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On-Station and On-Farm Evaluation of Sweet Pepper (*Capsicum annuum* L.) in Sylhet

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ABSTRACT

Two experiments were conducted with sweet pepper during the winter season of 2015-2016. One experiment was on-station evaluation of sweet pepper variety 'California Wonder' under two different protective structures (Net and Net + polythene), two different miticides application (Intrepid and Vertimec) and Open field (Control) at the Horticulture Research Field of Sylhet Agricultural University, Bangladesh. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Another experiment was on-farm evaluation of sweet pepper variety 'BARI Mistimoric-1' under Net + polythene protective structure in the farmer's field of Moulvibazar and Sunamganj district. In case of on-station study, Net and Net + polythene protection had significant influence on growth and yield of sweet pepper. The highest and almost similar performance were recorded from Net and Net + polythene in terms of plant height at first harvest (72.67 and 72.83 cm), harvest duration (34.33 and 34.33 days), individual fruit weight (76.45 and 75.95 g), fruit length (8.40 and 8.51 cm) and fruit diameter (7.33 and 7.07 cm). Next to Net and Net + polythene protective structures, individual fruit weight (46.80 g) of Intrepid treated plants was statistically higher than Vertimec and Open field treated plants. The number of fruits per plant (11.57), fruit yield per plant (893.90 g) and fruit yield per decimal (178.78 kg) were significantly higher for Net + polythene protected structure followed by Net protected structure. Benefit Cost Ratio (BCR) of Net (5.4) and Net + polythene (5.6) protected structures were measured more than half of the Open field condition (2.5) indicating bright scope of sweet pepper cultivation under protective structures in the Sylhet region. Although BCR of Intrepid treated plants (4.0) was little less than the protective structures, but considering the economic condition of the farmer sweet pepper cultivation in the open field with Intrepid as a miticide can be suggested. In case of on-farm study, the fruit yield per decimal of Moulvibazar district (163.13 kg) was little higher than the Sunamganj district (155.93 kg), therefore, BCR of Moulvibazar district (4.1) was obtained little higher than the Sunamganj district (3.9). The on-farm adaptive trial also revealed that sweet pepper cultivation can be spread to the farmer's field of the Sylhet region.

INTRODUCTION

Sweet pepper (*Capsicum annuumL.*) is an important vegetable crops cultivated extensively throughout the world especially in the temperate countries. It is a flowering plant under the genus Capsicum and belongs to the family Solanaceae. Tropical South America, especially Brazil is the original home of pepper (Shoemaker & Teskey, 1995). Sweet pepper fruits are mainly eaten as cooked or raw as well as sliced in salad and fruits are harvested either at green mature stage or at coloring stage (Singh *et al.*, 2011). Besides vitamins A and C, the fruits contain mixtures of antioxidants, carotenoids, ascorbic acid, flavonoids and polyphenols (Nadeem *et al.*, 2011). It is also rich in capsaicin that may help works against inflammation (Knott & Deanon, 1967).

Although sweet pepper is the most important summer crop of temperate regions, but efforts are being made recently to grow in Bangladesh (Paul, 2009). Some advanced farmer's grow sweet pepper sporadically in Bangladesh to meet the demand of big cities and earned very high price (Saha & Salam, 2004). But there are several problems associated with its production. First of all, low night temperature was found to have a negative effect on the production of this crop (Anon, 2008). The optimum temperature requirement for sweet pepper cultivation ranged from 16-25^{0}C while night temperature below 16°C and day temperature above 32°C causes blossom dropping (Boswell, 1964). In Bangladesh, night temperature is gradually decreased below 10^{0}C from December to January which is the optimum time for vegetative growth and fruit setting of sweet pepper (Halim & Islam, 2013). In that situation, vegetative and reproductive growth of sweet pepper plants become stunted and flower and fruit drops occur. Secondly, different types of mites were found important pests of sweet pepper (Weintraub, 2007). They possess needle-like chelicerae which pierce plant parts, often feeding on the undersurface of the leaf (Zhang, 2003). Some of them produce silk webbing which covers the leaf surface resulting reduced photosynthesis and eventually causes leaves to dry and drop off, while some other causes leaf edges become rigid and roll under (Weintraub, 2007). It is relatively serious pest for low tolerant species since less than five mites on a young sweet pepper plant can cause severe damage by reducing fruit number per plant as well and fruit weight (Cho *et al.*, 1996). They can easily move

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from infested plant to clean ones by farm workers or by whiteflies (Palevsky *et al.*, 2001). Once they get entry into a cultivated area it can spread rapidly and have severe economic impact.

