found in untreated control plot (24.00%) followed by Vertimec 1.8EC sprayed plot (18.89%). Percent infested fruit recorded from the plot treated with neem seed kernel extract, neem leaf extract, neem oil and mechanical control (hand picking) with clean cultivation were 15.82%, 12.67%, 14.59% and 13.25%, respectively and these were statistically similar with each other. Significantly the lowest fruit infestation by number was found in Tracer 45SC sprayed plot (10.88%) (Table 1).

At late fruiting stage, significantly the lowest rate of fruit infestation (11.28 %) was found in Tracer 45SC treated plot followed by mechanical control (hand picking) with clean cultivated plot (16.66%). Significantly the highest fruit infestation by number was found in untreated control plot (30.76%) followed Vertimec 1.8EC (25.08%) sprayed plot. Percent infested fruit recorded from neem oil, neem seed kernel extract and neem leaf extract treated plot were 20.53%, 21.42% and 23.28%, respectively and these were statistically significant with each other (Table 1).

Mittal and Ujagir (2005) evaluated newer molecule Spinosad 45SC along with other insecticides. Among different treatments lower number of *H. armigera*, *Maruca vitrata* (Geyer) and *Melanagromyza obtusa* (Malloch) larvae were recorded in Spinosad 90 g/ha and Spinosad 73 g/ha and also recorded lower pod damage compared to other treatments. Mechanical control comprising removal of infested fruits is a safe and cheap control technique. It was found that the larvae of *H. armigera* can be controlled successfully by this methods following every alternate day during marble size tomato to before ripen period. Report revealed that about 75% control is possible only by this method. But better result

was obtained by mechanical method + spraying of botanical pesticides (Uddin, *et al.*, 2002).

Table 1. Tomato fruit infestation by *H. armigera* at early, mid and late fruiting stages in different management practices

Treatment	Rate of fruit infestation (%)		
	Early fruiting stage	Mid fruiting stage	Late fruiting stage
Vertimec 1.8EC	22.62b	18.89b	25.08b
Tracer 45SC	11.05d	10.88c	11.28e
Neem seed kernel extract	18.17bc	15.82bc	21.42c
Neem leaf extract	23.76b	12.67bc	23.28bc
Neem oil	23.66b	14.59bc	20.53c
Mechanical control	17.37bc	13.25bc	16.66d
Untreated control	31.71a	24.00a	30.76a
CV (%)	8.56	6.85	6.18

Means within a column followed by same letter(s) do not differ significantly (P=0.05) according to Duncan's Multiple Range Test (DMRT).

Fruit infestation in total cropping season

In total cropping season, the lowest rate of fruit infestation by number was found in Tracer 45SC treated plot (11.05%) as against (27.63%) the highest fruit infestation in untreated control plot (27.63%). Percent infested fruit recorded from Vertimec 1.8EC, neem oil, neem seed kernel extract, neem leaf extract, and mechanical control (hand picking) with clean cultivation were 21.15%, 17.78%, 17.70%, 17.04% and 16.88%, respectively. The increase in number of healthy fruit over untreated control was 23.45%, 60.00%, 35.93%, 38.32%, 35.64% and 38.90% with Vertimec 1.8EC, Tracer 45SC, neem seed kernel extract, neem leaf extract, neem oil and mechanical control (hand picking) with clean cultivation, respectively (Table 2).

In total cropping season, the lowest rate of fruit infestation by weight was found in Tracer 45SC treated plot (8.85%). The highest fruit infestation was found in untreated control plot (36.29%) followed by plot sprayed with neem seed kernel extract (18.79%). Percent infested fruit recorded from Vertimec 1.8EC, neem leaf extract, neem oil treated plot and mechanical control (hand picking) with clean cultivated plot were 15.66%, 15.64%, 18.67% and 18.67%, respectively. The reduction percentage of weight of infested fruit over untreated control was 39.86%, 63.53%, 27.89%, 49.89%, 42.44% and 50.34% with Vertimec 1.8EC, Tracer 45SC, neem seed kernel extract, neem leaf extract, neem oil and mechanical control (hand picking) with clean cultivation, respectively (Table 2).

Sparks *et al*. (1995) reported that Spinosad has relatively broad spectrum activity and has been effectively used for the control of many species of insect pests in the order of Lepidoptera in various crop systems. The results on the mean percent fruit damage by *L. orbonalis* indicated that Spinosad was found to be effective in checking the fruit damage.

Botanical pesticides are becoming popular day by day. Now a days, these are using against many insects. It was found that Lepidopteran insect is possible to control by botanical substances. Weekly spray application of the extract of neem seed kernel showed effective against *H. armigera* (Karim, 1994).

Table 2. Effect of different management practices on fruit infestation by tomato fruit borer at entire cropping season

Treatment	Rate of infestation (n/n)		Rate of infestation (w/w)	
	% infestation	% reduction over untreated control	% infestation	% reduction over untreated control
Vertimec 1.8EC	21.15b	23.45	15.66b	39.86
Tracer 45SC	11.05d	60.00	8.85c	63.53
Neem seed kernel extract	17.70c	35.93	18.79b	27.89
Neem leaf extract	17.04c	38.32	15.64b	49.89
Neem oil	17.78c	35.64	15.26b	42.44
Mechanical control	16.88c	38.90	18.67b	50.34
Untreated control	27.63a	-	36.29a	
CV (%)	12.37	-	8.19	-

Means within a column followed by same letter(s) do not differ significantly (P=0.05) according to Duncan's Multiple Range Test (DMRT).

Yield of tomato

All bio-rational management approaches produced significant quantity of marketable yield and decreased the quantity of infested yield compared to untreated control plot. Significantly the highest marketable yield was recorded from Tracer 45SC treated plot (46.00 t/ha) (Table 3). The second highest yield of healthy fruits was found in Vertimec 1.8EC (37.67 t/ha) followed by neem seed kernel extract (36.17 t/ha), neem oil (35.08 t/ha), and neem leaf extract (33.16 t/ha) which were statistically similar to each other. The lowest weight of healthy fruits per plot was recorded from untreated control plot (21.49 t/ha) having significance difference with mechanical control (hand picking) with clean cultivation (26.49 t/ha).

Significantly the lowest infested yield t/ha was recorded from Tracer 45SC treated plot (4.47 t/ha) having no significance difference with mechanical control (hand picking) with clean cultivated plot (6.08 t/ha) and neem leaf extract (6.16

t/ha). Statistially similar infested fruit yield was obtained from in Vertimec 1.8EC treated plot (7.36 t/ha), neem seed kernel extract (8.83 t/ha) and neem oil treated plot (7.06 t/ha). The highest weight of infested fruits (12.24 t/ha) was observed in untreated control plot which was statistically different from all other treatments (Table 3).

Significantly the highest total yield/ha was recorded from Tracer 45SC treated plot (50.47 t/ha). The second highest yield was found in neem seed kernel extract (45.00 t/ha) which was statistically similar to Vertimec 1.8EC (45.03 t/ha), neem leaf extract (39.32 t/ha) and neem oil (42.14 t/ha). The lowest total yield (t/ha) was recorded from mechanical control (hand picking) and clean cultivated plot (32.57 t/ha) which was statistically similar to that of control plot (33.73 t/ha) and also with Neem Leaf Extract sprayed plot (39.32 t/ha) (Table 3).

Awal (2012) reported that the highest healthy fruit yield in brinjal 20.70 t/ha was obtained in the plots treated with IPM package comprising Tracer 45SC @ 0.4 ml/L + pheromone trap + mechanical control and field sanitation followed by IPM packages consisting Tracer 45SC 0.4 ml/L + pheromone trap (18.56 t/ha), and in sole use of Tracer 45SC @ 0.4 ml/L (16.78 t/ha). He also reported, the highest percent healthy fruit yield increased (116.60%) over control was recorded in the plots treated with IPM package consisting of Tracer 45SC 0.4 ml/L + pheromone trap + mechanical control and field sanitation followed by IPM package consisting of Tracer 45SC @ 0.4 ml/L + pheromone trap (94.20%) and then in sole use of Tracer 45SC @ 0.4 ml/L (75.57%) and IPM package consisting Bactoil @ 2.0 ml/L + pheromone trap + mechanical and field sanitation (68.36%).

Table 3. Fruit yield of tomato in different management approaches applied against tomato fruit borer

Treatment	Yield (t ha^{-1})		
	Marketable	Infested	Total yield
Vertimec 1.8EC	37.67b	7.36b	45.03b
Tracer 45SC	46.00a	4.47c	50.47a
Neem seed kernel extract	36.17b	8.83b	45.00b
Neem leaf extract	33.16b	6.16bc	39.32bc
Neem oil	35.08b	7.06b	42.14b
Mechanical control	26.49c	6.08bc	32.57c
Untreated Control	21.49c	12.24a	33.73c
CV (%)	7.45	8.97	10.43

Means within a column followed by same letter(s) do not differ significantly (P=0.05) according to Duncan's Multiple Range Test (DMRT).

Effectiveness of Spinosad 45EC along with other standard insecticides was tested against pigeon pea pod borer by Vishal and Ram (2005). Lower pod damage in pigeon pea was observed in Spinosad 90g, Spinosad 73g, Spinosad 56g and Spinosad 45g treated plots compared to untreated control plot over two years. Accordingly, greater grain yields were also obtained in Spinosad 90g (1741 kg/ha), Spinosad 73g (1463 kg/ha), Spinosad 45g (1218 kg/ha) and Spinosad 56g (1213 kg/ha) treated plots as compared to untreated control (768 kg/ha) plot.

Economic analysis

The management cost of different management approaches is presented in Table 4. The highest gross return of Tk. 460000.00 per hectare was found in Tracer 45SC treated plot followed by Tk. 376700.00 in Vertimec 1.8EC applied plot, Tk. 361700.00 in neem seed kernel extract sprayed plot and Tk. 350800.00 in neem oil sprayed plot. On the other hand, the lowest gross return Tk. 214900.00 was calculated in untreated control plot followed by Tk. 264900.00 in the mechanical control plot and Tk. 331600.00 in neem leaf extract treated plot (Table 4).

The highest net return of Tk. 428770.00 per hectare was found in Tracer 45SC treated plot followed by Tk. 354830.00 in Vertimec 1.8EC applied plot and Tk. 341270.00 in neem seed kernel extract sprayed plot. On the other hand, the lowest net return Tk. 214900.00 was calculated in untreated control plot followed by Tk. 253200.00 in the mechanical control plot, Tk. 311170.00 in neem leaf extract treated plot and Tk. 311370.00 in neem oil sprayed plot (Table 4).

The highest adjusted net return of Tk. 213870.00 per hectare was found in Tracer 45SC treated plot followed by Tk. 139930.00 in Vertimec 1.8EC applied plot and Tk. 126370.00 in neem seed kernel extract sprayed plot. On the other hand, the lowest adjusted net return Tk. 38300.00 was calculated in the mechanical control plot followed by Tk. 96470.00 in neem oil treated plot and Tk. 96270.00 in neem leaf extract sprayed plot (Table 4).

The highest benefit cost ratio of 6.84 was obtained from the treatment with Tracer 45SC and the second highest benefit cost ratio of 6.39 was recorded from the plot treated with Vertimec 1.8EC followed by neem seed kernel extract treated plot (6.18). The lowest benefit cost ratio of 2.44 was found in the treatment with neem oil. The benefit cost ratio in the mechanical control (hand picking) and clean cultivated plot and neem leaf extract sprayed plot were 3.27 and 4.71, respectively (Table 4).

The findings of the present study indicated that the insecticide Tracer 45SC, Vertimec 1.8EC and neem seed kernel extract are effective to manage infestation of tomato fruit borer in tomato. The result of this study reveal that Tracer 45SC, Vertimec 1.8EC and neem seed kernel extract showed effective result in suppressing tomato fruit borer infestation and also found as cost effective.

Spinosad and Emamectin benzoate have given good control of the southern armyworm and tomato pinworm (Stansly *et al.*, 2001). Dandale *et al.* (2000) studied the efficacy of Spinosad 48 SC against cotton bollworm and found effective.

Awal (2012) reported that in suppression of BSFB, the BCR was the highest (7.15) in an IPM package consisting of Tracer 45SC @ 0.4 ml/L + pheromone trap + mechanical control and field sanitation followed by 6.72 and 5.47 in the IPM packages consisting of Tracer 45SC @ 0.4 ml/L + pheromone trap and in sole use of Tracer 45SC 0.4 @ ml/L, respectively which is similar to the present findings. Patel *et al.* (1991) observed the highest BCR 5.26 by spraying Endosulfan against *H. armigera* attacking tomato.

Table 4. Benefit cost ratio analysis of different management practices applied against tomato fruit borer

IPM package	Management cost (Tk)	Gross return (Tk)	Net return (Tk)	Adjusted net return (Tk)	BCR
Vertimec 1.8EC	21870.00	376700.00	354830.00	139930.00	6.39
Tracer 45SC	31230.00	460000.00	428770.00	213870.00	6.84
Neem seed kernel extract	20430.00	361700.00	341270.00	126370.00	6.18
Neem leaf extract	20430.00	331600.00	311170.00	96270.00	4.71
Neem oil	39430.00	350800.00	311370.00	96470.00	2.44
Mechanical control	11700.00	264900.00	253200.00	38300.00	3.27
Untreated control	0.00	214900.00	214900.00	0.00	-

Market value of tomato=10Tk./kg, The cost of Vertimec 1.8EC @ Tk. 90/50 ml bottle, Tracer 45SC @ Tk 695/25ml bottle, Neem Seed Kernel Extract @ Tk 200/kg, Neem oil @ 120Tk/100 ml, Insecticide preparation and application @ 3 labor/ha, Labor wage @ Tk. 260/day, Sprayer rent @ Tk. 30/day.

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PERFORMANCE AND POSSIBILITY OF GROWING WHEAT VARIETIES IN CHALAN BEEL AREA

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Abstract

The experiment was conducted at Dobila, Tarash of Shirajgonj in Chalan Beel during *rabi* season of 2016-17 and 2017-18. The treatments were four wheat varieties *viz*. 'BARI Gom-25', 'BARI Gom-26', 'BARI Gom-28' and 'BARI Gom-30'. Wheat var. 'BARI Gom-30' produced the highest grain yield (5.02 t/ha in 2016-17 and 4.83 t/ha in 2017-18 with pooled value of 4.93 t/ha) associated with higher number of spikes/m^2 (372-444/m^2 with pooled value of 408/m^2) and higher number of grains/spike (pooled value of 45/spike). 'BARI Gom-30' required field duration of 113 days. Two years' results revealed that 'BARI Gom-30' performed better in Chalan Beel area in respect of higher mean grain yield (4.93 t/ha) and economics (Gross margin of Tk.100400/ha and BCR of 1.78). There was no blast infestation in the experimental field in both the years. Farmers showed moderate interest to grow wheat in Chalan Beel area specially in upland (medium low land of Beel) condition. Among the wheat variety 'BARI Gom-30' could be suitable for cultivation in Chalan Beel area.

Introduction

Beel (Low land and remains under water about 4-5 months from July to November) covering an area of 2.43 million hectares in Bangladesh (Aziz *et al.,* 2016). *Boro*-fallow is the major cropping pattern in beel area. Previous survey and experience indicate that farmers also grow maize, wheat, mustard, garlic, lentil, onion, pea, lathyrus and potato in beel area especially upper side land (*Kandha*) of beel (BARI, 2016). Although the farmers of this area grow some crops but they do not use improved crop varieties and production technologies (Islam *et al*., 2012). Previous research indicates that there is a possibility of improving productivity of different crops and cropping pattern through adaptation of HYV of crops along with their production technologies. *Boro* rice is the main crop in beel area which require huge amount of water *i.e*. one kg *boro* rice production requires 2500 liter water (Bouman, 2009). On the other hand, wheat and maize require 1300 litre and 900 liter water, respectively (Bouman, 2009). Consequently, *boro* rice cultivation depleted huge amount of underground water resulting depletion of underground water level. Chalan Beel is the largest wetland in northern Bangladesh, uniqueness for largely drastic falls in water level (Anon. 2017). Lifting of underground water is becoming a problem for farmers. Hence, alternate cropping rather than *boro* rice can save underground water

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resource as well as environment. Early flooding may cause damage the *boro* rice. In this context, *boro* rice can be replaced by wheat, potato, maize, mustard, garlic, lentil, onion and winter vegetables. These crops require low water as compared to *boro* rice. Wheat is the most important staple food crop in temperate zones and its demand is also increasing there. Being a major source of starch and energy, wheat also provides substantial amounts of protein, minerals, fat, calcium, iron, carotene, vitamin B-1, vitamin B-2 and other phytochemicals which are essential or beneficial for human and animal health (AIS, 2018). Wheat cultivation requires less cost as compared to *boro* rice. Moreover, use of HYV wheat and improved management practice can improve the yield of wheat and could save underground water use as compared to *boro* rice cultivation in beel area. Therefore, the experiment was undertaken to find out the performance wheat varieties in Chalan Beel area.

Materials and Methods

The experiment was conducted at Dobila, Tarash of Shirajgonj in Chalan Beel area during *rabi* seasons of 2016-17 and 2017-18. Soil of the experimental location was silty clay with pH value 7.24 and organic matter content 2.11% while nutrient like N, P, K, S, Zn and B were 0.088(%), 33.05 (ppm), 0.274 (meg/100 g), 17.08(ppm), 0.673 (ppm) and 0.23 (ppm) respectively (Appendix-1). The treatments were four wheat varieties *viz.* 'BARI Gom-25', 'BARI Gom-26', 'BARI Gom-28' and 'BARI Gom-30'. The experiment was laid out in a RCB design with four replications. The unit plot size was 8 m× 5 m. The crop was fertilized with 100-36-25-20-1.8-1.0 kg/ha of N-P-K-S-Zn-B (BARI, 2011). All the nutrients including 2/3 of N were applied as basal. Rest 1/3 of N was top dressed at CRI stage (17-21 days after sowing: DAS). Two irrigations were applied at 20 DAS and 50 DAS. Crop field was weeded once at 25 DAS. The crop was sown on 5 December 2016 and on 3 December 2017 but harvested on 27 March in both the years. Data on yield and yield components of wheat were recorded. The year wise and pooled data was subjected to statistical analysis with $LSD_{(0.05)}$ test following Statistix 10 Trial (Anon. 2018). Economic analysis of the study was also done. There was no blast infestation in the experimental field in both the years. Farmer's opinion about wheat cultivation was recorded. Cost and return analysis of *boro* rice cultivation was also done on the basis of five farmers' field of *boro* rice adjacent to wheat experimental field for comparison of economic returns. Agro-ecological information of the experimental site (Appendix-1) and weather data (Appendix-2) have been presented in appendices.

