DOI : 10.5958/0974-0112.2018.00105.6

Indian J. Hort. 75(4), December 2018: 631-638

Studies on yield and economics of high value vegetable crops grown under low-cost polyhouse in the mid-hill conditions of Meghalaya

Veerendra Kumar Verma*, Anjani Kumar Jha and Pankaj Baiswar
ICAR Research Complex for NEH Region, Umroi Road, Umiam 793103, Meghalaya

ABSTRACT

An experiment was conducted under naturally ventilated low-cost polyhouse during 2011-2013. The highest yield of tomato was recorded from cultivar Megha Tomato 3 (3.05 kg/plant), capsicum hybrid Pusa Deepti (0.88 kg/plant), chilli hybrid Fungale (0.99 kg/plant), King chilli genotype Red Long (0.98 kg/plant) and cucumber genotype, RCC 2 (4.28 kg/plant). From the economic analysis of cropping sequences, the highest per annum net income (₹ 19,02,043.4/ha) was recorded from the tomato (Megha Tomato 3) – capsicum (Pusa Deepti) followed by ₹ 18,10,082.0/ha from King chilli sole cropping and ₹ 15,60,163.4/ha from tomato (variety Megha Tomato 3) – chilli (hybrid Fungale) cropping sequence. However, the highest BC ratio (4.2) was observed from the King chilli sole cropping followed by tomato – capsicum cropping sequence (3.5). In all the crops, over 50% of the total cost of production was contributed by cost of polyhouse followed by operational cost. The farmers of the region can increase their income by adopting the above identified most economical crops, varieties and cropping sequences.

Keywords: Protected cultivation, tomato, capsicum, king chilli, cropping sequence.

INTRODUCTION

Protected cultivation of high value crops is in great demand due to year round production with higher yield and superior quality. In mid-hills of north eastern region of India, the low-cost naturally ventilated polyhouses are considered as best structures due to locational advantage having mild weather throughout the year. Amongst wide range of crops grown in the region- tomato, capsicum, cucumber and King-chilli have been found as most suitable high value crops for protected cultivation due to prevailing high demand in local markets. These crops are also rich sources of vitamin and minerals and, thus, having importance in nutritional security. King-chilli or *Bhoot Jholkia* is an indigenous high value multipurpose crop used as a vegetable, spices and medicinal crop and known worldwide for its pungency due to high capsaicin content. These crops are grown in open field condition for limited period having low yield and poor in quality due to prolonged period of rain (March-September) followed by serious moisture stress period (October-February). Consumers are totally dependent on the produce coming from other parts of the country at higher prices. Thus, protected structures provide best means for producing the crop of their choice with higher yield and superior quality. Protected structures also act as physical barrier and play a key role in integrated pest management by preventing spreading of insect, pests and viruses causing severe damage to the crop (Singh *et al*., 8). In addition, protected structures facilitate the utilization of nutrients from soil for longer duration (Singh *et al*., 7) and producing crops for longer period (Singh and Sirohi, 9). The cheaper availability of bamboo gives an additional advantage for the establishment of low-cost polyhouses in the region.

Under sustainable production system, there is a need to have technologies which is not only for higher yield but also economically viable in long run. Although, region is well suited for the protected cultivation of high value crops, but they are adopted in few pockets only on limited scale due to higher input cost, non–availability of suitable crop varieties and their profitable cropping sequences for protected cultivation. Majority of the farmers of the region are marginal and small and to double their income is one of the most challenging tasks. Moreover, a viable cropping sequence will play a significant role in making farming more profitable particularly for small and marginal farmers (Srivastava *et al*., 11). Protected cultivation of the crop with higher yield potential and economic value could be an option for them. There is very limited information on the protected cultivation of high value crops especially vegetables for the region. In this background, the present investigation was undertaken to identify the suitable varieties/hybrids of the high value crops and to study the economic feasibility of the high value crops and cropping sequences under naturally ventilated low-cost polyhouse.

MATERIALS AND METHODS

The experiment was conducted under naturally ventilated low-cost polyhouse (250 m^2 size, fabricated

*Corresponding author's E-mail: verma.veerendra@gmail.com

by using of bamboo wooden frame, top covered with 200µ thickness UV stabilized polythene sheets and all the sides were covered by insect proof net) during 2011–13 at the Horticulture Experimental Farm, ICAR Research Complex for NEH Region, Umiam Meghalaya. The experimental site is located at the 960 m above mean sea level (MSL) and average day/night temperature under the polyhouse ranged 22–27^{0}C/15–20^{0}C and relative humidity 47–68%. The experimental soil was sandy in texture with acidic reaction (pH: 5.38). The bulk density, soil organic carbon, available N, P, K, Ca and Mg were 1.46g/cc, 2.19%, 187kg/ha, 20.19kg/ha, 300kg/ha, 2.37 meq/100g and 0.66 meq/100g, respectively.