Sylhet is considered as a special agricultural zone in Bangladesh. Prevailing night low temperature is a limiting factor for growing sweet pepper in hilly areas of Sylhet. Therefore, to make its cultivation successful, polyhouses, poly-tunels and plastic mulching are most effective solutions (Chandra *et al.*, 2000 and Singh *et al.*, 2010). Night temperature under poly covers reported higher than the outside (Halim & Islam, 2013).

Again these structures also facilitate a longer duration use of nutrient elements from the soil by crop plant (Singh *et al.*, 2003).

Very limited information is available for growing sweet pepper under protected structures under Sylhet condition. So, the effectiveness of protective structures in Sylhet need to be addressed. Moreover, poor farmer sometime prefer to cultivate sweet pepper under open field condition considering the high price of the protective structures. They often harvest a lower yield due to severe mite infestation. No data regarding miticides application and their effect on yield was reported previously in this region. So, effectiveness of miticides on controlling of mites and yield performance of sweet pepper also need to be studied. Therefore, this study mainly focused on(a) on-station evaluation of a sweet pepper hybrid under different protective structures and miticides application, and (b) on-farm evaluation of another sweet pepper hybrid to the farmers field of Moulvibazar and Sunamganj district of Sylhet division under Net+polythene protective structure only.

MATERIALS AND METHODS

The on-station evaluation of sweet pepper was done at the Horticulture Research Field of Sylhet Agricultural University, during October 2015 to March 2016. A sweet pepper variety‘ California Wonder’ was evaluated under two different protective structures(T1 = only Net and T2 = Net + polythene), open field with two different miticides application (T3 = Intrepid and T4 = Vertimec) and open field without miticide (T5 = Control). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. For both net and net + polythene protected structures, the height of the structure was 1.0 meter above soil surface.

White colored polythene of 0.5mm thickness and 120 mesh white nylon net were used for to place over the structure for covering the plants. For miticides application, a hand sprayer has been used and sprayed @ 2 ml/L of water in the late afternoon at each seven days interval from transplanting until last harvesting. The seeds were sown in seedbed on 28th October 2015. Thirty days old and healthy seedlings were finally transferred to the experimental field. The unit plot size was 3.2 × 1.0 m and the plants were spaced 60 × 40 cm between plant-to-plant and row-to-row, respectively. Intercultural operations such as watering, weeding, gap filling, earthing up etc. were done as and when necessary. A recommended fertilizer dose with cowdung, urea, TSP, MP, gypsum and ZnO@5 t/ha, 217 kg/ha, 333 kg/ha, 200 kg/ha, 111 kg/ha and 5 kg/ha, respectively was applied (Saha, 2001).

Harvesting of the green fruits was done when they were relatively firm and crispy (Shoemaker and Tesky, 1995). Data were collected on growth, yield and yield related parameters and the collected data were statistically analyzed with the help of MSTAT-C software. Cost of cultivation (Tk/decimal), gross return (Tk/decimal), gross margin (Tk/decimal) and BCR were also calculated.

The on-farm evaluation of sweet pepper was done at the farmer’s field of Moulvibazar and Sunamganj districts during the same period as of the on-station study.

Four progressive farmers from each district were selected with the help of Upazila Agriculture Officer. In this experiment, the genotype ‘BARI Mistimorich-1’ was evaluated under net + polythene protective structure only and height of the structure was 1.0 meter above the soil surface. Each farmer was used a land area exactly one decimal (40.46 sq m). Healthy and uniform seedlings of 30 days old were transplanted in the main field maintaining a spacing of 60 cm × 40 cm. Fertilization and intercultural operations were done as of the on-station study. The plants were remained under net protection for whole cropping period while polythene cover was given only two coldest months of December and January.

Harvesting was done at mature green stage both in Moulvibazar and Sunamgang districts. Data were collected on different parameters such as days to first flower, number of fruits per plant, fruit yield per plant etc. Simple statistical parameters like mean and standard deviation were measured for interpretation of the results. Economic analysis was also made for this experiment.

Two different variety of sweet pepper were used for on-station and on-farm study mainly due to the availability of seed materials. Moreover, average yield performance of California Wonder and BARI Mistimorich-1 (21.31 and 20.38 t/ha, respectively) are more or less similar in Bangladesh condition as previously observed by Akther (2015) under different net protective structures.

RESULTS AND DISCUSSION

On-station evaluation of sweet pepper in Sylhet

Significant variation was observed among the treatments for all the parameters observed in this experiment (Table 1).The maximum number of days (56.33) to first flower was recorded from Vertimec treated plants compared to all other treatments. The reason for delay flowering in the Vertimec treated plants is unknown. Earliest harvest was recorded from net and net + polythene protected plants. The highest and almost similar plant height at first harvest was recorded from net and net + polythene protective structures (72.67 and 72.83, respectively).