Results and Discussion

There was no significant variation in yield and yield attributes, so pooled analysis was done. Spikes/m^2, grains/spike, 1000-grain weight, grain yield, straw yield, harvest index and field duration were significant as influenced by different

varieties but plant height was not significant as well as spikes/m^2 in 2016-17 (Tables 1 & 4). Plant height ranged 89-93 cm in 2016-17 and 90-91cm in 2017-18 while the pooled value ranged 90-92 cm. Number of spikes/m^2 was not varied significantly in 2016-17 but it was found significant in 2017-18 while the highest (444/m^2) was counted in 'BARI Gom-30' (Table 1). Pooled value of spikes/m^2 noticed higher in (408/m^2) in ' BARI Gom-30' followed by 'BARI Gom-28' (369/m^2) but other three varieties ranged 336-357/m^2 (Table 1). Variation of spikes/m^2 among the varieties was also reported by BARI, 2018. Number of grains/spike was found the highest (pooled value of 45/spike) in 'BARI Gom-30' in both the years while other varieties gave lower values (pooled value of 33-37/spike) (Table 2). Number of grains/spike of individual variety showed similar trend in both the years. This might be happened due to similar average temperature (28.5 ^{0}C in March both of 2017 and 2019) and total sun shine hours (313 in March 2017 and 314 in March in 2019) in grain filling stage (March) of wheat in both the years (Appendix-2). The Pooled 1000-grain weight was noticed the highest in 'BARI Gom-26' (49.28 g) followed by 'BARI Gom-28' (46.05 g) while lower value (40.55-41.00 g) was observed in 'BARI Gom-25' and 'BARI Gom-30' (Table 2). 'BARI Gom-26' produced higher 1000-grain weight due to bolder grain size as compared to other varieties (BARI, 2017). Variation of spikes/m^2, grains/spike and 1000-grain weight of varieties mainly controlled by genetical inheritance. Pooled grain yield was recorded higher (4.93 t/ha) in 'BARI Gom-30' (ranged 4.83-5.02 t/ha) followed by 'BARI Gom-28' (pooled value of 4.62 t/ha) (Table 3). The highest grain yield in 'BARI Gom-30' might be contributed by the cumulative effect of spikes/m^2 and grains/spike. Higher harvest index (44.22%) and biological yield could possibly enhanced to produce higher grain yield in 'BARI Gom-30' as compared to other varieties (Table 3). Similar results also have been reported by Mian and Begum (2018). On the contrary, 'BARI Gom-25' produced lower grain yield (4.21 t/ha), might be due to lower number of spike/m^2, grains/spike and lower 1000-grain weight. However, grain yield produced higher in 2016-17 as compared to 2017-18 irrespective of varieties (Table 3). This might be happened due to bit low temperature (32 ^{0}C) in March 2017 as compared to March (34 ^{0}C) of 2018 at grain filling stage and also of receiving higher total SSH (1001) in the growing season in 2016-17 as compared to 2017-18 (Appendix-2). Pooled straw yield was observed the highest (6.22 t/ha) in 'BARI Gom-30' followed by 'BARI Gom-25' (6.09 t/ha) and the lowest (5.91) in 'BARI Gom-26' followed by 'BARI Gom-28' (Table 3). Higher straw yield indicated better crop growth resulted higher grain yield in 'BARI Gom-30' (Table 3). Harvest index and field duration varied significantly among the varieties in both the years while mean value of field duration was not significant (Table 4). Pooled harvest index was higher (ranged in 43.20-44.22%) in all varieties except 'BARI Gom-25' (40.82%). Higher harvest index occurred possibly to better dry matter partitioning in grain or better sink in the grain. The results are in agreement with the observation of Mian (2008). 'BARI Gom-30'

required field duration of 113 days while other showed values of 110-111 days (Table 4). This difference might he due to interaction of varietal characters and environment (mainly temperature). Cost and return analysis of wheat as influenced by varieties have been presented in Table 5. The cost of cultivation was same in all varieties (Tk.56430/ha). The highest BCR (1.78) was found in 'BARI Gom-30' due to highest gross return (Tk.100400/ha). Gross return (Tk. 100400/ha) and gross margin (Tk.43970/ha) was also found higher in 'BARI Gom-30'. 'BARI Gom-30' was found superior in Chalan Beel area in respect of higher grain yield, monetary return and BCR (1.78). Results are in agreement with the findings of Mian and Begum (2018). There was no blast infestation in the experimental field. *Boro* rice cultivation gave lower values of monetary returns (Gross return of Tk. 90300/ha and gross margin of Tk.25410 /ha) and BCR (1.39) due to higher production cost and lower price of rice. Thus less economic returns and lower BCR were calculated in *boro* rice cultivation in Chalan Beel area.

Farmers showed moderate interest to grow wheat var. 'BARI Gom-30' in Chalon Beel area than that of *boro* rice cultivation.

Table 1. Plant height and spikes/m^2 of wheat varieties at Chalan Beel (2016-2018 and Pooled)

Variety	Plant height (cm)			Spikes/m^2 (no.)		
	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled
'BARI Gom-25'	90	91	91	362	309	336
'BARI Gom-26'	93	90	92	348	366	357
'BARI Gom-28'	89	91	90	369	369	369
'BARI Gom-30'	91	91	91	372	444	408
LSD $_{(0.05)}$	NS	NS	NS	NS	53	48
CV (%)	6.88	4.37	6.12	5.69	9.93	8.25

Table 2. Grains/spike and 1000-grain weight of wheat varieties at Chalan Beel (2016-2018 and Pooled)

Variety	Grains/spike (no.)			1000-grain weight (g)		
	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled
'BARI Gom-25'	35	34	34	40.60	40.50	40.55
'BARI Gom-26'	33	33	33	49.30	49.25	49.28
'BARI Gom-28'	37	37	37	46.10	46.00	46.05
'BARI Gom-30'	45	45	45	41.50	40.50	41.00
LSD $_{(0.05)}$	2.07	2.94	2.37	4.41	4.06	4.62
CV (%)	3.45	3.60	3.98	6.22	6.14	6.67

Table 3. Grain yield and straw yield of wheat varieties at Chalan Beel (2016-2018 and Pooled)

Variety	Grain yield (t/ha)			Straw yield (t/ha)		
	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled
'BARI Gom-25'	4.59	3.83	4.21	6.35	5.83	6.09
'BARI Gom-26'	4.52	4.46	4.49	6.06	5.75	5.91
'BARI Gom-28'	4.63	4.60	4.62	6.09	5.79	5.94
'BARI Gom-30'	5.02	4.83	4.93	6.45	5.97	6.22
LSD $_{(0.05)}$	0.45	0.39	0.44	0.33	0.25	0.24
CV (%)	6.42	5.53	6.13	4.25	5.38	4.86

Table 4. Harvest index and field duration of wheat varieties at Chalan Beel (2016-2018 and Pooled)

Variety	Harvest index (%)			Field duration (day)		
	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled
'BARI Gom-25'	41.96	39.69	40.82	111	110	111
'BARI Gom-26'	42.72	43.68	43.20	110	109	110
'BARI Gom-28'	43.19	44.27	43.73	112	108	110
'BARI Gom-30'	43.77	44.68	44.22	112	113	113
LSD $_{(0.05)}$	0.97	1.11	1.79	1.91	3.71	NS
CV (%)	2.19	2.45	2.61	2.18	3.11	2.89

Table 5. Cost and returns of analysis of four wheat varieties at Chalan Beel (Average of 2016-2017 and 2017-2018)

Variety	Cost of cultivation (Tk./ha)	Gross return (Tk./ha)	Gross margin (Tk./ha)	BCR
'BARI Gom-25'	56430	91800	35370	1.63
'BARI Gom-26'	56430	90400	33970	1.60
'BARI Gom-28'	56430	92600	36170	1.64
'BARI Gom-30'	56430	100400	43970	1.78
Boro rice	64890	90300	25410	1.39

Wheat grain: Tk.20/kg, *Boro* rice grain: Tk. 15/kg, Wheat straw: Tk.0.50/kg Rice straw: Tk. 4/kg

Conclusion

Two years' results revealed that wheat var. 'BARI Gom-30' performed better in Chalan Beel area in respect of higher grain yield (4.93 t/ha) and economic return (BCR of 1.78). Wheat cultivation was more profitable as compared to *boro* rice

cultivation in upland (medium low land of beel) of Chalan Beel area. So wheat var. 'BARI Gom-30' could be recommended for Chalan Beel area.

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Appendix 1. Agro-ecological information of the experimental site

Name of information	Description
Agro-ecological Zone (AEZ)	Site belongs to AEZ-5 (Sirajganj)
Rainfall (Average)	1784 mm
Temperature (Average)	25.5 ^{0}C
Land Type	Medium low land (generally water depth 1.4-2.30 m) Water logged 4-5 month from July to end of October
Soil texture	Silty clay
Major cropping pattern	*Boro*-Fallow
Soil pH	7.24
Organic matter (%)	2.11
N (%)	0.088
P(ppm)	33.05
K (meq/100g)	0.274
S (ppm)	17.08
Zn (ppm)	0.673
B (ppm)	0.235

Source: Adapted from Mian, M.A.K and A.A. Begum 2018. and https://www.worldweatheronline.com/sirajganj-weather-averages/bd.aspx(Sirajganj Monthly Climate Averages: visited on 19 .7.2019).

Appendix 2. Weather data (2016-17 and 2017-2018) of the experimental location at Chalan Beel (Sirajganj)

Month	Monthly average temperature ^{0}C		Total Sun shine hour (TSSH)	Total rainfall (mm)	Relative humidity (%)
	Maximum	Minimum			
1st year (2016-2017)					
December 2016	28	18	233	0.01	56
January 2017	27	20	231	0.19	43
February 2017	30	23	224	0.11	39
March 20107	32	25	313	31.15	52
Total	*Av. 29.25	Av.21.50	1001	31.46	Av. 47.50

Month	Monthly average temperature ^{0}C		Total Sun shine hour (TSSH)	Total rainfall (mm)	Relative humidity (%)
	Maximum	Minimum			
2nd year (2017-2018)					
December 2017	27	19	127	8.65	60
January 2018	24	15	230	0.00	46
February 2018	30	19	220	0.55	41
March 20108	34	23	314	8.63	40
Total	Av. 28.75	Av.19.00	891	17.83	Av. 46.75

Source: Adapted from https://www.worldweatheronline.com/sirajganj-weather-averages/bd.aspx(Sirajganj Monthly Climate Averages: visited on 19 .7.2019), * Av.=Average value

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PROFITABILITY ANALYSIS OF STRAWBERRY CULTIVATION IN SELECTED LOCATIONS OF BANGLADESH

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Abstract

The study was conducted in strawberry growing areas namely, Joypurhat and Rajshahi districts to examine the profitability of strawberry cultivation in Bangladesh. A total of 100 strawberry growing farmers were randomly selected for this study. Descriptive statistics and Cobb-Douglas (profit) function were used to analyze data. In the farm level 63% of the farmers' cultivated strawberry in medium high land and majority of them mentioned the soil of their strawberry field was sandy loam (54%) and loam (35%). American Festival and Rabi-3 were found cultivating in the study areas. They performed some intercultural operations like weeding, spraying, and irrigating the crop. Per hectare cost of producing strawberry was estimated at Tk. 7, 30,811 and sapling cost was the major cost item which covered about 37% of total cost. Per hectare net return from strawberry cultivation were found Tk. 15, 57,355 and BCR was 3.13 which indicates strawberry cultivation is highly profitable. Farmers' experience had positive and cost of hired labour, sapling and chemicals had negative influence on the profitability from strawberry farming. From the results of SWOT analysis it is observed that though it has strength and opportunities of cultivation in Bangladesh, it also has some weaknesses and threats. If the shortcomings are overcome, it is possible to increase strawberry cultivation in Bangladesh.

Keywords: Strawberry, Profitability, Cobb-Douglas production function, SWOT analysis, Gross return, BCR.

1. Introduction

Strawberry (*Fragaria ananassa*) is one of the most popular berry fruits in the world. This fruit is widely popular for its characteristic like aroma, bright red color, juicy texture, and sweetness. It is consumed in large quantities, either fresh or processed as preserves, fruit juice, ice creams, milkshakes, jam, jelly, pickles, chocolates, biscuits, cake and flavored drinks. Strawberry has great dietetic value and is one of the potential sources of vitamin C. Each 100 g edible portion contains 89 g water, 0.07 g protein, 0.5 g fats, 8.4 g carbohydrates and 59 mg ascorbic acid (Afridi *et al.*, 2009).

Strawberry is grown in many countries of the world but it is cultivated extensively in USA, Italy, Japan, and Mexico (Afridi *et al.*, 2009). Strawberry is

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one of the top 10 agricultural crops in California with a fresh market of more than $ 1 billion per year. So, there is a huge opportunity for marketing it around the world as well in Bangladesh because, recently it has been cultivating in Bangladesh and expanding its cultivation day by day. It could easily achieve self-reliance in strawberry production to save foreign exchange being spent every year in importing this costly fruit. This is because Bangladesh has milder winter compared to the United States, where strawberries are only grown during late spring. As a result, it hits the market early in the year, coinciding with a spike in the demand for winter fruits. The high popularity of the berry locally increases the prospects of rigorous market expansion. This prospect has attracted many potential investors, large and small. Strawberries have numerous health benefits as they are rich in nutrients. According to World Health Organisation (WHO), Bangladesh is a nutrient-deficient country and promoting the fruit will help overcome this deficiency, such as by reducing the risk of heart attacks, as studies suggest.

In Bangladesh, there are few studies on production technology, resource use efficiency, farmers' knowledge and post-harvest technology, of strawberry. Rahman (2011) accompanied a research on the production technology of strawberry in Bangladesh. Rahman (2012) conducted a research on characterization, production and postharvest technology of strawberry. Khatun *et al.* (2019) studied resource use efficiency analysis in strawberry production. They found that production inputs such as sapling and fertilizer had positive and labour and chemicals had negative and significant effect on outputs. Sapling, land and water were under-utilized and labour, cowdung, fertilizer and chemicals were over used. Mondal *et al.* (2016a) assessed Farmers' knowledge on strawberry cultivation. They observed that level of education, strawberry cultivation area, annual income from strawberry cultivation, extension contact, cultivation experience had significant positive relationship with their knowledge on strawberry cultivation and problem faced had significant negative relationship with their knowledge on strawberry cultivation. Mondal *et al.* (2016b) evaluated use of improved practices in strawberry cultivation. They found that annual income from strawberry cultivation and extension contact had significant positive relationship with their use of improved practices in strawberry cultivation and problem faced had significant negative relationship with their use of improved practices in strawberry cultivation. Bangladesh Agricultural Research Institute also conducted some research on the postharvest technology of strawberry. The reviews reveal that, as strawberry cultivation is new among the Bangladeshi farmers, no extensive study was found on the profitability analysis of strawberry cultivation in Bangladesh.

Therefore, it is very important to estimate the profitability of strawberry cultivation and its production technique. It is also important to evaluate the potentiality and acceptability of the strawberry cultivation on the farmers' field.

Keeping these in mind, this study was undertaken with the following specific objectives:

i. To know the technology involved in strawberry cultivation at farm level;
ii. To assess the financial profitability of strawberry cultivation;
iii. To determine the factors that influence the profitability of strawberry cultivation and;
iv. To find out the possibility of this crop cultivation through SWOT analysis.

2. Methodology

2.1 Sampling technique and sample size

Multistage sampling technique was followed to collect sample farmers for this study. At first, two districts namely Joypurhat and Rajshahi were selected on the basis of availability of strawberry farmer. In the second stage, concentrated strawberry growing upazila (Sadre upazila from Joypurhat and Charghat upazila from Rajshahi) were selected on the basis of area and production of strawberry in consultation with DAE personnel. Thirdly, 2-3 agricultural blocks were selected for selecting sample farmers. Finally, the samples were randomly selected from the complete list of strawberry farmers for interview. As 60 samples was appropriate for decision making in case of large population stated by Mari (2009) and Ali *et al.* (2017), a total of 100 strawberry growers taking 50 farmers from each district were selected for the study.

2.2 Data collection

The study was mainly based on primary data that were collected through face to face interview using a pre-tested interview schedule which was conducted through field survey during the month of December 2016 to March, 2017.

2.3 Analytical technique

The collected data were first edited and tabulated for analysis to fulfill the objectives of the study. Descriptive statistics such as averages and percentages were used in this study. SWOT analysis was also used to assess the potentialities of strawberry cultivation in Bangladesh.

Profitability analysis

Both fixed cost and variable cost were taken into account in calculating cost of strawberry cultivation. Land use cost was calculated on the basis of per year existing lease value of land. Irrespective of strawberry varieties, the profitability of strawberry production was examined on the basis of gross return, gross

margin, net return and benefit cost ratio analysis by using the following profit function (Sujan *et al.*, 2017a):

$\Pi = GR\text{-}TC$

$GR = \sum Q_m P_m + \sum Q_b P_b$

$TC = \sum X_i P_{xi} + IOC + TFC$

Where,

π = Net return (Tk. ha^{-1})
GR = Gross return (Tk. ha^{-1})
TC= Total Cost (Tk. ha^{-1})
Xi = Quantity of the i^{th} inputs (kg ha^{-1})
Pxi = Per unit price of i^{th} inputs (Tk. kg^{-1})
IOC = Interest on Operating Capital (Tk. ha^{-1})
TFC = Total fixed cost (Tk. ha^{-1})
Q_m = Quantity of the main product (Kg ha^{-1})
P_m = Average price of the main product (Tk. Kg^{-1})
Q_b= Quantity of the by- product (kg ha^{-1})
P_b = Average price of the by-product (Tk. Kg^{-1})
i = 1,2,3,……, n (number of inputs).

Benefit-Cost Ratio (BCR) analysis

This ratio was calculated by using the following formula (Sujan *et al.*, 2017b):

$$BCR = \frac{GR}{TC}$$

Where, GR = Gross return, TC = Total Cost

the decision rules are that, when

BCR>1, the return from strawberry cultivation is economically satisfactory;

BCR<1, the return from strawberry cultivation is not economically satisfactory;

and BCR=1, there is economic breakeven point of strawberry production.

Model specification

The functional analysis was carried out to identify the factors that influenced the profitability of the strawberry farmers. The Cobb-Douglas production function

model was employed following Gujarati and Porter (2008). The specification of the model is as follows:

$Y = aX_i^{bi} + e^{ui}$..... (1)

Equation (1) is a non-linear equation. In order to make it linear, a natural logarithm is used on both sides as follows:

$\ln Y = \ln a + b_i \ln X_i + U_i$ …….(2)

Where,

Y = Net return/Profit (Tk. ha^{-1});

X_i = different socioeconomic variables such as age of the respondents (years), farm size (ha), strawberry cultivation experience (year) and farm-specific variables such as costs of sapling (Tk. ha^{-1}), hired labour (Tk. ha^{-1}), fertilizer (Tk. ha^{-1}), irrigation (Tk. ha^{-1}) and chemicals (insecticides, pesticides and fungicides, (Tk. ha^{-1}); a = constant or intercept term; bi =coefficients of the respective input variables to be estimated; and U_i = Error term.

Finally, the functional model was run using STATA 14.2.

3. Results and Discussion

3.1 Technology involved in strawberry cultivation

Soil and land type

Land and soil are key inputs of better crop production. The land where rain water does not stay and loamy to sandy loam soil is suitable for strawberry cultivation (Azad *et al.,* 2019). In the farm level 63% of the farmers cultivated strawberry in medium high land. Majority of the farmers mentioned the soil of their strawberry field was sandy loam (54%) and loamy soil (35%). They also used high land (30%) and medium low land (7%). The soil type of the land was also sandy soil (7%) and clayey loam soil (4%) (Table1).

Land preparation and Planting

Before planting, the land should be ploughed several times and laddered well. Sapling should be planted in bed (*Azad et al*., 2019). The farmers in the study areas ploughed 3 times followed by laddering of 2 times for land preparation of strawberry cultivation. They also made bed before planting. Strawberry is grown in Rabi season. In the case of Bangladeshi weather optimum time of planting is mid-September to mid-October, but it can also be planted in mid-November to mid-December (*Azad et al*., 2019). Farmers in the study areas planted in mid-November to mid-December and followed the line method on raised bed.

Variety used

Two varieties of strawberry, namely 'American Festival' and 'Rabi-3' were found cultivating in the study areas. All the farmers of Joypurhat and 76% farmers of Rajshahi cultivated 'American Festival' and only 24% farmers of Rajshahi district cultivated 'Rabi-3' variety of strawberry (Table 1).