The growth of plant was higher under both net and net + polythene protective structures could be due to the better environmental conditions for development. Similar

result in terms of plant height under different protective structures in comparison to open field condition was previously reported by Halim and Islam, 2013.They also reported that the low night temperature along with other biotic and abiotic stresses in the open field might play a significant role for low plant growth. Boswell (1964) reported that low night temperature is very detrimental for growth of sweet pepper.

The congenial atmosphere prevailed in both the protective structures in this experiment encouraged the plants for more vegetative growth, therefore, longer and similar harvesting duration of fruits (34.33 days) in comparison to other treatments. The highest number of fruits per plant was recorded from the net + polythene protected structure (11.57) followed by only net protected structure (10.53). No differences in case of fruits number per plant was observed among Intrepid, Vertimec and open field treated plants.

Individual fruit weight, fruit length and fruit diameter were the highest and statistically similar for both net and net + polythene protected structures. Among five different treatments the maximum fruit yield per plant was obtained when plants were grown under net + polythene protected structure (893.90 g), followed by only net protected structure (801.00 g). While the fruit yield per plant was minimum in open field condition (358.20 g) which was statistically similar to Vertimec treated plants (375.01 g). Similar result has previously been observed by Sayed (2016). Islam and Halim (2014) obtained the lowest fruit yield per plant under open field condition while it was the highest under tunnel cover with polythene and nylon net. Result indicated that in open field condition (with or without miticides application) having various biotic and abiotic stresses, therefore, plants produced the lowest yield. Fruit yield was maximum (178.78 kg/decimal) under net + polythene protected structure, followed by only net protected structure (160.20 kg/decimal). The lowest yield (71.68 kg/decimal) was obtained from open field condition. This variation in fruit yield might be attributed due to shade-nets provide physical protection against hail, wind, bird and insect-transmitted virus diseases (Shahak, 2006).Ahemd *et al.* (2016) opined that reducing the transmitted solar radiation under different protective structures reduce the canopy and air temperatures as well as the transpiration rate. This consequently enhances the water use efficiency and increases the crop productivity up to 40%.

Benefit Cost Ratio Analysis

Table 2 sowing the benefit cost ratio analysis of sweet pepper grown under protective structures and open field with and without miticides application. Plants grown under net + polythene protected system incurred the highest total cost compared to other treatments. The lowest total cost was required for open field cultivation. Cost analysis showed that plants grown in net + polythene protected structure gave the highest gross return followed by only net protective structure. Gross margin and BCR were also the highest in net + polythene protective structures closely followed by only net protective structure. Considering the open field with and without miticides application, the maximum BCR (4.0) was obtained from Intrepid treated field. The lowest BCR was recorded from open field condition which was less than half of the BCR of both net and net + polythene protected structures. Similar result in terms of BCR was reported earlier when crops were grown under different protective structure compared to open field (Singh *et al*, 2011).

Table 1: Growth, yield and yield attributes of sweet pepper grown under different protective structures and open field with and without miticides application

Treat-ments	Days to first flower	Days to first harvest	Plant height at first harvest (cm)	Harvest duration (days)	Number of fruits per plant	Individual fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield/ plant (g)	Fruit yield/ decimal (kg)
T1	27.67 b	85.33 b	72.67 a	34.33 a	10.53 b	76.45 a	8.40 a	7.33 a	801.00 b	160.20 b
T2	30.67 b	85.67 b	72.83 a	34.33 a	11.57 a	75.95 a	8.51 a	7.07 a	893.90 a	178.78 a
T3	37.67 b	96.00 a	45.20 bc	24.67 bc	9.57 c	46.80 b	5.59 b	5.47 b	447.90 c	89.58 c
T4	59.33 a	98.00 a	37.30 c	22.33 c	9.37 c	40.01 c	6.17 b	5.50 b	375.01 cd	75.00 cd
T5	36.33 b	91.33 ab	50.53 b	27.33 b	9.03 c	39.71 c	5.18 b	5.61 b	358.20 d	71.68 d
F-test	*	**	**	**	**	**	**	**	*	*
CV(%)	**11.38**	**3.62**	**5.31**	**9.81**	**3.09**	**5.22**	**11.33**	**6.14**	**16.3**	**16.3**

T1 = Net protected, T2 = Net + polythene protected, T3 = Intrepid application,
T4 = Vertimec application and
T5 = open field;
***=Significant at 1% level of probability, *= Significant at 5% level of probability; and*
Means followed by same letter (s) in a column do not differ significantly by LSD
On-farm adaptive trial of sweet pepper

Table 2: Benefit cost ration analysis of sweet pepper grown under different protective structures and open field with and without miticides application

Treatments	Price/ kg fruit (Tk)	Gross return (Tk/ decimal)	Cost of production (Tk/ decimal)	Gross margin (Tk/decimal)	Benefit cost ratio (BCR)
T1	100	16020.0	2939	13081.0	5.4
T2	120	21453.6	3839	17614.6	5.6
T3	35	3135.3	779	2356.3	4.0
T4	35	2625.0	794	1831.0	3.3
T5	20	1433.6	584	849.6	2.5

Moulvibazar District

Yield and yield attributes of sweet pepper under net + polythene protective structure in Moulvibazar district were presented Table 3. Average number of days required to first flower of sweet pepper at Moulvibazar district was 56.75. The days to first harvest varies from 90 days to 99 days among the farmers with an average of 93.75 days. The average number of fruits/plant was 10.5, average fruit yield/plant was 906.25 g and average fruit yield/ decimal was (163.13 kg) at Moulvibazar district. A little variation in per plant and per decimal fruit yield among the farmers might be due to the variation of management practices followed by the farmers.

Sunamganj District

Yield and yield attributes of sweet pepper under net + polythene protective structures in Sunamganj district were presented in Table 4.Average number of days required to first flower was 54.00 in this district. The days to first harvest was varies from 86.00 to 96.00 days with an average of 91.00 days. The average fruit number per plant of Sunamganj district was similar as Moulvibazar district (10.5).The average per plant and per decimal yield was 866.25 g and 155.93 kg, respectively. Yield variation in the farmers field were observed might be due to the variation in management practices.

Comparative study between Moulvibazar and Sunamganj District

Comparison between two districts for sweet pepper yield and economic profitability is presented in Table 5. The highest fruit yield/plant (906.25 g) as well per decimal (163.13 kg) were recorded from Moulvibazar district. Average market price of sweet pepper obtained by the farmer was 100Tk/kg. Economic analysis revealed that per decimal cost for sweet pepper cultivation in the farmer field was Tk. 4000.The gross return as well as gross margin (16,313.00 and 11,813.00 Tk, respectively)

Table 3: Yield and yield attributes of sweet peeper under Net + polythene protective structure at Moulvibazar district

Farmers	Days to first flower	Days to first harvest	No. of fruits/ plant	Fruit yield/ plant (g)	Fruit yield/ decimal (kg)
Farmer 1	55	90	12	980	176.40
Farmer 2	59	94	10	930	167.40
Farmer 3	55	99	11	950	171.00
Farmer 4	58	92	9	765	137.00
Mean	**56.75**	**93.75**	**10.50**	**906.25**	**163.13**
Stdev	**2.06**	**3.86**	**1.29**	**96.38**	**17.35**

Table 4: Yield and yield attributes of sweet peeper under Net + polythene protective structure at Sunamganj district

Farmers	Days to first flower	Days to first harvest	No. of fruits/ plant	Fruit yield/ plant (g)	Fruit yield/ decimal (kg)
Farmer 1	54	96	7	660	118.80
Farmer 2	53	95	10	840	151.20
Farmer 3	58	86	12	975	175.50
Farmer 4	51	87	13	990	178.20
Mean	**54.00**	**91.00**	**10.50**	**866.25**	**155.93**
Stdev	**2.94**	**5.23**	**2.65**	**153.15**	**27.57**

Table 5. Comparison of sweet pepper yield and cost analysis between Moulvibazar and Sunamganj districts

Location	Number of fruits/ plant	Fruit yield/ plant (g)	Fruit yield/ decimal (kg)	Gross return (100 Tk/kg)	Cost/ decimal (Tk.)	Gross margin (Tk.)	BCR
Moulvibazar	10.50	906.25	163.13	16,313.00	4,000.00	11,813.00	4.1
Sunamganj	10.50	866.25	155.93	15,593.00	4,000.00	11,093.00	3.9

of Moulvibazar district were little higher than Sunamganj district (15,593.00 and 11,093.00, respectively). The BCR of Moulvibazar district (4.1) also little higher than Sunamganj district (3.9).

CONCLUSION

The on-station experiment revealed that the capsicum production in Sylhet can be taken under consideration when protective structures are used. Different protective structures provide a suitable environment inside the shade congenial for plant growth and development. Wien *et al.* (1989) concluded that a little shade in the tropics might benefit sweet pepper growth. Halim and Islam (2013) observed 2-3°C higher temperature inside the protective structures than open field temperature. This temperature variation might be the cause of yield variation between open field and protective structure. Both miticides application provide only protection from mite but unfavorable environmental condition (low night temperature) might played a role in reduced growth and improper fruit size. Considering the economic conditions of farmer, cultivation of capsicum under open field with Intrepid application can be suggested since a BCR of four (4.0) is not negligible at all. The on-farm adaptive trial also revealed that sweet pepper cultivation can be spread to the farmer's field of the Sylhet region, although the BCR of on-farm experiment a little lower than the on-station study. This was mainly due to the facts of higher production cost and less price of per unit product in the remote area.

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