Intercultural operation

Farmers in the study areas performed some intercultural operations like weeding, spraying, and irrigating the crop. The average number of weeding, irrigation, and insecticide spraying per farm were 8.62, 9.64, and 24.32 times respectively (Table 1).

Crop harvesting

The harvesting time of strawberry in the study areas is started in the month of January and continued up to the month of March. During the whole season, farmers harvested strawberry about 40 to 70 times from their field.

Table 1. Technology involved in strawberry cultivation in the study areas

Particulars	Joypurhat	Rajshahi	All areas
Land and soil type (%):			
High land	24	36	30
Medium high land	66	60	63
Medium low land	10	4	7
Sandy soil	-	14	7
Clayey loam	4	4	4
Sandy loam	48	60	54
Loamy soil	48	22	35
2. Land preparation			
No. of ploughing	3	3	3
No. of laddering	2	2	2
3. Planting			
Time of planting	Mid November-mid December	First week of November-mid December	First week of November-mid December
Planting method	Line on raised-bed	Line on raised-bed	Line on raised-bed
4. Variety used			
American Festival	100	76	88
Rabi-3	-	24	12
5. Intercultural operation			
No. of weeding	9.04	8.2	8.62
No. of irrigation	9.82	9.46	9.64
No. of spraying	24.1	24.54	24.32
6. Crop harvesting			
Time of harvesting	January-March	January-March	January-March
No. of harvesting (times)	45-65	40-70	40-70

3.2 Cost and return of strawberry cultivation

Inputs use pattern in strawberry cultivation

Strawberry is highly perishable and hence a great deal of care is needed in handling as well as its marketing. So for its careful handling more labour is required. On an average 792 man-days of labour was required to cultivate one hectare of land. Farmers in the study areas used more family labour (427 man-days/ha) and a lot of women labour also worked in strawberry field (Table 2**)**. On an average 34079 sapling was planted in one hectare of land. Application of nutrients in the form of fertilizer is one of the important factors that contribute to the yield of any crop. Farmers used both bio and chemical fertilizers. On an average they applied 12.16 t ha^{-1} bio-fertilizer. Farmers in Joypurhat applied slightly higher amount of TSP, MoP and Boric acid than that of Rajshahi and the farmers of Rajshahi applied slightly higher amount of Zipsum and Zinc sulphate than that of Joypurhat district. Only the farmers of Rajshahi applied DAP (264 kg ha^{-1}).

Table 2. Input use pattern of strawberry cultivation

Inputs	Joypurhat	Rajshahi	All areas
Human labour (man-day)	784	798	792
Family Labour (man-day)	422	431	427
Hired labour (man-day)	362	367	365
Sapling (no)	33605	34553	34079
Bio-fertilizer (ton)	17.72	6.50	12.16
Urea (kg)	167	167	167
TSP (kg)	311	299	305
MoP (kg)	270	267	269
DAP (kg)	-	264	264
Zypsum(kg)	138	151	144
Zinc Sulphate(kg)	16	17	17
Boric acid (kg)	22	15	19

Cost of strawberry cultivation

The cost of producing strawberry included different variable cost items like human labour, sapling, fertilizer, irrigation, chemicals etc. Both cash expenditure and imputed value of family supplied inputs (i.e. labour, land) were included in the analysis. Besides, interest on operating capital was also considered for the estimation of cost of strawberry production. The fixed cost of strawberry cultivation included cost of land use and family labour. The cost of land use was calculated on the basis of lease value of land. Per hectare total cost of strawberry

cultivation was estimated Tk. 730811 in which share of fixed cost was 21.81% and variable cost was 78.18% (Table 3). Highest share of total cost was sapling (36.64%). Human labour was the major cost item incurred in both areas, which covered about 32.47% of total cost. A large number of family labour (17.51% of total cost) was engaged in strawberry cultivation. Cost of fertilizer in Rajshahi (Tk. 33018 ha^{-1}) was slightly higher than that of Joypurhat district (Tk. 23221 ha^{-1}) due to using DAP and comparatively high amount of other fertilizers. Cost of irrigation was comparatively high in Rajshahi (Tk. 46130 ha^{-1}).

Table 3. Cost of strawberry cultivation

Cost Items	Joypurhat		Rajshahi		All areas	
	(Tk.ha^{-1})	(%)	(Tk.ha^{-1})	(%)	(Tk.ha^{-1})	(%)
Cost of Land preparation	9502	1.31	9368	1.27	9435	1.29
Hired labour	108600	15.02	110100	14.90	109350	14.96
Cost of Sapling	230843	31.94	304623	41.23	267733	36.64
Cowdung	22924	3.17	10372	1.40	16711	2.29
Fertilizer	23221	3.21	33018	4.47	32720	4.48
Urea	2677	0.37	2758	0.37	2710	0.37
TSP	8295	1.15	9352	1.27	8823	1.21
MoP	4360	0.60	4432	0.60	4395	0.60
DAP	-	-	9146	1.24	9146	1.25
Zinc Sulphate	2996	0.41	3285	0.44	3131	0.43
Zypsum Cost	1411	0.20	1839	0.25	1610	0.22
Boric acid	3482	0.48	2206	0.30	2905	0.40
Cost of Irrigation	40871	5.65	46130	6.24	43501	5.95
Cost of chemicals (insecticides, pesticides and fungicides)	54308	7.51	52430	7.10	53369	7.30
Cost of Fencing	12174	1.68	6341	0.86	8639	1.18
Cost of Shading	56611	7.83	0	0.00	56611	7.75
IOC@ 6% for 4 months	5591	0.77	5724	0.77	5657	0.77
Total variable cost	564645	78.12	578106	78.25	571375	78.18
Family labour	126600	17.51	129300	17.50	127950	17.51
Land use cost	31586	4.37	31386	4.25	31486	4.31
Total fixed cost	158186	21.88	160686	21.75	159436	21.82
Total cost	722831	100	738792	100	730811	100

Profitability of strawberry cultivation

Average yield of strawberry was 20.80 t ha^{-1}. Though yield difference in both the district, was not prominent, the variation of gross return was due to getting comparatively high price of strawberry in Rajshahi district. Average gross margin was found 17, 16,971 Tk. ha^{-1}. Net return and BCR from strawberry cultivation were found 15, 57,355 Tk. ha^{-1} and 3.13 respectively which indicates strawberry cultivation is highly profitable in the study areas (Table 4). Average cost of producing one kg of strawberry was Tk. 35.14 whereas; the selling price was found 104.56 Tk. kg^{-1}.

Table 4. Per hectare profitability of strawberry cultivation

Particulars	Joypurhat	Rajshahi	All areas
A. Yield (t ha^{-1})	20.64	20.97	20.8
B. Price (Tk. Kg^{-1})	103.3	105.82	104.56
C. Gross return (Tk.)	2251806	2315359.4	2288166
D. Return from strawberry (Tk.)	2132112	2219045.4	2174848
E. Return from runner (Tk.)	119694	96314	113318
F. Total variable cost (Tk.)	564645	578106	571375
G. Gross margin (C-F)	1687161	1737253.4	1716791
H. Total fixed cost (Tk.)	158186	160686	159436
I. Total cost (F+H)	722831	738792	730811
J. Net return (C-I)	1528975	1576567.4	1557355
K. BCR (C/I)	3.12	3.13	3.13
L. Cost per kg (Tk.)	35.02	35.23	35.14

3.3 Factors affecting profitability of strawberry cultivation

The functional analysis reveals that among the independent variables, farmers experience in strawberry cultivation, cost of hired labour, sapling and chemicals had a significant influence on the level of profit earned from strawberry cultivation. The coefficient of experience is positive which implies that profitability from strawberry farming will be greater than before with the increase of farmers experience in strawberry cultivation. On the contrary, profitability is negatively related to the cost of hired labour, sapling and chemicals (insecticide, pesticide and fungicide), indicates that, an additional unit increase in these costs will lessen the profit from strawberry farming by the coefficient values associated with these variables (Table 5).

The value of the coefficient of determination (R^2) was 0.622 which indicated that around 62% of the variation in output was explained by the independent variables included in the model (Table 5). The value of F was 3.38 which was significant

at 1% level indicates the good fit of the model. The total elasticity (sum of the partial elasticity -0.7051) showed decreasing returns to scale implies that when all other variables are held constant, a unit increase in one of them results in less than proportionate increase in net returns.

Table 5. Estimated value of coefficients and related statistics of Cobb-Douglas (Profit) function

Dependent Variable: LN NET RETURN			
Included observations: 100			
Variable	Coefficient	Std. Error	t-statistic
Age	-0.0469	0.1187	-0.40
Experience	0.1068**	0.0531	2.01
Farm size	0.0056	0.0470	0.12
Hired Labour	-0.1903**	0.0789	-2.41
Sapling	-0.2592***	.0705776	-3.67
Fertilizer	0.0694	0.1535	0.450
Irrigation	-0.1215	0 .1027	-1.18
Chemicals	-.269**	0.1175	-2.29
Constant	21.004***	2.097	10.02
R-squared		0.622	
F-ratio		3.38***	
Returns to scale ($\sum b_i$)	-0.7051		

Note: ***, ** and * indicate significant at 1% and 5% and 10% level respectively

3.4 Potentialities of strawberry cultivation in Bangladesh

SWOT analysis was used to assess the potentialities of strawberry cultivation in Bangladesh (Table 6). SWOT analysis is a strategic planning method used to evaluate the Strengths, Weaknesses, Opportunities and Threats involved in any venture (Kumar and Nain 2013).

Strengths:

From SWOT analysis it is observed that land of northern region is suitable for strawberry cultivation, Yield (20.80 ton/ ha) is comparatively higher than other crops, it is short duration crop (4 month), farmers received profit within 50 to 60 days after planting which were the advantage of strawberry cultivation over other crops. Besides these, since strawberry is a new crop in Bangladesh and it also a

tasty and attractive fruit, unemployed youths are encouraging to engage in its cultivation and marketing. Another important strength is, it fulfills the nutrition in off season (November to April) when most of the fruits are not available in Bangladesh (Ahmad and Uddin, 2012).

Weaknesses: Strawberry cultivation in Bangladesh has some weaknesses. Strawberry is comparatively highly perishable crops. Attack of insect and disease is more common which a noticeable weakness of strawberry cultivation is. Production cost (Tk. 622957/ha) is comparatively higher than other crops. Being a new crop in Bangladesh, farmers do not have adequate knowledge about its right cultivation method and its handling. Besides these, availability of quality sapling is also a major weakness of strawberry cultivation.

Opportunities: There is a great opportunity to cultivate strawberry in Bangladesh. Since strawberry is a seasonal crop and its shelf life is limited, it must be processed to keep the quality (Ocibisz and Mitek, 2007). There are also an increasing number of strawberry products (frozen fruits, concentrates, jam, juice, nectar, syrup, dairy products, etc.) available in the market. The colour intensity and stability are of relevance for processing companies (Gössinger *et al.,* 2009) and processing industries have strong demand for strawberry. The climate in the northern region of Bangladesh provides the optimum conditions for strawberry cultivation. The country can earn huge foreign currencies by exporting strawberry if the farmers are motivated for strawberry cultivation. Consumption pattern of Bangladeshi people has been changing (increased raw consumption) and there is abundant low cost labour. With the boom in strawberry cultivation, well-paying employment opportunities have been opened up for many farmers who were previously unemployed or had low income during early years of strawberry cultivation in Bangladesh. So there is a room for increasing production.

Threats: Due to climate change, duration of winter season is becoming short, due to fog plant is damaging and due to untimely raining fruits have been damaging which are the threats of strawberry cultivation. Bangladesh lacks the proper infrastructure for storing and freezing (e.g. warehousing and cold storage) required by this delicate fruit, which prevents the viability of mass production. At this stage the country is unable to compete with the international market, which is dominated by the United States. With high quality strawberries being produced in mid-sized economies such as Turkey, Spain and Mexico, there is barely any international demand for Bangladeshi strawberries. There is a lack of advanced machinery and tools for adaptation and cultivation that compromise productivity and quality. There is lack of technical knowledge for strawberry processing. These are all the threats of strawberry farming.

Table 6. SWOT analysis of strawberry cultivation in Bangladesh

Strengths	Weaknesses
• Land is suitable for strawberry cultivation • Yield is high • Short duration crop • Profit are reaped quickly as well • Low wage rate of labour (specially unemployed youth) • Demand is high • Ensure nutrition	• Highly perishable nature • Attack of insect and disease • Production cost is very high • Lack of knowledge about strawberry cultivation practices • Lack of quality sapling • High price of sapling
Opportunities	**Threats**
• There is strong demand in the processing industries. • The soil and climate in the northern region of Bangladesh provides the optimum conditions for strawberry cultivation. • The country can earn huge foreign currencies by exporting strawberry. • Consumption pattern has been changing (increased raw consumption) • Employment creation • Poverty reduction	• Duration of winter season is short • Damage of plant due to fog and fruits due to untimely raining • Lack of proper infrastructure for storing and freezing • Lack of international demand for Bangladeshi strawberries. • Lack of advanced machineries and tools for adaptation and cultivation that compromise productivity and quality. • Technical knowledge is very little for strawberry processing

4. Conclusions and Recommendations

4.1. Conclusions

Farmers in the study areas cultivated strawberry in medium high land with sandy loam and loamy soil. They planted in mid-November to mid-December and followed the line method on raised bed. Mainly they cultivated American Festival and Rabi-3 variety of strawberry. They planted in mid-November to mid-December. They also performed some intercultural operations like weeding, spraying, and irrigating the crop. The harvesting time of strawberry started in the month of January and continued up to March. Strawberry is highly perishable and hence a great deal of care is needed in handling as well as its marketing. So for its careful handling more labour is required. Comparatively high cost involved in its cultivation providing higher return. Farmers experience in

strawberry cultivation, cost of hired labour, sapling and chemicals had a significant influence on the level of profit earned from strawberry cultivation. Though it has strength and opportunities of cultivation in Bangladesh, it also has some weaknesses and threats. If the shortcomings are overcome, Bangladesh can move towards mass production and cultivation of the fruit, thereby achieving economies of scale and making it a more profitable venture.

4.2. Recommendations

Farmers in the study areas were cultivating strawberry without any type of training or technical knowledge about it. As a result, they faced some difficulties to produce and market it. To overcome these difficulties and extend its cultivation, training on production technology of strawberry should be arranged for the farmers. Strawberries have a short shelf life. Proper storage and freezing facilities can elongate the shelf life whereby the consumers can potentially buy strawberries throughout the year and post-harvest loss will be reduced. Good quality sapling in low cost should be made available to the farmers and for this academic and research institutions should work to innovate and help to attain genetic diversity in strawberries, which is one of the primary needs in the strawberry cultivation sector. Research institutions should undertake research to control insect and disease. As the production cost of strawberry is high, farmers need more capital. Financial institutes should take initiative to give special credit on strawberry cultivation. If done so, production of strawberry will be increased, import will be decreased and foreign currency will be saved. With a great potentiality, the sweet and attractive fruit will open a new horizon for farmers.

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POSTHARVEST LOSS ASSESSMENT OF TOMATO IN SELECTED LOCATIONS OF BANGLADESH

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Abstract

Tomato is a very well-known horticultural crop in Bangladesh. In order to make tomato production profitable postharvest management is very important. The present study assessed tomato postharvest losses in four intensive growing sites of Jamalpur and Rangpur districts of Bangladesh. Farm level postharvest losses were measured through using descriptive and inferential statistics. Cobb-Douglas type multiple linear regression model was used to identify the factors affecting farm level tomato postharvest loss in the survey areas. Farm level postharvest loss of tomato was 12.45% per farm in the survey area. From this3.59% was due to partial damages and the rest 8.86% was for full damages of tomato. The major causes for postharvest loss of tomato were rotten, disease and insect infestation. This loss incurs financial loss at farm level by BDT 152.45 per decimal of tomato cultivation. Total harvested amount, family member and selling price were some of the important factors for tomato postharvest loss in the survey area. Wide practices of improved postharvest management practices are essential to reduce tomato postharvest loss in the survey area.

Keywords: Farmer, Tomato**,** Postharvest loss, Farm level, Bangladesh.

Introduction

Tomato (*Solanum lycopersium)* is a very popular vegetable in Bangladesh. It is now growing all over the country due to its adaptability to wide range of soil and climate (Ahmed, 1976). In 2016-17, the area under tomato production was 68366 acres and total production was 388725 metric ton (BBS, 2017). It is popularly grown in mid-August to mid-November. December to mid-January is the appropriate time for tomato harvesting. Demand for tomato exists throughout the year, so it also has great potentiality to grow in summer season.Tomato is highly perishable crop and 50% of tomato productions in tropical areas are lost between rural production and town consumption (Oyeniran, 1988). Decay, external damages and harvesting at improper maturity stage are the principle causes for postharvest losses of tomato (Thorne and Alvarez, 1982).

The safety and quality of horticultural crops depends on postharvest management (Khatun and Rahman, 2019). Likelihood of postharvest losses depends on the level of openness of a product to the pathogens as they attack through wounds

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(Muhammad *et. al.,* 2012). So, reducing mechanical damage during postharvest practices greatly decreases the level of postharvest losses due to pathogens. This simple step can improve the safety and quality of the vegetables which ensures better access to different stakeholders. However, the country like Bangladesh suffers much of the postharvest losses due to a number of factors such as lack of adequate knowledge and information, the unavailability of appropriate practices under funded research and development (Hasan *et al.* 2010 and Azad *et al.,* 2013). The quality and nutritional value of fresh vegetables are also affected by postharvest handling and storage condition (Sablani *et al.,* 2006).

Postharvest operations like sorting, grading, packaging, cooling, storage, proper loading and unloading are very important loss reducing activities in vegetable supply chains. But these are not very common at farm level in Bangladesh which results 23.6% to 43.5% fruits and vegetable postharvest loss (Hasan *et al.,* 2010). Seasonal oversupply and absence of proper marketing system causes huge wastage of harvested vegetables. Insect infestation and rotten were the primary causes of full damages of brinjal in some areas of Bangladesh (Khatun & Rahman, 2019). Beside this conventional method of packaging also causes higher postharvest loss compared to improved cool chain method. Matin *et al.* (2016) showed that tomato postharvest loss in conventional method is 22% compared to 17.7% in improved method. A number of studies were conducted in Bangladesh on tomato postharvest loss. Khatun *et al.* (2014) found 15.37% and 10% postharvest loss of tomato at farmers and intermediaries level in some tomato growing areas of Bangladesh. Beside this Hossain *et al.* (1999) found 8% to 15% farm level postharvest loss of tomato. But still precise estimation of tomato postharvest loss is necessary. In line with this fact the present study was conducted to fulfill the following objectives:

1. To quantify farm level postharvest loss of tomato;
2. To assess the factors affecting tomato postharvest loss and
3. To identify the problems of tomato cultivation at farm level;

Methodology

Jamalpur and Rangpur districts of Bangladesh were the survey area for the present study. Four intensive growing villages were selected for the survey from the selected districts. Purposive random sampling was used for farmer selection. Total respondents were 144 of each 36 were chosen from each of the villages. Survey was conducted during January to March 2018. A pretested structured schedule was used for data collection. Besides primary data collection, BBS, published articles in referred journal and newspaper, reports and unpublished thesis were also used to gather relevant information for the study.

Analytical techniques

Postharvest losses Assessment

Studies like Amiruzzaman (1990), Kader (1992), Hasan *et al.* (2010), Khatun *et al.* (2014), Kaysar *et al*. (2016) measured loss of different vegetables which were mostly based on field survey. Matin *et al.* (2016) estimated both the quantitative and qualitative loss of vegetables through physical monitoring of vegetable lots. Khatun and Rahman (2019) quantified postharvest loss of brinjal by using both quantitative and qualitative losses. The present study quantified both quantitative and qualitative losses of tomato. The losses were also distributed to their causes as done by Khatun and Rahman (2019). Two types of physical damages *viz*., full and partial were found for tomato of which they were considered as quantitative and qualitative losses respectively. The total loss was quantified by adding both the quantitative and qualitative loss (Khatun and Rahman, 2019).

Financial loss assessment

Farmers have to incur significant financial loss due to postharvest losses of tomato. The present study measured financial loss by using the following formula as done by Khatun and Rahman (2019):

$$F_1 = Q_{fd} \times P_{fx} + Q_{pd} (P_{fd} - P_{pd})$$

Where,

F_l = Financial loss (Tk/decimal)

Q_{fd} = Amount of full damaged tomato (kg/decimal)

P_{fd} = Price of full damaged tomato (Tk/kg)

Q_{pd} = Amount of partial damaged tomato (kg/decimal)

P_{pd}= Price of partial damaged tomato (Tk/kg)

Factors affecting farm level postharvest losses of tomato

A functional analysis was applied to identify the factors affecting farm level post harvest loss of tomato as done by Nag *et al.* (2000), Khatun *et al.* (2014), Kaysar *et al.* (2016) and Khatun & Rahman (2019). The following multiple linear regression model was used to analyze the factors:

$$Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \mu_i$$

Where,

Y = Loss of tomato (kg/farm)

α = Constant term

$\beta_1, \beta_2 \ldots\ldots \beta_9$ = coefficients of the explanatory variables

X_1 = Total harvested amount (kg/farm)

X_2 = Education (year of scholing)

X_3 = Total family member (no.)

X_4= Farming experience (year)

X_5= Selling price (Tk/kg)

X_6= Vehicle type dummy (pulled van=0, others = 1)

X_7= Packaging dummy (traditional packaging=0, improved packaging = 1)

X_8= Training dummy (got training = 0, no training = 1)

X_9= Selling place dummy (farm level = 0, market level = 1)

μ_i= Error term

Problem face index (PFI) of farmers

Farmers have to face various problems during tomato cultivation. Tomato farmer responded to the problems they faced by no problem (score-0), little problem (score-1), moderate problem (score-2) and severe problem (score-3). In order to know the weight of these problems PFI was constructed by using the following formula as done by (Khatun & Rahman, 2019).

$$PFI = (P_s \times 3) + (P_m \times 2) + (P_1 \times 1) + (P_n \times 0)$$

Where,

PFI = Problem Faced Index

Ps = Respondents numberfacing severe problems

Pm = Respondents numberfacingmoderate problems

P_l = Respondents numberfacinglittle problems

P_n = Respondents numberfacingno problems

Results and discussion

Postharvestloss of tomato

The Table 1 shows postharvest loss of tomato in the survey area. It is evident that 12.45% of harvested tomato was fallen under postharvest loss. This loss was due to partial damages (3.59%) and full damages (8.86%) of tomato. Storing stage accounted to be the highest percentages of losses in case of partial damages while sorting and grading stages were the main stages for postharvest loss due to full damages of tomato.

Table 1. Postharvestloss of tomato on different postharvest activities

Items	Tomato	
	Quantity (kg)	%
Total harvested amount (kg)	38990	100
A. Partial damage (kg)		
Damage during tomato collection	123	0.32
Damage during tomato sorting & grading	381	0.98
Damage during tomato storing	710.5	1.82
Damage during tomato transportation	185	0.47
Total	1399.5	3.59
B. Full damage (kg)		
Damage during tomato collection	110	0.28
Damage during tomato sorting & grading	1849	4.74
Damage during tomato storing	1141	2.93
Damage during tomato transportation	356	0.91
Total	3456	8.86
C. Total damage (kg)		
Damage during tomato collection	233	0.60
Damage during tomato sorting & grading	2230	5.72
Damage during tomato storing	1851.5	4.75
Damage during tomato transportation	541	1.39
Total postharvest loss	4855.50	12.45

Source: Field survey, 2018

Full and partial damages occurred due to several causes which is outline by the Table 2. Partial damages occurred due to over mature and bruising while rotten, infested by insect and bird attack were responsible for full damages of tomato at farm level in the survey area.

Table2. Postharvestloss of Tomato based on causes of damages

Items	Tomato	
	Quantity (kg)	%
Total harvested amount (kg)	38990	100
A. Partial damage (kg)		
Infested by insect	0	0.00
Infested by diseases	0	0.00
Rotten	0	0.00
Over mature or ripen	472	1.21
Skinning	313.5	0.80
Bruising	414	1.06
Shrinking	55	0.14
Bird	145	0.37
Total	1399.5	3.59
B. Full damage (kg)		
Infested by insect	580.1	1.49
Infested by diseases	418	1.07
Rotten	1023.2	2.62
Over mature or ripen	348.05	0.89
Skinning	9	0.02
Bruising	63.5	0.16
Shrinking	484	1.24
Bird	530.15	1.36
Total	3456	8.86
C. Total wastage (kg)		
Infested by insect	580.1	1.49
Infested by diseases	418	1.07
Rotten	1023.2	2.62
Over mature or rippen	820.05	2.10
Skinning	322.5	0.83
Bruising	477.5	1.22
Shrinking	539	1.38
Bird	675.15	1.73
Total postharvest loss	4855.50	12.45

Source: Field survey, 2018

Financial loss of tomato farmers due to postharvest losses

The Table 3 represents financial losses of tomato. Farmer had to incur loss BDT 152.45 per decimal of tomato production due to postharvest loss of tomato.

Table 3: financial loss of tomato

Sources of Financial loss	Quantity (Tk/decimal)	Percentages
Loss due to partial damage	20.78	13.6
Loss due to full damage	131.67	86.4
Total loss	152.45	100.0

Source: Authors estimation

Factors affecting farm levelpostharvest loss of tomato

Factors responsible for farm level postharvest loss of tomato is shown by the following Table 4.Total harvested amount, selling price and selling place were found significant factors that elevate postharvest loss of tomato. Coefficients of multiple determination (R^2) was 0.73 meaning that 73% of the variation in postharvest loss was explained by the variables included in the model.

Table 4: Values of coefficients and related statistics of multiple linear regression model for factors affecting postharvest loss of tomato

Regression variables	Regression coefficient	t-statistic	p-value	Standard error
Intercept (α)	10.661	-.486	.329	20.212
Total harvested amount (X_1)	1.40***	12.220	.000	.011
Education X_2)	0.831	.455	.651	17.876
Total family member (X_3)	-3.466*	-.130	.097	2.764
Farming experience (X_4)	9.078	.915	.364	9.922
Selling price (X_5)	0.986*	.156	.076	6.302
Vehicle type dummy (X_6)	2.879	.499	.619	5.666
Packaging dummy (X_7)	-0.305	-.512	.610	5.736
Training dummy (X_8)	-0.415***	-.733	.016	5.654
Selling place dummy (X_9)	6.295*	.747	.098	8.255
Number of observations	144			
R^2	0.73			
F (144, 9)	18.324***			

'***','**', and'*' denote 1%, 5%and 10% level of significance

Problems of tomato cultivation

The Table 5 enumerates various problems faced by tomato farmer. The PFI indicates the ranking of problems based on their severity. It is evident that lower price, lack of tomato storage, infested by white fly and viral infection were the top most problems faced by tomato farmers in the survey area.

Table 5. Rank of problems faced by tomato farmers

Problems	Extent of problem faced				PFI	Rank
	No problem (0)	Little problem (1)	Medium problem (2)	High problem (3)		
Lower price	0	4	21	49	193	1
Lack of tomato storage	0	14	14	44	174	2
Infested by white fly	4	12	24	32	156	3
Viral infection	8	12	15	36	150	4
Lack of labour during harvesting	10	20	10	32	136	5
Infected by diseases	15	6	18	35	147	6
Over production and supply in the peak season	12	12	23	25	133	7
Higher input price	6	28	14	24	128	8
Adulterated inputs	6	18	36	12	126	9
Higher cold and fog in winter	18	27	18	9	90	10
Adulterated seed	21	30	14	7	79	11
Unavailability of technical support for tomato storage	36	27	0	9	54	12

Source: Field survey, 2018

Conclusion and Recommendation

Tomato farmers have to bear a significant financial loss due to its postharvest losses. One of the main causes is over production. As much as tomato produces, it increases the tomato damages. To reduce the postharvest loss farmer are practicing postharvest technologies and improved management which includes mode of transportation, packaging, grading, sorting etc. But farmers have to

struggle a lot in the peak season to get a better margin as price is far lower than the profitable margin. Besides, lack of storage, white fly infestation and viral diseases incurred a significant financial loss in tomato production each year. Total harvested amount, family member and selling price at retail level were logically important for tomato postharvest loss in the study area. Therefore, wide demonstration of improved postharvest management and technologies is prerequisite for tomato postharvest loss reduction in the survey area.

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IN-VITRO EVALUATION OF PLANT EXTRACTS AND FUNGICIDES AGAINST MYCELIAL GROWTH OF *SCLEROTIUM ROLFSII* CAUSING FOOT AND ROOT ROT OF BETELVINE

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A. LATIF[4] AND H. RAHMAN[5]

Abstract

Betelvine (*Piper betle* L.) is an important cash crop of Bangladesh. Foot and root rot caused by *Sclerotium rolfsii* is the most important disease of the crop. It decreases the production of betel leaf to a great extent. Management of the disease, the experiment was conducted to determine the effect of botanical extracts, chemical fungicides and bio-agents on *in-vitro* mycelium growth of *S. rolfsii*. Ten fungicides, 11 plant extracts and 2 bio-agents were evaluated. Among the fungicides, 100% inhibition of mycelium growth of *S. rolfsii* was achieved with the fungicide Provax 200. It was proved to be the best in inhibiting the radial mycelial growth of *S. rolfsii*. The highest growth inhibition of *S. rolfsii* was obtained with Garlic clove extract (96.67%) followed by Allamonda (51.12%), and bio-fungicide, *Trichoderma harzianum* reduced the colony diameter by 56.39% over untreated control.

Keywords: Betelvine, bio-fungicides, foot and root rot, plant extracts, *in-vitro* growth inhibition

Introduction

Betelvine (*Piper betle* L.) in Bengali called 'Pan' under the family *Piperaceae* is a perennial climber cultivated largely for its shiny, green heart-shaped leaves. It is an important cash crop of Bangladesh and used as a masticatory. Total cultivated area under the crop in Bangladesh in 2016-17 was about 23,803.20 hectares and the total annual production was about 2,14,252 metric tons. The average yield per hectare is 9.0 metric tons (BBS, 2018). Betelvine is usually plucked throughout the year but maximum production obtained in the months of July to October. At present, betelvine has a worldwide market. But in competition with India and other betelvine producing countries, Bangladesh has a very small share of the world betelvine market for low production of quality betelvine due to various diseases and insect pests. Foot and root rot caused by *S. rolfsii* is the most important disease of betelvine. It decreases the production of betelvine to a great extent (Islam, 2005). To increase its production management of the diseases is necessary.

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Sclerotium rolfsii Sacc is a serious soil borne fungus and harmful to many valuable crops in most of the tropical and subtropical regions of the world (Aycock, 1966).

Botanical extracts and bio-control agents are biodegradable and free from environmental contamination and health hazards (Grange and Ahmed, 1988). Many species of fungi and bacteria are reported to be effective bio-control agents against soil borne plant pathogens (Papavizas, 1985; Mukhopadhyay, 1994).

Hence, efforts have to be made to retain pathogen activity below economic threshold level by choosing methods alternative to chemicals only. So, the present experiment was undertaken to evaluate the effect of some chemical fungicides, bio-agents and botanical extracts on *in-vitro* growth of *S. rolfsii* the causal fungus of foot and root rot disease of betelvine.

Materials and Methods

The experiment was conducted in the Laboratory of Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka during May 2016 to June 2017.

Evaluation of botanical extract

A total of 11 plant species were collected from different areas of Bangladesh (Table 1). Their inhibitory effect on *in-vitro* growth of *S. rolfsii* was evaluated following Poison food technique using potato dextrose agar (PDA) as basic medium (Islam, 2005). Water extracts of suitable parts of botanicals were prepared according to Islam (2005). The plant parts were collected, washed with tap water, cut into small pieces, weighed on an electric balance and again washed with sterilized water. After soaking with blotting paper, weighed plant parts were blended in an electric blender adding equal amount of sterile water for preparing 1:1 botanical extract (100 ml water for 100 g plant parts). The blend was filtered through sterile cheesecloth. For getting 1:2 suspensions, another 100 ml sterilized water was added to the filtrate. PDA medium was prepared and poured into conical flasks and autoclaved. The requisite quantity of botanical extracts was added to the medium before solidification at 2 ml per 20 ml PDA and mixed thoroughly by stirring, and poured into sterilized Petriplate at 20 ml per plate.

Mycelial discs of 5 mm diameter were cut from 5 days old PDA culture of the pathogen with a sterile cork borer. The discs were transfered aseptically in the centre of the Petriplate containing amended PDA medium. The Petriplate of PDA without botanical extract was maintained for control. The inoculated Petriplates were incubated at 25±2^{o}C in an incubator. Control plates received non ammended PDA. Each treatment was replicated 4 times. The radial growth of mycelium of the causal pathogen was recorded at 24 hr interval until the colony in control plates reached the rim of Petriplates (Islam *et al.*, 2001).

Evaluation of chemical fungicides

Ten fungicides were evaluated *in-vitro* against *S. rolfsii* following Poison food technique in grove (Islam *et al*., 2001). Fungicide suspensions were prepared in requisite quantity of water. The suspensions were poured into 250 ml Erlenmeyer flasks. Flasks were labeled appropriately and shaken thoroughly before use.

Petriplates were prepared with 20 ml PDA medium. After solidification, 5 mm discs of the medium were scooped from PDA plate in three places maintaining an equal distance from the centre using a sterilized disc cutter. One milliliter of suspension (Table 2) was put into each hole and the plates were stored overnight in refrigerator for diffusion of fungicide into the medium around the hole. The next day, one 5 mm blocks of 5 days old PDA culture of *S. rolfsii* was placed at the centre of the plate. The plates were placed in an incubation chamber at 25±2^{o}C. The radial mycelial growth of *S. rolfsii* was recorded at 24 hr interval until the colony reached the rim of Petriplate in control plates (Islam *et al*., 2001; Islam, 2005).

***In-vitro* evaluation of bio-agents**

Two bio-agents, *Trichoderma harzianum* and *Pseudomonas fluorescens* were evaluated against mycelium growth of *S. rolfsii* following Growth inhibition techniques in Dual culture method (Islam, 2005). The bio-agents were collected from Plant Pathology Division, Bangladesh Agriculture Research Institute (BARI), Gazipur. The fungal antagonists *Trichoderma harzianum* was cultured on PDA and the bacteria *Pseudomonas fluorescens* was cultured on Nutrient Agar (NA) medium.

PDA media was prepared and sterilized in an autoclave at 121^{o}Cunder 1.1 kg/cm^{2} for 15 minutes. The medium was poured into sterilized Petriplates (90 mm) at 20 ml per dish. Five millimeter diameter blocks of 5 days old PDA culture of both bio-agents and pathogen were cut separately with the help of sterilized cork bores (5 mm). The culture discs of pathogen and bio-agent were transferred aseptically and placed at periphery of Petriplate at opposite to each other. The inoculated Petriplates were incubated into an incubator at 25±2^{o}C. The inoculated plate with pathogen culture without antagonists was maintained for control. The growth of the pathogen was observed periodically and measured the colony diameter in each Petriplate.

Measurement of radial mycelia growth and computation percent inhibition

The radial growth of mycelium in each plate was measured by taking average of the two diameters taken at right angles for each colony. The linear growth of mycelium of the causal pathogen was recorded at 24 hr interval until the colony reached the rim of control plates (Islam *et al*., 2001; Nene and Thaplial, 1979).

Inhibition percentage of radial growth was computed based on colony diameter at 4 DAI in control plate using the following formula:

% growth inhibition of pathogen over control, $I = \frac{C - T}{C} \times 100$ (Vincent, 1947)

Where C = Colony diameter in control (T_{10}) and T= Colony diameter in treatment ($T_{n,n=1-9}$)

Table 1. List of plant species tested in bioassay against *Sclerotium rolfsii*

Local name	English name	Scientific name	Plant parts
Neem	Margosa	*Azadiracta indica*	Leaf
Biskatali	Knotweed	*Polygonum hydropiper*	Leaf
Allamanda	Allamanda	*Allamanda cathartica*	Leaf
Lemon grass	Lemon grass	*Cymbopogon citratus*	Leaf
Korobi	Yellow oleander	*Cascabela thevetia*	Leaf
Tamak	Tobacco	*Nicotiana tabacum*	Leaf
Durba	Burmuda grass	*Cynodon dactylon*	Leaf
Roshun	Garlic	*Allium sativum*	Clove
Ada	Ginger	*Gingiber officinales*	Rhizome
Peaz	Onion	*Allium cepa*	Bulb
Mahogany	Mahogany	*Swietenia mahagoni*	Seed

Table 2. List of fungicides tested in the bioassay *in vitro* against *Sclerotium rolfsii*

Trade name	Chemical name	Active ingredient	Conc. used
Tilt 250 EC	1-[2- (2,4-Dicholorophenyl4-propyle- 1 ,3-diooxalane-2 EI-Methyl]-IH, 1,2,4-Triyazole	25% Propiconazole	0.1 %
Score 250 EC	Difenconazol	25% Difenconazole	0.05 %
Rovral 50 WP	3-(3,5 dichlorophenyl)-N-(1methyl ethyl)-2,4 dioxuimidazolidene Carboxamide $(C_{13}H_{13})_3N_3C_{12}$	50 % Iprodione	0.2 %
Bavistin 50 WP	Mythyl-2-Benzimidazole Carbamate	50 % Carbendazim	0.2 %
Provax 200	$C_{12}H_{13}NO_2S + C_6H_{12}N_2S_4$	Carboxin 17.5%+ Thiram 17.5%	0.25%
Topgan	Copper-oxychloride	50% Copper-oxychloride	0.2 %
Ridomil Gold MZ-68 WP	N- (2,6 dimethyl phenyl)-N-(methoxyacetyl)-alanine methyl ester (C14H2N04)	Metalaxil- 4% Mancozeb- 64%	0.5 %
Pencozeb 80 WP	Mancozeb	80 % Mancozeb	0.45 %
Cuprofix 30 D	Copper + Mancozeb	30% Mancozeb+ 12% Copper	0.45%
Bordeaux mixture	Copper sulphate + Calcium Hydro-oxide + Water	$CuSO_4$ - 5 lbs $Ca(OH)_2$ - 5 lbs H_2O - 50 gallons	100.00%

Experimental design and analysis of data:

Completely Randomized Design (CRD) was followed for the experiments. The data were statistically analyzed by using computer package program (Statistix 10). The significant differences of the treatment means were compared by Duncan's Multiple Range Test (DMRT).

Results and discussion

Effect of botanicals on *in-vitro* mycelial growth of *Sclerotium rolfsii*

At 1, 2 and 3 days after inoculation, *in-vitro* radial mycelium diameter was 22.75, 49.75 and 74.25 mm, respectively under control. The growth ranged 0.00-21.50 mm at 1 DAI, 0.00-47.50 mm at 2 DAI and 0.00-66.75 mm at 3 DAI, due to amendment of PDA with different botanicals. During first three days after inoculation, the fungus failed to grow on PDA amendment with Garlic clove extract. The lowest colony diameter was achieved with Allamanda leaf extract and the highest under tobacco leaf extract. At 4 DAI, the *in-vitro* colony diameter under different treatments including control ranged 3.00-89.50 mm (Table 3). The maximum growth was observed under control and the minimum under Garlic clove extract. The highest growth inhibition was obtained with Garlic clove extract followed by Allamanda and Bishkatali leaf extract. Garlic clove extract and Allamanda leaf extract were noted as most effective botanicals to inhibit colony growth of *S. rolfsii*. Colony growth increased gradually with the progress of incubation period under every botanicals and control (Plate 3).

The findings of the present investigation are in agreement with many other investigators. Masuduzzaman *et al*. (2008) found that at higher concentrations of 1:1 and 1:2 completely inhibited *in-vitro* growth of *S. rolfsii* whereas at lower concentrations of 1:3 and 1:4 its growth was suspended to some extent.

Sahana *et al*. (2017) conducted an experiment to evaluate the efficacy of leaf extracts of Neem, Eucalyoptus, Jathropa, Tulsi and Marigold, extracts of Garlic clove and Onion bulb at 0, 5, 10 and 15% concentrations to inhibit *in-vitro* colony growth of *S. rolfsii*. Among the botanicals tested in the present investigation Garlic clove extract showing 97.77, 98.88 and 100% inhibition at 5, 10 and 15% concentrations, respectively. The least inhibition of mycelium diameter was 22.55, 24.44 and 44.07% at 5, 10 and 15% concentrations, respectively in Jathropa leaf extract.

Effect of fungicides on *in-vitro* colony growth of *S. rolfsii*

At 1, 2, 3 and 4 DAI, the colony diameter under control was 24.25, 54.75, 81.25 and 89.25 mm, respectively. The fungus failed to grow when PDA was amended with Provax-200. Other nine fungicides reduced the colony growth of the pathogen within the ranges of 10.25-21.25, 12.75-49.25, 17.50-78.75 and 9.50-87.75 mm at 1, 2, 3 and 4 DAI, respectively (Table 4). At 4 DAI, Provax-200, Score 250 EC, Tilt 250 EC, Pencozeb 80 WP and Rovral 50 WP gave 100.00,

78.15, 75.64, 59.10 and 44.53% growth inhibition, respectively. These five fungicides were noted as highly effective (Plate 4).

Similar findings were also reported by many other investigators. Suryawanshi *et al*. (2015) conducted an *in-vitro* experiment and found that Vitavax, Tebuconazole and Penconazole gave 100.00, 99.25 and 99.03% mycelial growth inhibition, respectively of *S. rolfsii*.

In vitro evaluation of bio-agents against *S. rolfsii*

The *in-vitro* radial colony diameter was 23.75, 62.00, 81.00 and 90.00 mm at 1, 2, 3 and 4 DAI, respectively under control. The colony diameter was reduced to 12.50, 20.75, 31.00 and 39.25 mm due to use of *Trichoderma harzianum* and 19.00, 32.25, 45.25 and 60.50 due to *P. fluorescens* at 1, 2, 3 and 4 DAI, respectively (Table 5).

The findings of the present investigation are in agreement with many other investigators. Almeida and Landim (1981) reported that an isolate of *Trichoderma* sp. was hyper parasite of *S. rolfsii* on PDA culture and found to be most effective in controlling *S. rolfsii* on cowpea in green house. Parvin *et al*. (2016) conducted an experiment *in-vitro* to observe inhibition of mycelial growth of *S. rolfsii* in dual culture method. The performance of *T. harzianum* in reduction of radial mycelial growth was the best followed by *P. fluorescens*.

Table 3. Efficacy of plant extracts in inhibition of *in-vitro* mycelial growth of *Sclerotium rolfsii*

Treatments	Radial colony diameter (mm) at different days after inoculation (DAI)			
	1	2	3	4
Neem leaf extract	16.50 d[α](4.12)*	36.25 c(6.06)	53.00 de(7.31)	66.50 d(8.19)
Biskatali leaf extract	16.25 d(4.09)	28.25 e(5.36)	36.50 g(6.08)	50.00 e(7.11)
Allamanda leaf extract	14.75 e(3.90)	26.00 e(5.15)	31.75 h(5.68)	43.75 e(6.65)
Garlic clove extract	0.00 f(0.71)	0.00 f(0.71)	0.00 I (0.71)	3.00 f(1.41)
Zinger rhizome extract	16.75 d(4.15)	27.25 e(5.27)	39.50 f(6.32)	50.75 e(7.16)
Lemon grass leaf extract	21.50 b(4.69)	37.25 c(6.14)	52.00 de(7.25)	74.25 bcd(8.65)
Onion bulb extract	16.25 d(4.09)	35.50 c(6.00)	54.50 d(7.42)	70.50 cd(8.43)
Korobi leaf extract	16.25 d(4.09)	31.00 d(5.60)	51.00 e(7.18)	72.25 bcd(8.53)
Tobacco leaf extract	20.50 b(4.58)	43.50 b(6.63)	66.75 b(8.20)	81.25 ab(9.04)
Bermuda grass leaf extract	21.25 b(4.66)	47.50 a(6.93)	62.75 c(7.95)	82.50 ab(9.11)
Mehagony seed extract	18.75 c(4.38)	31.25 d(5.63)	54.50 d(7.41)	79.50 abc(8.94)
Control	22.75 a(4.82)	49.75 a(7.09)	74.25 a(8.64)	89.50 a(9.49)

[α]Values within the same column with a common letter(s) do not differed significantly (P=0.01).

*Data within parenthesis are square root or arc-sine transformed values

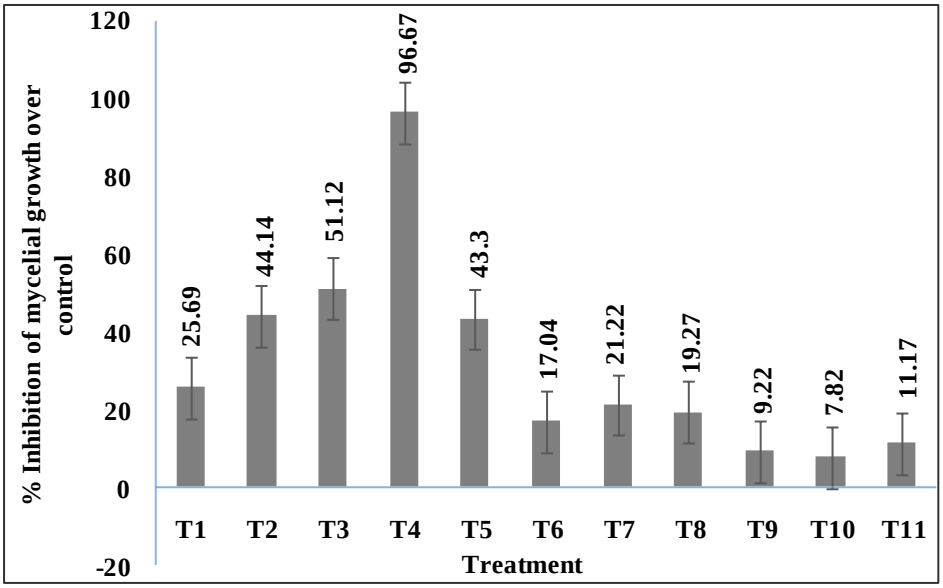

Fig. 1. Percent inhibition of mycelial growth of *S. rolfsii* over control at 4 days after inoculation [T_1= Neem leaf extract, T_2= Biskatali leaf extract, T_3 = Allamanda leaf extract, T_4= Garlic clove extract, T_5= Zinger rhizome extract, T_6= Lemon grass leaf extract, T_7= Onion bulb extract, T_8= Korobi leaf extract, T_9= Tobacco leaf extract, T_{10}= Bermuda grass leaf extract and T_{11}= Mehagony seed extract]

Table 4. Efficacy of fungicides to inhibit *in-vitro* mycelial growth of *Sclerotium rolfsii*on PDA Growth Inhibition Technique (Cup method)

Fungicides	Radial colony growth (mm) of *S. rolfsii* at different days after inoculation (DAI)				% Inhibition of mycelial growth over control at 4 DAI
	1	2	3	4	
Tilt-250 EC	10.50 ef$^{\alpha}$ (3.31)*	14.75 g (3.90)	18.25 h (4.32)	21.75 f (4.72)	75.64 b (58.29)
Score 250 EC	10.25 f (3.28)	12.75 h (3.64)	17.50 h (4.24)	19.50 g (4.47)	78.15 b (59.95)
Rovral 50 WP	11.00 ef (3.39)	22.50 e (4.79)	36.00 f (6.04)	49.50 d (7.07)	44.53 d (40.38)
Bavistin 50 WP	19.50 c (4.47)	45.50 c (6.78)	57.00 e (7.58)	65.00 c (8.09)	27.16 e (30.29)
Provax 200	0.000 g (0.71)	0.00 i (0.71)	0.000 i (0.71)	0.00 h 0(.71)	100.00 a (86.82)

Fungicides	Radial colony growth (mm) of *S. rolfsii* at different days after inoculation (DAI)				% Inhibition of mycelial growth over control at 4 DAI
	1	2	3	4	
Topgan	19.00 c (4.42)	40.00 d (6.36)	63.00 d (7.97)	79.00 b (8.92)	11.48 f (19.08)
Ridomil Gold MZ-68 WP	21.25 b (4.66)	48.25 b (6.9)	72.25 c (8.53)	87.75 a (9.40)	1.67 g (6.48)
Pencozeb 80 WP	11.50 e (3.46)	16.75 f (4.15)	26.25 g (5.17)	36.50 e (6.08)	59.10 c (48.47)
Cuprafix 30 D	16.25 d (4.09)	40.75 d (6.42)	63.00 d (7.97)	79.25 b (8.93)	11.19 f (18.80)
Bordeaux mixture	17.50 d (4.24)	49.25 b (7.05)	78.75 b (8.90)	87.75 a (9.39)	1.69 g (5.84)
Control	24.75 a (5.02)	54.75 a (7.43)	81.25 a (9.04)	89.25 a (9.47)	0.00 h (0.062)

[α]Values within the same column with a common letter(s) do not differed significantly (P=0.01).

*Data within parenthesis are transformed (square root and arc-sine for percent inhibition) values

Table 5. Efficacy of bio-agents to inhibit *in-vitro* radial mycelial growth of *Sclerotium rolfsii* in dual culture method

Treatments	Radial mycelial growth (mm) at different days after inoculation (DAI)				% Inhibition of mycelial growth over control at 4 DAI
	1	2	3	4	
Trichoderma harzianum	12.50 c[α]	20.75 c	31.00 c	39.25 c	56.39 a(46.96)*
Pseudomonas fluorescens	19.00 b	32.25 b	45.25 b	60.50 b	32.78 b(33.69)
Control	23.75 a	62.00 a	81.00 a	90.00 a	00.00 c(0.062)

[α]Values within the same column with a common letter(s) do not differed significantly (P=0.01).

*Data given in parenthesis are transformed values

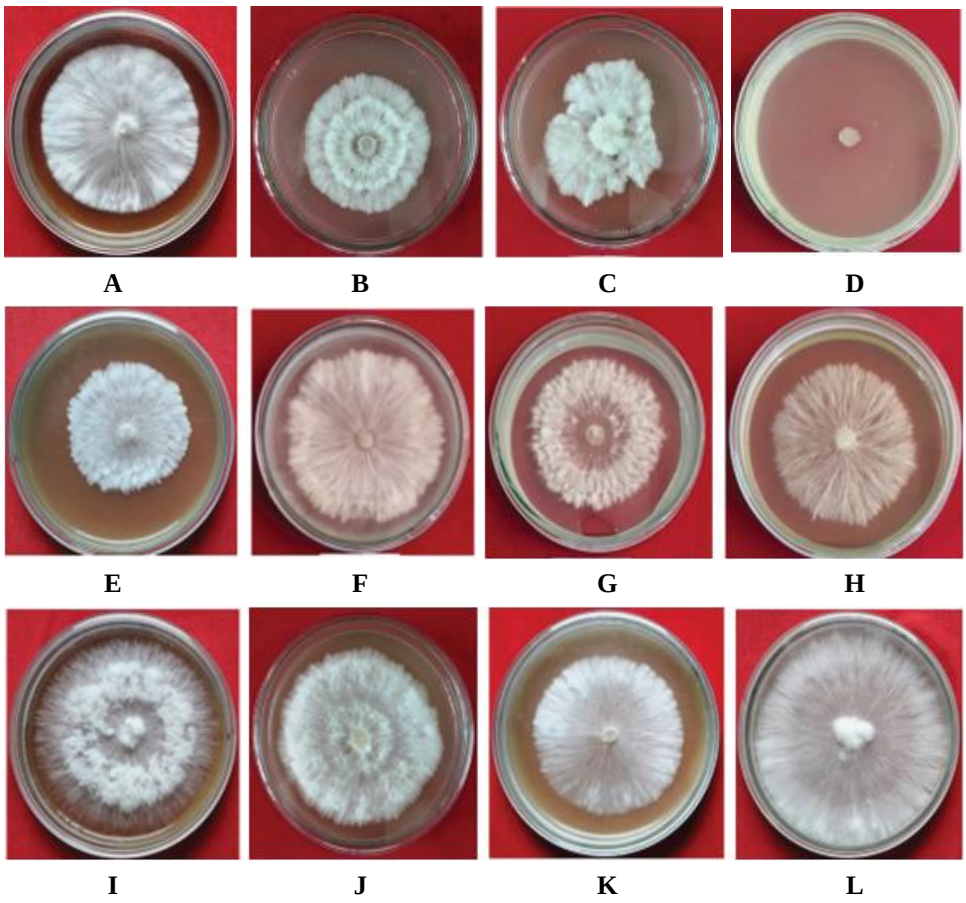

Fig. 1. Pictorial view of radial mycelial growth of *Sclerotium rolfsii* in Petriplates containing PDA amended with botanicals [(A) Neem leaf extract, (B) Biskatali leaf extract, (C) Allamanda leaf extract, (D) Garlic clove extract, (E) Zinger rhizome extract, (F) Lemon grass leaf extract, (G) Onion bulb extract, (H) Korobi leaf extract, (I) Tobacco leaf extract, (J) Bermuda grass leaf extract, (K) Mehagony seed extract and (L) Control at 4 DAI of pathogen]

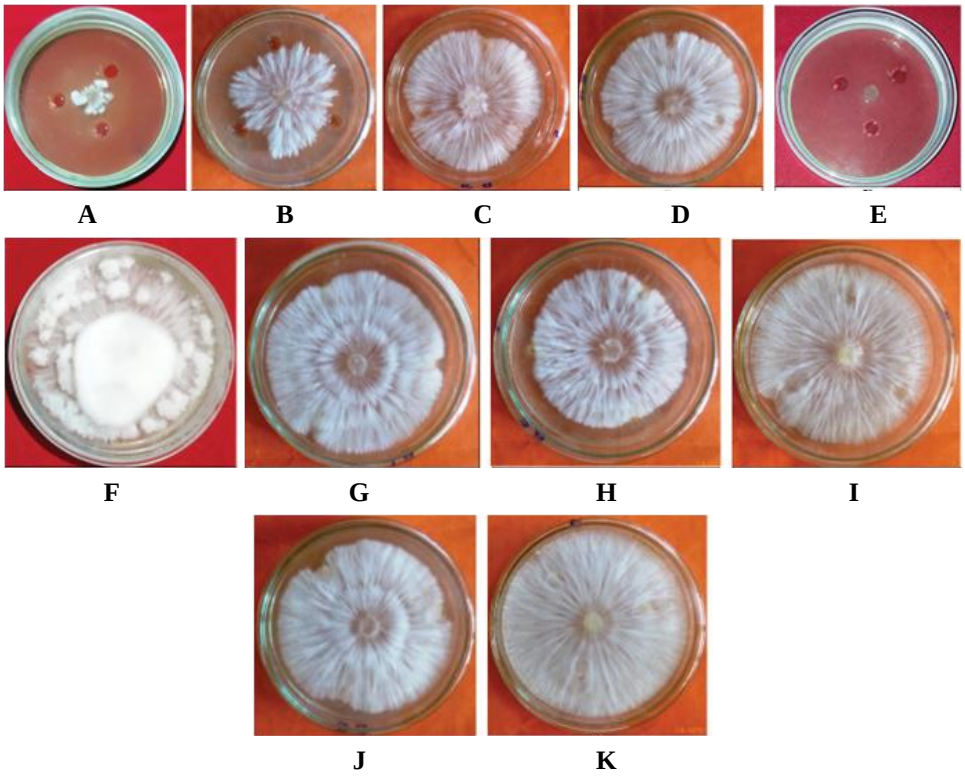

Fig. 2. Pictorial view of radial mycelial mycelial growth of *Sclerotium rolfsii* against (A) Tilt-250 EC, (B) Score 250 EC, (C) Rovral 50 WP, (D) Bavistin 50 WP, (E) Provax 200, (F) Topgan,(G) Ridomil Gold MZ- 68 WP, (H) Pencozeb 80 WP, (I) Cuprafix 30 D, (J) Bordeaux mixture and (K) Control at 4 days after inoculation

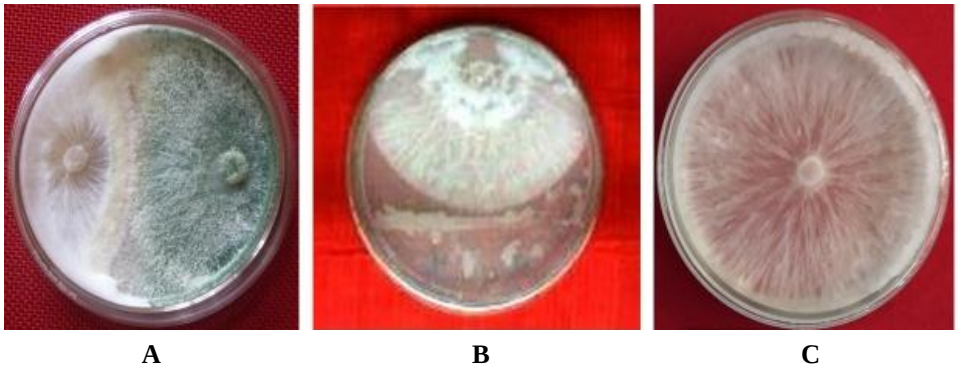

Fig. 3. Pictorial view of radial mycelial growth of *S. rolfsii* against (A) *Trichoderma harzianum*, (B) *Pseudomonas fluorescens* and (C) Control at 4 days after inoculation of pathogen.

Conclusion

Based on findings of three *in-vitro* tests, two botanicals viz., Garlic clove extract and Allamanda leaves extract, five fungicides, *viz*., Provax 200, Tilt 250 EC, Score 250 EC, Rovral 50 WP and Pencozeb 80 WP and a bio-agent *T. harzianum* are most effective against *in-vitro* growth of *S. rolfsii*. The materials may be tested under pot and field condition to find out the efficacy to control betelvine foot and root rot disease.

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MANAGEMENT OF CUCUMBER MOSAIC VIRUS (CMV) INFECTING CUCUMBER IN BANGLADESH

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Abstract

Cucumber mosaic virus (CMV) is the most important and widespread virus. It attacks cucumber **(***Cucumis sativus***)** causingsevere yield loss. A research project was undertaken with a view to developing appropriate management option against CMVof cucumber in Bangladesh.Six integrated disease management packages were tested under field condition. A non-treated control was included for comparison with the packages. The experiment was conducted in the research field of Bangladesh Agricultural Research Institute, Gazipur during *rabi* season of 2018. All the treatment packages appreciably reduced CMV incidence of cucumber over control. Disease incidence was reduced to 35.71 to 76.97% over control and yield was increased to 0.37 to 6.40 t/h due to all treatment combinations compared to control. Two treatment packages T_2- Netting seedling, sticky yellow trap, polythene mulch and 4 sprays of Imidacloprid 0.1 % at 15 days interval and T_1- T_2+Bio-neem0.2 % instead of Imidacloprid were considered as the most effective management options on the basis of minimum disease incidence (9.67; 10.5), higher yield (13.04 t/ha; 12.96 t/ha) and Marginal benefit cost ratio (1:3.17&1:2.93), respectively. Marginal cost benefit analysis indicated that the two management packages $T_1$and T_2may be economically viable and cost effective.These management packages may be recommended for management of CMV infecting cucumber.

Keywords: CMV; Cucumber; management; sticky yellow trap.

Introduction

Cucumber **(***Cucumis sativus***)** is a year round important commercial vegetable crop having export potential, throughout the world (Zitter and Murphy, 2009; Rahman *et al*., 2016). In Bangladesh, the crop is cultivated in an area of about 9,593 ha with a total production of 65,499 metric tons. and the average yield is only 6.83 tha^{-1} (Annon, 2018) which is very low as compared to other cucumber growing countries where average yield is more than 30 t ha^{-1}. CMV was first found in cucumbers showing mosaic symptoms in 1934 hence the name *Cucumber MosaicVirus* (Price, 1934). It is the type member of the genus *Cucumovirus* in the family Bromoviridaeand has the broadest host range known for any plant virus with approximately 1200 plant species in over 100 plant families (Fauquet *et al.*, 2005; Zitter and Murphy, 2009). Disease, particularly those caused by viruses are considered the major constraints to economic

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production of cucumber and yield losses ranging from 60-100 % in case of early infection (Akbar *et al.*, 2015; Singh and Cheema, 1989). There are essentially two approaches to manage virus diseases. The first approach is to decrease the sources of infection (reservoirs) and secondly to minimize the rate of spread by vector control.

Spraying of insecticides is the only option available to the farmers for managing CMV through vectors control. Only insecticides may not successfully control aphid-transmitted Non-persistent viruses (Hooks *et al.*, 2007)). As the CMV is anaphid-transmitted Non-persistent virus, only insecticidal spray may not control the disease effectively. Moreover, dependence on a single method is highly vulnerable to failure (Lepidot *et al.*, 2001). However, when integrated with more than one management strategies may repress disease significantly more than any single tactic alone (Irwin *et al*., 2000). Therefore, if available an integrated approach is preferred. Many reports are available on the successful application of integrated management tactics for CMV (Anandam and Doraiswamy, 2002; Jones, 2001, Alegbejo and Abo, 2002). Cohen and Marco (1973) reduced the spread of CMV of peppers by using sticky yellow polyethylene along the edges of the field or surrounding the plots. However, such approach has not been tried yet for the management of CMV in Bangladesh. Considering the above facts, the present piece of research was undertaken to evaluate some integratedmanagement approaches against CMV of cucumber.

Materials and methods

CMV is an aphid transmitted virus. So, attempts were to control the insects as indirect method to manage the Cucumber mosaic disease of Cucumber. The control tactics tested in the experiment in integrated approaches were as follows:

i) Growing seedling of cucumber under insect proof net.

ii) Use of sticky yellow trap to catch, count and kill the aphids in the experimental plot.

iii) Use of dark color polythene mulch to enhance soil temperature, conserve soil moisture and suppress weeds in the plot.

iv) Four spray with Bio-neem at 15 days interval

v) Spraying with Imidacloprid (0.1%) at 15 or 20 days interval for 4 or 2 times.

The test trial comprised of six treatment packages along with an untreated control was conducted in the research field of Plant Pathology Division, Bangladesh Agricultural Research Institute, Gazipur during *rabi* season of 2018. A year round cucumber variety (Lal teer) susceptible to CMV was used in the experiment. The management packages tested were as follows:

Table 1. Treatments of the experiment

Treatments	Description
T_1	Netting Seedling + sticky yellow trap + Polythene mulch + 4 sprays of Bio-neem at 15 days' interval
T_2	T_1+ spray with Imidacloprid 0.1%
T_3	Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval
T_4	Netting Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval
T_5	Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval
T_6	Netting Seedling + Maize as barrier crop (Maize were sown in line at 10 cm spacing around the plot at 20 days before transplanting of seedling.) + sticky yellow trap + straw mulch + 2 spray of Imidacloprid
T_7	Untreated control

The efficacy of the treatment packages was evaluated based on disease incidence and severity as described as below (Monma and Sakata, 1997)

Diseases incidence was calculated using the the following formula:

$$\text{Diseases incidence (\%)} = \frac{\text{No. of infected plants}}{\text{Total plants in the plot}} \times 100$$

Disease incidence were confirmed by DAS-ELISA and RT-PCR.

Disease severity

Severity of CMV was determined according to Monma and Sakata (1997) with some modification. The disease severity was index based on a 0-4 scale, where,

0= No Symptom, 1= Mild Mosaic, 2= Mosaic, 3= Mosaic and deformed leaf 4= mosaic and stunted plants

$$\text{Severity Index} = \frac{\sum(\text{Symptom index} \times \text{Number of plants with each symptom indeed})}{\text{Total number of plants}}$$

Number of aphidwas counted from randomly selected 10 leaves/plot.Average populations of the insects/leaf was computed. Yield data were recorded in Kg/plot and converted into ton/ha

Economic analysis was performed by partial budget technique as described by Rahman *et al*. (2011) to find out the economically suitable package. Following points were considered for economic analysis:

Variable Cost = Cost (Taka) that vary in different packages

Gross Return (TR) = Yield in terms of money

Gross margin = Gross Return – Variable cost

Marginal benefit = Gross margin (Packages) – Gross margin (control)

Marginal benefit cost ratio (MBCR) was calculated by the following formula:

$$\text{MBCR (over control)} = \frac{\text{Marginal benefit}}{\text{Var. Cost}}$$

Design of experiment and data analysis

Randomised complete block design with 3 replications was used for field experiments. Data were analyzed statistically for analysis of variance (ANOVA) using open source R software and means were compared according to Duncan's Multiple Range Test (Gomez and Gomez, 1984). Data were transformed as and when necessary using Arcsine transformation method.

Results and Discussion

Aphid population

The effect of different management options on aphid population per leaf is shown in Fig. 1. The highest number of aphid per leaf (14.50) was recorded from the plants under control. Every management packages caused significant reduction in number of aphid population per plant over untreated control. Significantly lower number of aphids was recorded from plant treated with management packages T_2 and T_1 compared to other packages. However, efficacy of two packages was statistically similar and very few aphid was observed in treatment plot of T_2 and T_1. It might be due to effectively control of aphids in the treatment i.e. Sticky yellow trap act as continuous barrier against the aphid and again spray with insecticide reduce the colonization of aphid vector on leaf in the treated plot. Therefore, the disease incidence was less in treated plot as compared to control.

Incidence and severity of CMV: Disease incidence and severity of CMV under different treatments are presented in Fig. 2. Incidence of CMV under all the management packages (T_1-T_6) ranged 9.67-25.10 %, which was lower compared to control. The highest disease incidence (42.00%) was recorded from T_7 (control). The lowest incidence (9.67%) was observed under T_2 which was statistically similar to T_1 (10.5%). The incidence of CMV in T_4, T_5 and T_6, was statistically similar but significantly higher compared to T_1, T_2 and T_3. Similarly, the highest disease severity index was found in T_7 (control) and each of the management packages (T_1-T_6) reduced severity of CMV significantly over control. The lowest severity was found under T_2, which was statistically similar to T_1. Among the treatments T_2 and T_1 was found very much effective in reducing both disease incidence and severity. However, treatments involving sticky yellow trap, polythene mulch with 4 spray of Bio-neem or imidacloprid

(T_2 and T_1) was better than other management packages. It might be due to better control of CMV vectors (aphids) in the treated plot. CMV is an aphid transmitted non- persistent virus, so only insecticides spray is not enough to control the vector as it required only few seconds to transmit virus from infected to healthy plant. So use of disease free seedling, sticky yellow trap, polythene mulch and then spray insecticide effectively controlled the vectors and reduced the disease incidence and severity in the management packages.

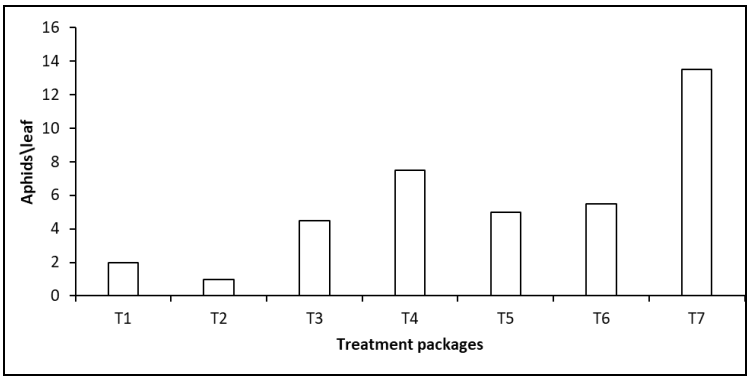

Fig. 1. Effect of different management packages on number of aphids/leaf.(T_1: Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval; T_2: T_1 + spray with Imidacloprid 0.1%; T_3: Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval; T_4: Netting Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval; T_5: Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval; T_6: Netting Seedling + Maize as barrier crop + sticky yellow trap + straw mulch + 2 spray of Imidacloprid; T_7: Control).

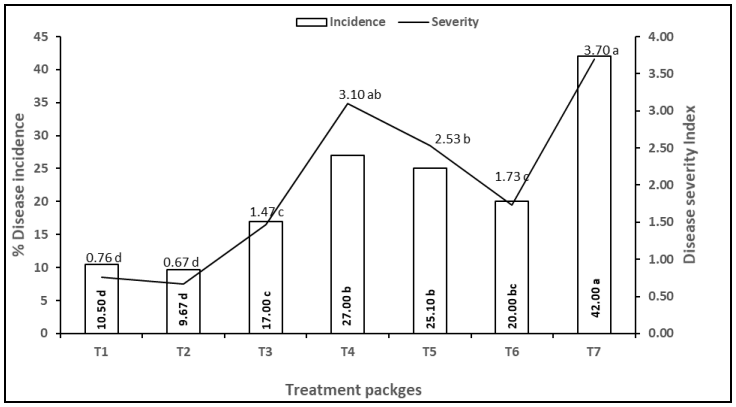

Fig. 2. Effect of different management packages on the incidence and severity index of CMV in Cucumber. (T_1: Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval; T_2: T_1 + spray with Imidacloprid 0.1%; T_3: Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval; T_4: Netting

Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval; T_5: Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval; T_6: Netting Seedling + Maize as barrier crop + sticky yellow trap + straw mulch + 2 spray of Imidacloprid; T_7: Control).

Relationship between aphid population and incidence of CMV

In the field trial it was found that the number of CMV infected plants were higher with the increase of aphid number per plant. The relationship was linear, positive and significant (R^2 = 0.7553, r=86.901*) and could be expressed by the regression equation Y= 3.6484x + 4.8546, where Y= incidence of CMV (%) and x =number of aphids per plant (Fig. 3). The R^2 value indicates that the spread of CMV in the field might be attributed by aphid population by 75.53 %.

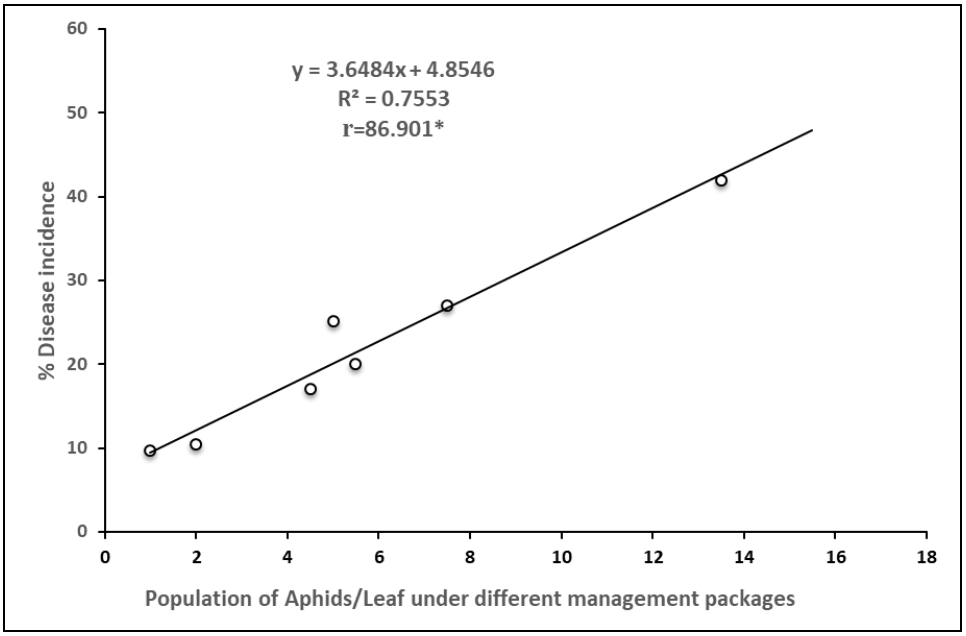

Fig. 3. Relationship between aphid population and percent disease incidence in different management options.

Effect of management packages on yield

All the management options reduced disease incidence and gave higher yield as compared to control (Table 2). The highest yield was found 13.07 ton/ha in treatment packages T_2 (Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of imidacloprid 0.1% at 15 days' interval) which was statistically similar to T_1 (Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval) but significantly higher from other management options. The lowest yield (6.67 t/ha) was found in T_7 (untreated

control). The yield of other treatments ranged from 7.04 to 10.15 t/ha. The highest reduction of disease incidence was found 76.97% in treatment T_2 which was statistically similar to T_1 (75 %). Other treatment packages also reduced disease incidence at a considerable level (35.71-59.52 %). However, among the treatment packages, performance of packages T_2 and T_1 was the best.

Table 2. Effect of management packages on disease reduction and yield of cucumber

Treatments	Disease Incidence (%)	Reduction in disease incidence (%)	Yield (t/ha)	Yield increase (t/ha)
T_1=Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval;	10.50 d (18.88)	75.00	12.96 a	6.29
T_2=T1 + spray with Imidacloprid 0.1%;	9.67 d (18.05)	76.97	13.07 a	6.40
T_3=Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval	17.00 c (24.31)	59.52	10.15 b	3.48
T_4=Netting Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval	27.00 b (31.29)	35.71	7.04 d	0.37
T_5=Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval	25.10 b (30.06)	40.23	9.30 b	2.63
T_6=Netting Seedling + Maize as barrier crop + sticky yellow trap + straw mulch + 2 spray of Imidacloprid	20.00 bc (26.51)	52.38	8.52 c	1.85
T_7=Control	42.00 a (40.36)	-	6.67 d	-
LSD	4.76		0.87	
CV %	9.91		14.50	

* Means followed by same letter are not significantly different at 5% level by DMRT. Value within parenthesis are arcsine transformed value.

Economic analysis

Results obtained from economic analysis of various treatments are presented in Table 3 and 4. All treatments more or less increased the gross return over

control. However, gross return was highest in T_2 followed by T_1, T_3, T_5, T_6 and T_4. The lowest was obtained from Control. Marginal analysis has pointed out that all the management packages increased marginal benefit as well as marginal benefit cost ratio (MBCR) over control (Table 4). The highest MBCR was obtained from T_2 and the lowest from T_4. The results showed that additional investment of Taka 1 in T_2 over control had additional income of Taka 3.17 and similarly Tk. 2.93 in T_1, Tk. 1.61 in T_3, Tk. 1.47 in T_5, Tk. 1.31 in T_6, respectively. Considering cost and return and MBCR from the economic analysis indicated that all the management packages except T_4 (MBCR 1:0.85) were economically viable and maximum gain could be obtained from T_2 (integration with netting seedlings, sticky yellow trap, polythene mulch and 4 spray with imidacloprid 0.1%).

Table 3. Cost and return in different management packages

Packages	*Var. Cost (Tk ha^{-1})	Yield (t ha^{-1})	**Gross return (Tk ha^{-1})
T_1=Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval;	24000.00	12.96	194400.00
T_2=T1 + spray with Imidacloprid 0.1%;	23000.00	13.07	196050.00
T_3=Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval	22000.00	10.15	152250.00
T_4=Netting Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval	5000.00	7.04	105600.00
T_5=Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval	19000.00	9.30	139500.00
T_6=Netting Seedling + Maize as barrier crop + sticky yellow trap + straw mulch + 2 spray of Imidacloprid	12000.00	8.52	127800.00
T_7=Control	-	6.67	100050.00

* Var. Cost: Cost that vary in different packages

** Whole Sell rate of cucumber @ TK 15.00/Kg

Table 4. Marginal analysis of different treatment packages

Packages	Gross return (Tk ha^{-1})	Var.Cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Marginal benefit (Tk ha^{-1})	MBCR
T_1=Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval;	194400.00	24000.00	170400.00	70350.00	1: 2.93
T_2=T1 + spray with Imidacloprid 0.1%;	196050.00	23000.00	173050.00	73000.00	1: 3.17
T_3=Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval	152250.00	20000.00	132250.00	32200.00	1: 1.61
T_4=Netting Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval	105600.00	3000.00	100600.00	550.00	1: 0.85
T_5=Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval	139500.00	16000.00	123500.00	23450.00	1: 1.47
T_6=Netting Seedling + Maize as barrier crop + sticky yellow trap + straw mulch + 2 spray of Imidacloprid	127800.00	12000.00	115800.00	15750.00	1: 1.31
T_7=Control	100050.00	-	100050.00	-	-

(MBCR: Marginal benefit cost ratio)

Different management packages caused 35.71-76.97% reduction in disease incidence and increased yield 0.37-6.40 ton/ha (Table 2). In the present investigation, treatment packages comprising with Netting Seedling, sticky yellow trap, Polythene mulch and 4 sprays of Imidacloprid 0.1% /Bio-neem at 15 days interval (T_2& T_1) were found better than any other packages in terms of disease suppression and yield improvement (Table 2). Successful application of integrated management for CMV has also been postulated in the review by Hooks and Fereres (2006). Among the treatment packages, T_4 was found less effective. This is obvious, because the non-persistent manner of virus transmission like CMV. Only use of insecticides is not always effective as the aphids become irritated and therefore jump from leaf to leaf or plant to plant in an attempt to avoid the insecticides, subsequently infecting healthy plants because the acquisition and inoculation time is very short. For this, aphids are

capable to inoculate healthy plants within few seconds. That is why disease incidence and severity was high as compared to other packages and ultimately reduced the yield (Table 2). Because of the very short time needed to transmit a virus, aphids are capable of transmitting NPVs (Non-persistent viruses) prior to being killed by an insecticide. This observation is an agreement with the findings of Hooks *et al*. (2007).

Again treatment T_2 gave higher yield than T_1but their difference was not significant. It might be due to less suppression of aphids by Bio-neem as compared to Imidacloprid 0.1 %. However, in case of diseases incidence and yield both the packages more or less similar. The better result was achieved with the treatment packages T_2 and T_1,it might be due to sticky yellow trap acted as continuous "spread breakers" by attracting aphids and preventing the colonization on the cucumber leaves and insecticidal sprays further suppressed disease spread. The finding is also in conformity of the previous findings of Anandam and Doraiswamy (2002)in case of non-persistent virus like CMV.

Economic analysis revealed that profit varies depending on the management packages. Results of the present investigation indicate that T_2 is the best treatment in terms of economic gain. It has got chemical back up in addition to sticky yellow trap. So that successful control was achieved against aphid vector which reduced incidence and severity of CMV. Furthermore, polythene mulch increases the soil temperature that enhance the growth and development of cucumber as well as suppress weeds in the field. Therefore, higher yield was achieved from that treatment. From the environmental point of view T_1 may be used. Because it has got botanical insecticide (Bio-neem) instead of chemical which is environmentally safe although marginal benefit cost ratio (MBCR) was little lower than T_2. Although the variable cost of $T_2$and T_1 (Tk 24000 and 23000) is higher but the treatments are cost effective considering return for additional cost.

Effect of CMV on yield depends on a number of factors, including plant age and growth stage when infected, viruliferous vector population, environmental conditions etc. (Agrios, 1988 Rahman, 2008). Results of the present investigation demonstrate that CMV of cucumber may be effectively managed through integration of netting seedlings, use of sticky yellow trap, polythene mulch (winter season) and four spray of imidacloprid 0.1% or Bio-neem 0.2 % at 15 days interval. This is the first report of an integrated management of *Cucumber mosaic virus* (CMV) of cucumber in Bangladesh.

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Bangladesh J. Agril. Res. 45(1): 77-87, March 2020 **Short Communication**

PROSPECT OF FLORICULTURE ON SOCIO-ECONOMIC CONDITION OF FARMERS IN GADKHALI, JASHORE, BANGLADESH

M. R. SHAIBUR[1], H. HUSAIN[2] AND A. AKTER[3]

This study was endeavored to explore the channels through which the floriculture elevated the socio-economic profiles of farmers in Gadkhali, Jhikargachcha, Jashore based on field survey data generated by face to face interview of 200 respondents from 1 July to 15 August, 2016. Farmers of studied area considered floriculture as profitable venture. Because in our surveyed sample, 73% of the respondents achieved high yield, 16% opted for lower production cost and 11% selected less reliance on imported inputs. Socio-economic profiles improved as farmers' monthly income greater than Tk. 10,000 increased from 10% to 17%. Ownership of earthen house declined from 59% to 17% on the contrary brick-built house increased from 9% to 18%. Primary school enrolment rose from 25% to 65%. Use of electric stove increased from 0% to 25%. Usage of sanitary latrine increased considerably from 10% to70%. Farmers chose floriculture rather than conventional farming as commercial use of arable land to grow floral products increased considerably. However, majority of the cultivators were not aware of the adverse impact of inappropriate use of pesticides on environment and a very small proportion had consciousness about the detrimental impact of pesticides on health.

Background Information: Bangladesh with a population of over 170 million within a territory of 144 thousand Km^2 is one of the densely populated countries in the world. About 80% of the total population lives in the rural areas whose livelihood are centered on agriculture and related activities (Bangladesh Bureau of Statistics, BBS; 2011). The total area of Jashore District is 2,606.94 Km^2 of which 23.39 Km^2 is riverine. The District lays between 22º48' and 23º22' North Latitudes and between 88º51' and 89º34' East Longitudes (BBS; 2011; Figure 1). The study was conducted in Gadkhali of Jhikargachcha Upazila (sub District) in Jashore District under Khulna Division. Jhikargachcha has a total area of 307.96 Km^2. According to 2011 census, population was 2,98,908 with 43,439 units of households. Average literacy rate was 27.9% which was lower than the national average of 32.4% (BBS, 2011). The annual average temperature fluctuates between 11.20 °C to 37.1 °C (Islam and Miah, 2003). These climatic factors may

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be favourable for flower production in Gadkhali. This area is well known for large scale cultivation of flowers in Bangladesh. Flower is also cultivated in different parts of the world.

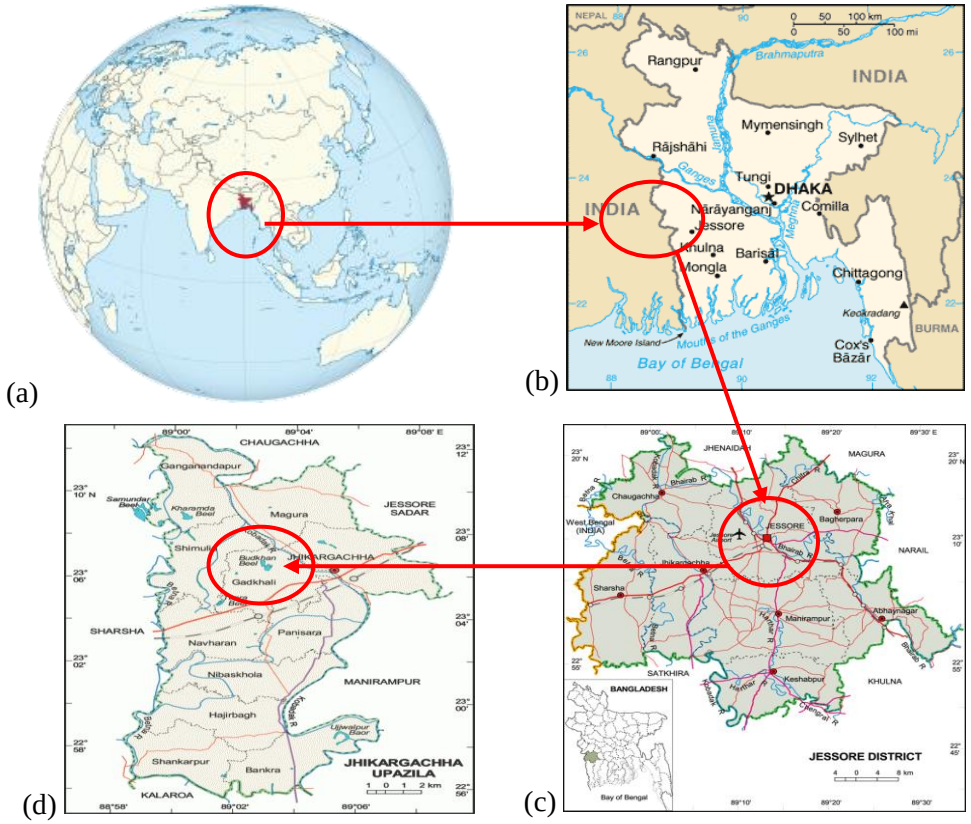

Fig. 1. Pointing out the study area (Jhikargachcha Upazila) in context of world. (a) Map of the World, (b) Map of Bangladesh, (c) Map of Jashore District, and (d) Map of Jhikargachcha Upazila..

Floriculture is a popular practice in some African countries e.g. Kenya, Uganda and Ethiopia (Gudeta, 2012). Most of the people of African countries are poor and are used to cultivate flower for low wage income. The marginal farmer cannot maintain the minimum standard of living and most of them are victimized. In order to keep the right of the farmers they build association. The global value chain (GVC) analysis of floriculture industry in Kenya demonstrates that apart from industrial development, labor agency should be incorporated in GVC (Riisgard, 2009). Labor should be segregated from the producer at production node, so that retailer chains offer more space for labor than conventional auction strand. He also found that labor organization's power to influence the existing

governance structure of GVC is still constrained. Social standards stipulate that labor organizations are not contingent upon governance structure. Furthermore, cost-saving and timely ordering by retailers exerts additional pressure on suppliers and could enhance labor flexibility instead of strengthening labor organizations. The flower cultivation in Bangladesh is different from that in Africa.

Bangladesh being gifted with appropriate soil quality, favorable climatic condition and cheap labor has potential for producing floriculture products like wide varieties of flowers, foliage, ornamental plants of international standard (Chowdhury and Khan, 2015). Because of lower production cost as a result of reduced price of labor, the farmers are able to offer lower price of this cash crop to consumers. Bangladesh started flower or ornamental plant production in mid 1980's on commercial basis in Jashore District which produces nearly 70% of country's total production (Islam and Rahman, 2013). Despite the huge potential, this industry has not been considered as a thriving industry in agricultural sector's value added in gross domestic product (GDP). Around 1,20,000 people are involved in flower cultivation to earn their livelihood in Gadkhali. Roughly, Bangladesh spends around 3 million Bangladesh Taka (Tk.) for importing ornamental plants to meet domestic demand (Mou, 2006). On the other hand, it could utilize 15,14,000 acres of fallow land for exporting this cash crop (BBS, 2011). Floriculture industry in agricultural sector has the potential to create employment opportunities especially for women by expediting income generating activity. Several qualitative studies (Mou, 2006; Islam and Rahman, 2013) are available in this line of research in existing literature but this is the first paper to analyze the socio-economic profiles of farmers engaged in flower cultivation in Jashore District, based on face to face interview and primary data. Thus, this paper aims to fulfill the existing gap in the literature. The main objective of our study was to observe the impact of floriculture on the socio-economic profiles in Gadkhali region of Jashore.

Study area selection: The study was conducted in Gadkhali of Jhikargachcha Upazila in Jashore District under Khulna Division; Bangladesh (Figure 1). In Bangladesh, the flower is cultivated in different regions but in Gadkhali floriculture is popular as a livelihood of farmers. Therefore, Gadkhali was chosen as our study area.

Sampling technique and sample size: The data were collected by using random sampling technique covering almost all the areas of Gadkhali. Both male and female respondents of physically and mentally sound were asked to get the answer. Our sample included people aged between 21 to 60 years who has clear

idea about floriculture and about Gadkhali. About 200 people were included in our survey.

Method of data collection and period of study: Primary data were collected from survey responses. Questionnaires were designed to conduct face to face interview with farmers engaged in flower cultivation. The survey was conducted from 1 July to 15 August, 2016. The collected data have been coded, edited and processed in MS Excel. Cultivation procedure especially pest control system was carefully monitored during the primary data collection. Secondary data were collected from published and unpublished sources. We have used published and unpublished reports like research papers from government and non-government sources.

Analytical Technique: The average was made by simple calculation. Then the results were calculated on percentage basis. Data were collected in randomized blocks.

Terminologies Used: The 2010 was the terminal time that distinguished terms before and after. In this article before indicates the time before 2010 and after indicates time after 2010.

Age distribution and education level of respondents: Greater proportion of the participants aged from 41 to 45 years (Table 1). Around one third of the respondents were found to be illiterate. It was worth mentioning that percentage of the difference between primary and secondary school enrolment was only 3% (Table 1). Our result found that most of the people in the study area were at least literate.

Table 1. Demographic characteristics and educational level of the participants (N = 200)

Age Distribution (Years)	Respondent (%)	Education	Respondent (%)
21 - 25	12	Literate	30
26 - 30	21	Primary	22
31 - 35	10	Secondary	25
36 - 40	17	Higher Secondary	10
41 - 45	23	Graduate	13
46 - 50	13		
51 - 60	4		

N = Sample size

Table 2. Comparative study of socio-economic benefits based on farmer's perception (%)

Category	Cultivation		Category	Cultivation	
	Before	After		Before	After
Land use (Bigha)			**Cooking Facilities**		
(a) 1	47	5	(a) Fuel Wood	60	20
(b) 2 - 3	35	44	(b) Kerosene Stove	25	0
(c) 4 - 9	15	31	(c) Gas	15	55
(d) ≥ 10	3	20	(d) Electric Stove	0	25
Monthly income (Tk.)			**Sanitation**		
(a) ≤ 2000	20	0	(a) Pit latrine (without slab)	50	30
(b) 2001 - 4000	45	5	(b) Sanitary latrine	10	70
(c) 4001 - 6000	15	33	(c) Hanging	40	0
(d) 6001 – 10,000	10	45	**Occupation**		
(d) ≥ 10,000	10	17	(a) Floriculture	20	70
Household Type			(b) Agriculture	60	20
(a) Earthen	59	17	(c) Others	20	10
(b) Semi-brick	32	65	**SE Status**		
(c) Brick built	9	18	Extreme Poor	25	0
PS Enrollment	25	65	Poor	40	10
No comment	10	10	Middle Class	30	65
			Rich	5	35

NB: PS = Primary School; SE = Socio-economic status

Land use and monthly income (Tk): It was found that flower cultivation was not popular in Gadhkhali before 2010, but over the years the popularity of flower cultivation increased gradually (Table 2). Before the intensive practicing of floriculture, only 1 bigha land each was under cultivation by 47% farmers, which decreased to 5% after commercial flower production. Size of arable land amounts to ≥ 10 bigha was under cultivation by 3% farmers previously, and the percentage increased to 20% (Table 2). The range of income level from Tk 4,001 to Tk 6,000 increased by more than double (from 15% to 33%) and income level from Tk 6,001 to Tk 10,000 increase by more than 4 times. Income level greater or equals to Tk 10,000 has risen by 7%. It is worth mentioning that monthly income below Tk 2,000 has dropped to almost 0%. We thus observed that flower cultivation was found to be lucrative and profitable. As the relationship between the size of arable land under floriculture and farmers monthly income was found to be monotonically positive.

Our findings are in line with Islam and Rahman (2013). They found that rose cultivation in Jhikargachcha was profitable at firm level. Other cultivation practices e.g. mixed crop cultivation has extensively enhanced the socio-economic condition of farmers in Gopalganj District (Shaibur et al., 2019). Several factors hindered the productivity and profitability of floriculture such as inappropriate training and knowledge of cultivation, limited access to high yielding variety seedlings, infestation of insects and diseases (Haque et al., 2013; Zaman, 2013). Higher input price, lower selling price, insufficient credit facilities were found to be the major impediments and issues for higher profitability (Haque et al., 2013).

The increase in income level was actually related to the local development of the study area which resulted from commercial flower production. Usually, the farmers sell their final products to agents who sell those either in biggest wholesale market of Jashore located in Gadkhali or directly sell them to wholesale markets in capital and or other divisional cities. Transaction volume of flowers is around 1.0 to 1.5 million Tk per day in Gadkhali wholesale market (Islam and Rahman, 2013). A group of farmers sell their flowers to a farmer who acts as a representative of exporter's agent. Eventually the final products are sent to exporter's agent in Dhaka. Flowers go through further processing in Dhaka before the product is exported to foreign countries for earning currencies.

Household type and primary school enrolment (PSE): Table 2 depicts that ownership of semi–brick and fully brick constructed house have increased by more than double and double, respectively. Primary school enrolment of the family members of the farmers has also risen by 3 times after floriculture practice. Previously, most of the household structures were earthen. About one third was semi-brick built and only few were brick built. During the survey only 17% house hold was earthen. On the contrary, about 65% households' construction materials were semi-brick. The mentioned percentage almost halved (32%) and the ownership of brick-built house increased from 9 to 18% which was exactly 2 times. This abrupt change of house hold material was most probably due to increase level of income from flower cultivation. Especially, increase in real income which promoted farmers' purchasing power. Most of the farmers believe that the flower cultivation has elevated their economic condition which eventually has transformed their household type. As the economic condition improved, this ultimately helped to elevate educational attainment. People believed that they were able to spend their money for their school going children. Thus profile of the primary school enrolment also improved. Mixed crop cultivation has extensively enhanced the socio-economic condition in Gopalganj District which ultimately enhanced the household type and elevated the number of school going students (Shaibur et al., 2019).

Cooking facilities and sanitation: Previously, about 60% household used fuel wood, 25% used kerosene stove, 15% used gas cylinder and no electric stove was

used for cooking. After introducing floriculture, only 20% used fuel wood, 55% used gas cylinder and 25% used electric stove as cooking equipment (Table 2). The use of kerosene stove for cooking dropped to 0%. The changing pattern of cooking facility towards gas or electric stove is expensive. We deduced that required money was obtained from selling floral products. We found that the income level increased after introducing floriculture (Table 2). The change of cooking system reflects the ultimate change in life style of the farmers in the study area. Previously, because of insufficient access to electricity there was no use of electric stove, but after getting the access to electricity, people utilized it in using electric stove. Along with the improvement of cooking facilities, sanitation pattern was also changed. Usage of sanitary latrine was increased by 7 times after introducing floriculture (Table 2).

Occupation and socio-economic status: Floriculture got popularity among the farmers (Table 2) and simultaneously farmers were less interested in conventional agriculture. It was evident that floriculture was considered as a lucrative and profitable venture for them. We observed that the area of arable land under floriculture practice was expanded substantially. Concurrently, we also observed that socio-economic status improved as proportion of middle class increased by more than double and percentage of extreme poor declined to 0%. On the other hand, the wealthiest group revealed substantial increase from 5% to 35%.

Scenario of floriculture: Most of the farmers had been practicing floriculture around 5 years (Table 3). Before that, they did not have notion of potential benefits or advantages of floriculture. During our survey, about 90% of the farmers thought that they were better –off in terms of improved economic and social standing. About 63% farmers did not have idea about the use of fertilizer and pesticide and their negative impacts on environment. About 22% of the participating farmers had some knowledge about the proper use of pesticide. Currently, some organizations are providing motivation of using high yield varieties of flowers.

Table 3. The scenario of floriculture in surveyed sample

Involvement (Years)	%	**Knowledge of pesticide using**	%
(a) ≤ 1	0	(a) Do not know	63
(b) 1 - 5	49	(b) Some knowledge	22
(c) 6 - 8	31	(c) Knowledge regarding health	15
(d) ≥ 8	20	(d) Knowledge regarding environment	0
Perception regarding benefit		**Economic motivation**	
Yes	90	(a) Lower production cost	16
No	10	(b) Less dependent on imported inputs	11
		(c) High Yield	73

Bangladesh is a densely populated and agriculture based developing country. About 52% people of the study area were illiterate or have primary education only (Table 1). This situation needs to be changed with changing cropping pattern. Flower cultivation could be one of the best alternative options and the people of the area were involved in flower cultivation for improving social and environmental condition.

We find that conventional agriculture was shifted to floriculture. Our study finds that at present, only 20% farmers' used conventional agriculture but 70% used floriculture and 10% was reluctant to make any comments (Table 2). A study on rose cultivation in two Indian Districts of West Bengal (Howrah and Medinipur) reveals slightly contradictory findings (Majumder and Lahiri, 2012). Farmers have adopted floriculture as a secondary occupation but land size under rose cultivation has increased relative to other floral products. Both male and female are involved in floriculture. A study demonstrates that tribal women in dry lands of Western India are engaged in growing floriculture products (Agoramoorthy and Hsu, 2012). The small-scale cottage type flower industry has enabled them to earn their livelihood and to enhance local bio-diversity. Women workers have started participating in local politics and have been elected as members of village councils (Panchayati Raj). They have also mobilized themselves in dairy cooperatives, savings and credits as group members and integrated in community development process. Findings of a more recent field study by Dar and Nazki (2017) on 140 registered flower growers of two Districts of Kashmir (Srinagar and Budgam) unfold several economic constraints for farmers. Price of inputs such as fertilizers and insecticides, under developed transportation, variability of market price of the final products, little access to adequate market information, inappropriate storage facility and fluctuation in demand for final good, political uncertainty impose serious constraints for growth of the industry. On the other hand, levels of education, experience, training and probable profitability are major positive factors influencing to grow floriculture products for farm workers. Kenyan flower growers have been in the apex of initiatives to upgrade social and environmental standards in floriculture through the development of their own industry and compliance with the overseas buyers' code (Dolan et al., 2003). Overall, we draw the inference that the socio-economic profiles of the farmers involved in floriculture have progressed based on basic indicators. In the above analysis, we surmised that the cost of living in our studied union remains unchanged before and after cultivation.

Greater proportion of the participating farmers agreed that they did not have adequate knowledge on the right use of pesticides in the production process (Table 3). Only 15% were informed about its negative impact on environment. Before using fertilizer or pesticide farmers must have sufficient knowledge about the specific chemicals, otherwise it may create severe problem on health or environment. The intensive use of chemical fertilizer, pesticides and waste water

management system should be carefully monitored along with air, water and soil pollution in the production process as well as farm workers' right for health and occupational safety, improved working conditions especially for women laborer should be given utmost priority (Gudeta, 2012).

The major economic advantages are 'High Yield', lower cost of production and less reliance on imported inputs give flower growers impetus for cultivation (Table 3). According to the 'Finance for Enterprise Development and Employment Creation (FEDEC, 2014)", linkages between the cultivator and the exporter constitute several informal channels. Supply of high-quality mother plants of several varieties (such as gerbera), availability of packaging materials, specialized vehicle for quick transportation, appropriate facilities for wholesale flower market for farmers, preservation system of unsold products especially in summer are some important factors to be addressed for developing the supply chain management. This will enhance farmers' income from flower cultivation. Initially farmers used to collect the seeds and seedlings from Indian suppliers at border, now majority of the cultivators collect these from local suppliers. Farmers in Panishara Union grow their own seeds. They have access to technical and financial support from 'Rural Reconstruction Foundation' (RRF) through the project. A study on Uganda manifests all farms producers of cut flower have been able to upgrade economically in global value chain (Evers et al., 2014). This is the result of investment in technical equipment by multinational corporations like water filtering, upgrading greenhouse, restructuring production sites, introducing satellite communication system, refrigerating trucks etc (Evers et al., 2014). Moreover, governance structure of GVC is controlled by European multinationals which has enabled them to control intellectual property rights, and their direct ownership and investment and engagement with trusted producers. This has played pivotal role for economic upgrading for Ugandan producers.

Final Remarks

No doubt, floriculture promoted the monthly income, standard of household, cooking facilities, sanitation system and primary school enrollment. We found that flower cultivation had been successful in upgrading the socio-economic status of the cultivators in studied area to some extent, as this result is evident in our face to face interview with 200 farmers. It is worth mentioning that the strongest economic motivation for production is domestically produced inputs which have cost advantage and this eventually increases greater profitability. Most of the participants were not aware of the environmental impact of inappropriate use of pesticides and lower fractions of farmers have conjecture of its hazardous impact on health. Therefore, it is recommended that adequate training should be provided to farmers about the careful use of pesticides to build resilience for soil, air and water pollution. The positive impacts of commercial flower production on socio-economic lives of farmers in Gadkhali were good and

reliable examples for farmers to grow floral products in other Districts of Bangladesh.

There is an exigency of establishing state-of-the-art laboratory in the studied area which could facilitate and organize regular seminars and meetings to help the cultivators to grow floral products in sustainable manner. Concurrently, appropriate governance structure of supply chain management is needed to commercialize the flower production in large scale but definitely not at costs of social and economic welfare of farmers in remote areas of Bangladesh.

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CORRELATION STUDIES ON SEED YIELD AND FRUIT WEIGHT OF FOUR Bt EGGPLANT VARIETIES

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Eggplant (*Solanum melongena* L.) commonly known as 'brinjal' or 'aubergin' is one of the most popular vegetables in Bangladesh as well as in the world. It is cultivated across the country throughout the year. It is an important vegetable crop in Bangladesh next to potato and tomato in terms of area and production that covers about 32 thousand ha of land with total productions of 355 thousand metric tons during winter season of 2017-18 (BBS, 2019). The major constraints of brinjal cultivation is the shoot and fruit borer (BSFB) which infests tender shoot tips and growing fruits and cannot be controlled easily by spraying insecticides. The development of Bt brinjal involves the introduction of Cry1Ac gene (isolated from soil bacterium, *Bacillus thuringiensis*) resistant against BFSB. Upon approval the commercialization, Bangladesh becomes the first country in the world to approve four varieties of Bt eggplant in 2013. Bt eggplant provides essentially complete control of eggplant fruit and shoot borer, dramatically reduces insecticide sprays, provides a six fold increase in grower profit, and does not affect non target arthropod biodiversity (Shelton *et al.,* 2019). It has gotten off to a good start with increased yearly adoption and very favorable socioeconomic benefits, it was distributed among the 20 farmers in 2014 due to rapid adoption, 27012 farmers used this technology in 2018 (Shelton *et al.,* 2018). Seed yield per fruit varied significantly among the varieties (Rahman *et al.,* 2015). An effort was made to find out the relationship between seed yield and fruit weight in this present study. The breeder seed production of four Bt eggplant varieties *viz*., 'BARI Bt Begun-1', 'BARI Bt Begun-2', 'BARI Bt Begun-3' and 'BARI Bt Begun-4' was carried out in four locations viz. Rangpur, Barishal, Gazipur and Bagura, respectively during 2018-19 under the supervision of Biotechnology Division, BARI, Gazipur. Standard crop management practices like land preparation, fertilization, irrigation, drainage, roughing, weeding clipping of side branches, harvesting, seed extraction, drying etc. were followed in seed production (Hasan *et al.,* 2017). Twenty five ripe fruits were randomly selected from each of BARI Bt eggplant varieties to make correlation between fruit weight with seed weight and number of seed. After extraction, seeds were dried to maintain a moisture level of about 6-8%. Seed weight of each fruit was weighted and expressed in gram. Number of seed from each fruit was counted. Fruit weight was plotted in X-axis; where, seed weight and number of seeds were

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plotted in Y axis of MS-excel program. Relationship of fruit weight and seed yield of four Bt eggplant varieties is presented in the Fig.1. Seed weight increased with the increasing of fruit weight. The relationship was significant at $p \leq 0.05$. The functional relationship between fruit weight and seed weight implies the seed weight could be increased at the rate of 0.0203, 0.0138, 0.0215 and 0.0155 g with an increase in 1 g of fruit weight in 'BARI Bt Begun-1', 'BARI Bt Begun-2', 'BARI Bt Begun-3' and 'BARI Bt Begun-4', respectively. Relationship of fruit weight and number of seeds of four Bt eggplant varieties is presented in the Fig.2. Like seed weight, number of seed per fruit also increased with the increasing of fruit weight. There was a positive and significant correlation between fruit weight and number of seeds per fruit. It might be due to bigger fruit size which contained more seeds. This finding is in agreement with Angadi *et al.*, 2017 and Islam and Hasan, 2018. On an average, individual fruit weight, seed weight per fruit and number of seed per fruit is presented in the Table 1. The ratio of fruit weight and seed weight was varied from 35:1 to 40:1 in four different varieties. This information may be helpful to estimate the amount and number of seeds from fruit of Bt eggplant varieties.

Bt eggplant is a new genetically engineered crop in Bangladesh. It has great potentiality and high demand in the country. From the equations of Fig. 1 and Fig. 2, a seed producer may predict how much and number of seeds would be produced from the four Bt eggplant varieties.

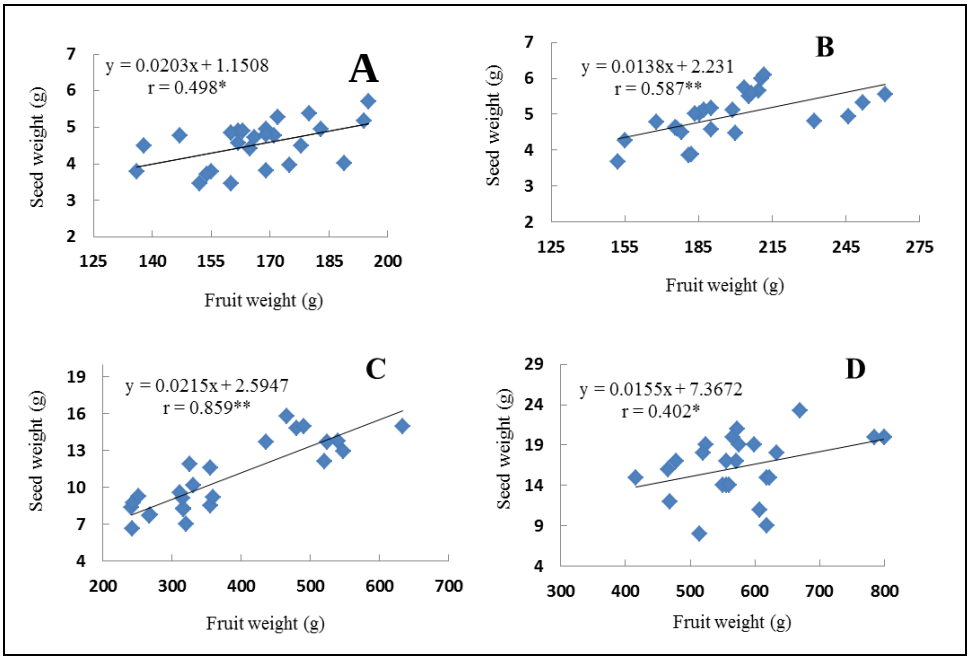

Fig. 1. Relationship between fruit weight and seed yield of different Bt eggplant varieties; A) 'BARI BtBegun-1', B) 'BARI Bt Begun-2', C) 'BARI Bt Begun-3' and D) 'BARI Bt Begun-4'.

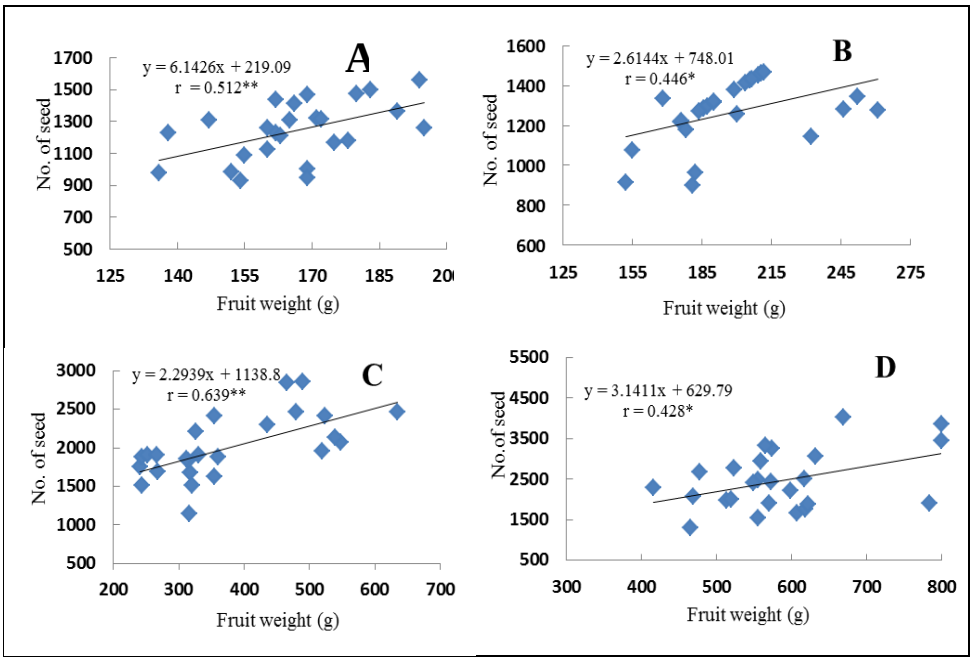

Fig. 2. Relationship between fruit weight and number of seeds of different Bt eggplant varieties; A) 'BARI Bt Begun-1', B) 'BARI Bt Begun-2', C) 'BARI Bt Begun-3' and D) 'BARI Bt Begun-4'.

Table 1. Average fruit weight, seed weight per fruit and number of seed per fruit from different Bt eggplant varieties

Variety	Individual fruit weight (g)	Seed weight per fruit (g)	Number of seeds per fruit	Fruit wt.: Seed wt.	Fruit yield for seed purpose (t/ha)	Seed yield (kg/ ha)
'BARI Bt Begun-1'	166.56±15.22	4.52±0.62	1242±182	37	12.03	302
'BARI Bt Begun-2'	197.67±27.67	4.95±0.65	1265±162	40	13.26	343
'BARI Bt Begun-3'	378.44±114.91	10.73±2.87	2007±411	35	10.33	276
'BARI Bt Begun-4'	585.88±98.12	16.49±3.78	2470±720	35	9.68	256

Data shown in average with standard deviation

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Bangladesh J. Agril. Res. 45(1): 93-97, March 2020 **Short Communication**

INFLUENCE OF SEED PRIMING ON THE GERMINATIONAND YIELD OF MAIZE AT FARMERS FIELD CONDITION

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Keywords: Maize, seed priming, germination, yield

Maize (*Zea mays* L.) is one of the most important food grains of the world. In Bangladesh, maize ranks third in respect of total acreage after rice and wheat but ranks first in respect of average yield which are 5.47 t ha^{-1} (BBS, 2016). Seed priming is a process in which seeds are imbibed in water or osmotic solutions followed by drying before radical emergence. Harris *et al*. (1999) promoted a low cost, low risk technology called 'on-farm seed priming' that would be appropriate for all farmers. On-farm seed priming involves soaking the seed in water, surface drying and sowing at the same day. Seed priming has been reported as to improve germination, reduce seedling germination time and improve stand establishment, increase emergence, earlier flowering, earlier maturing and higher grain yield. Seed priming can be accomplished through different methods such as hydropriming, osmopriming and solid matrix priming (Harris *et al*., 1999). The success of seed priming is influenced by the complex interaction of factors including plant species, water potentiality of the priming agent, duration of priming, temperature, seed vigor and storage conditions of the primed seed.In Bangladesh maize can be produced successfully at low moisture content of soil after harvesting transplant *aman* rice by priming of seeds. However, the priming techniques of this crop is not well established in Bangladesh. Although a good number of research works have been done on seed priming of maize in abroad but research works in Bangladesh is scanty. Therefore, the present trial was undertaken to know the performance of seed priming on the yield of maize and associated characters.

The experiment was carried out in the farmers' field at MLT site of Bangladesh Agricultural Research Institute, Jhikargacha, Jessore during *rabi* season 2013-14 and 2014-15.The soils of the experimental plots are sandy loam with low organic matter and pH (7.45) under Agro Ecological Zone-11. The maize variety was 'BARI Hybrid maize-9'. The experiment includes three priming methods *viz*., T_1= Hydropriming, T_2= Osmopriming (3% $ZnSO_4$ solutions) and T_3= Non priming (dry seed). The experiment was laid out in a randomized complete block design with four replications. Maize seeds were taken in plastic bowls and

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submerged with distilled water / osmotic solution of 3% $ZnSO_4$ for 18 hours. After 18 hours of treatment the seeds were taken out from the bowl and washed under tap water for several times. Then it was surface dried for two hours under shade condition. Seeds were sown on 28 November 2013 and 25 November 2014 maintaining the spacing of 60 cm × 20 cm. The moisture content of the soil of experimental plot was 20% at the time of sowing in both the years. Individual plot size was 5m × 3m. Fertilizers were applied at the rate of 253, 52, 110, 42, 5 and 1 kg N, P, K, S, Zn and B ha^{-1}, respectively in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid (BARI, 2010). One-third of urea and all other fertilizers were applied as basal during final land preparation. The rest amount of urea was applied in two splits at 30 DAS (Days after sowing) and 50 DAS. Two hand weeding were done at 20 DAS and 40 DAS. Earthing-up was done at 50 DAS after second irrigation. Four irrigations were applied at 30, 50, 75 and 100 DAS. The crop was harvested on 07 April 2014 and 05 April 2015. Harvested cobs were husked and sun dried. Then cobs were shelled by electric power driven corn sheller followed by cleaning and winnowing. Data on different parameters were recorded following the procedures as below-

Germination percentage: The seedlings were counted daily until complete emergence. Germination was calculated in percentage using the following formula:

$$\% \text{ Germination} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

Germination index: The germination index (GI) was calculated by following formula (AOSA, 1983):

$$GI = \frac{\text{Number of germinated seeds}}{\text{Days of first count}} + \frac{\text{Number of germinated seeds}}{\text{Days of final count}}$$

Mean germination time: The mean germination time (days) was calculated according to the following formula (Scott *et al*., 1984):

$$MGT \text{ (days)} = \frac{\sum Ti\, Ni}{S}$$

Where, Ti = Number of days after beginning of experiment

Ni = Number of seed germinated on day i

S = Total number of seed germinated

After shelling the cobs, it was well dried in the sun for 24 hours and adjusted at 13% moisture content of grain and stover. Data were subjected to statistical

analysis using ANOVA technique through computer based statistical package programme MSTATC.

Germination of maize seeds varied significantly due to priming (Table 1). Germination of maize was the highest (85%) with hydroprimed seeds and the lowest (76%) from non-primed seeds (Table 1). This might be due to positive effect of seed priming. Nagar *et al*. (2011) also stated that hydropriming increased percent and speed of maize seedling emergence. Similar result was also found in maize by Murungu *et al*. (2004). Germination index of maize seeds varied significantly due to seed priming. Germination index showed similar trend as in germination of seeds (Table 1). Seed priming improves emergence at low moisture content of soil. Similar result was also found in maize by Harris *et al*. (2001). Mean germination time of maize seeds varied significantly due to seed priming. Mean germination time was the lowest (5.73 day) with hydroprimed seeds while the highest (6.98 day) for non primed seeds (Table 1). Afzal *et al.* (2009) reported that faster germination is occurred in primed seed due tothe earlier synthesis of DNA, RNA and protein.Dry matter plant^{-1} varied significantly due to seed priming at 30 DAS (Days after sowing). DM (Dry matter) plant^{-1} was highest (0.79 g) with hydroprimed seeds followed by osmoprimed seeds (0.77 g), while the lowest (0.57 g) for non primed seeds (Table 1). Seed priming was induces a faster biochemical changes such as hydrolysis, activation of enzymes and dormancy breaking (Farooq *et al.*, 2010) resulted in improvement of maize dry matter and grain yield.DM plant^{-1} of maize showed significant variation due to seed primingat 110 DAS. DM plant^{-1} was the highest (203.89 g) with hydroprimed seeds and the lowest (149.19 g) for non primed seeds. Dry matter of maize seedling improved with seed priming in the experiment. Similar result was reported by Zaidi *et al* (2004).

Cob length, cob diameter, 100 grain weight, grain yield and straw yield showed significant difference due to priming of seeds. The maximum cob length (19.38 cm), cob diameter (4.49 cm), 100-grain weight (33.43 g) and stover yield (10.74 t ha^{-1}) were obtained from hydroprimed seeds and the lowest from non-primed seeds. The highest grain yield (9.85 t ha^{-1}) was obtained from hydroprimed seeds due to higher yield attributes but the lowest (8.29 t ha^{-1}) from non-primed seeds. It might be due to more activity of enzymes involved in sucrose metabolism in primed seed that extended vigorous crop growth and eventually contributed to higher 100-grain weight and as well as yield.This result is at par with the findings of Harris *et al*. (2007). Hydro-priming of maize seeds exhibited significantly better performance as compared to osmopriming and no priming (i.e. dry seeds) under farmers' field condition. The highest emergence and the lowest mean germination time of maize seeds were found in hydroprimed seeds at low moisture content of soil (20%). Yield and yield contributing characters were also the highest with hydroprimed seeds. So, hydropriming could be used as a

technique to ensure seedling establishment and to improve yield of maize at low moisture content of soil.

Table 1. Characters of maize as influenced by seed priming at multi-location testing (MLT) site, Jhikargacha, Jessore (Pooled average of 2013-14 and 2014-15)

Priming	Germination percentage	Germination index	Mean germination time (day)	Dry matter plant^{-1} (g)	
				30 DAS	110 DAS
Hydro-priming	85 a	15.28 a	5.73 c	0.79 a	203.89 a
Osmo-priming	81 b	14.42 b	5.81 b	0.77 a	194.68 b
No priming	76 c	11.09 c	6.98 a	0.57 b	149.19 c
CV%	1.46	1.34	1.55	5.22	2.33
Priming	Cob length (cm)	Cob diameter (cm)	100 grain wt. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
Hydropriming	19.38 a	4.49 a	33.43 a	9.85 a	10.74 a
Osmopriming	18.33 b	4.39 ab	32.03 b	9.17 b	10.33 b
Non priming	17.18 c	4.20 c	29.60 c	8.29 c	9.63 c
CV (%)	2.51	0.89	1.60	1.87	1.20

Figures with dissimilar letter(s) differ significantly at 0.05 level of probability by DMRT

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