The crops evaluated in sequence were tomato (January – June) – capsicum (August –December), chilli (January – August) – cucumber (August – December), cucumber (February – June) – tomato (July – December) and King chilli (March – December) in sole cropping sequence under naturally ventilated low–cost polyhouse. The varieties were selected as Megha Tomato 2 (MT 2), Megha Tomato 3 (MT 3), VL Tomato 4, Sel 9A, MCTR 4B and Pusa Rohini of tomato; Fungale and Angel of chilli (both long type hybrids from Sultan Seed Farm, Srinagar); California Wonder, Capsicum Long, Mahabharat (F_1 from Indo-American Hybrid Seeds (India) Pvt. Ltd, Bengaluru) and Pusa Deepti (F_1) of capsicum; RCC 1, RCC 2, RCC 3, RCC 4 (all local collection from Wokha and Mokokchung of Nagaland), Kalyanpur Hara and Green Long of cucumber and four local landraces viz., Red Long, Red Small, Chocolate Long and Chocolate Small of King chilli. The experiments were laid down in Complete Randomized Block Design with three replications. The varieties were evaluated without check as there is no recommended variety for the protected cultivation in the region.

Thirty days old seedlings of tomato, chilli, capsicum and 40 days old seedlings of King chilli were transplanted in double row system at 60 × 45 cm, 45 × 30 cm and 50 × 30 cm and 90 × 75 cm spacing, respectively. The seeds of cucumber were sown directly in the pits (2 seeds per pit) at 1.5 × 0.80 m spacing. The seedlings were irrigated immediately after transplanting and alternate date till plant establishment and further at 5 days intervals (at 27.50±2.3% soil moisture and 20.33±1.50 kPa tension). The plants of tomato, capsicum, cucumber were trained with the help of bamboo sticks while, chilli and King chilli were grown without any support.

The soil was fertilized by the application of FYM 10 t/ha and 2.5 q/ha lime and recommended dosage of fertilizers (RDF) i.e. NPK (120: 80: 60 kg/ha), respectively for all the solanaceous crops. The recommended doses of chemical fertilizers i.e., NPK were applied as urea, single super phosphate and muriate of potash, respectively for all the treatments. Full dosage of organic manure as FYM (10 t/ha) and lime was applied in pits 15 days before planting. Half dose of nitrogen and full dose of phosphorous and potassium were applied in pits before planting and the remaining half dose of nitrogen was applied in two split doses at 30 and 60 days after planting in tomato, chilli and capsicum and three split dosages at 30, 60 and 90 days after transplanting in King chilli. For cucumber, the recommended dosage of NPK was applied as 80: 50: 50 kg/ha. Full dosage of FYM (10 t/ha) and chemical fertilizers P and K and half of N was applied in pits at the time of land preparation and the remaining half was applied at 30 days after planting. The lime was applied only once in the polyhouse during July every year. The standard plant protection measures were practiced throughout the cropping period. The observations for growth and yield related attributes were taken from the six randomly selected plants in each replication. The quality analysis was done by the procedure as described by Ranganna *et al*. (5).The observed data were analyzed using statistical tool for agricultural research (STAR) software and treatment means were compared by the least significant difference (LSD) at $P < 0.05$ level of significance.

For economic analysis, budgeting techniques and cost concepts (establishment of polyhouse cost, fixed cost, variable cost and total cost) and economic efficiency measure benefit – cost ratio was estimated. Due to cheaper availability of bamboos, the establishment cost of naturally ventilated low cost polyhouse was ₹ 16.0 lakhs/ha (₹ 160/m^2) only. The cost for polyhouse in each crop (₹ 2.0 lakhs per crop) was estimated based on the equated monthly installments (EMI) paid by the farmers at 9.25 per cent interest rate. The interest on working capital was at 7 per cent. The price of the produce was considered as the selling price by the farmers in whole sale market at Bara Bazaar (Shillong), Meghalaya.

RESULTS AND DISCUSSION

The perusal of the Table 1, showed significant differences among the genotypes of tomato (*Solanum lycopersicum* L.) for all the growth, yield and quality traits except acidity. Out of 7 varieties, the highest plant height was observed in Sel-9A (140 cm) followed by VL Tomato-4 (135.7 cm) and both were statistically at par. The minimum plant height was recorded from the genotype Pusa Rohini (103 cm). Among the genotypes, maximum fruit weight was recorded from the Megha Tomato-3 (73.3 g) followed by Megha Tomato-2 (71.2 g) and VL Tomato-4 (68.7g)

Table 1. Performance of tomato varieties under low cost polyhouse.

Genotype	Plant height (cm)	Fruit wt. (g)	No of fruits/ plant	Yield (kg/plant)		Yield (t/ha)		Vitamin-C (mg/100 g)	TSS (°B)	Lycopene content (mg/100 g)	Total sugar (%)	Acidity (%)
				2011-12	2012-13	2011-12	2012-13					
MCTR-4B	114.1^{e}	61.9^{b}	24.0^{e}	1.6^{c}	1.61^{c}	52.7^{d}	57.8^{c}	13.4^{e}	4.5^{c}	8.8^{a}	1.3^{bc}	0.7
MT-3	118.0^{de}	73.3^{a}	42.5^{a}	3.1^{a}	3.00^{a}	83.9^{a}	79.7^{a}	19.1^{bc}	5.8^{a}	8.8^{a}	1.7^{a}	0.6
Sel-11	130.9^{bc}	47.9^{c}	32.3^{cd}	1.5^{c}	1.54^{c}	49.1^{de}	57.3^{c}	20.4^{b}	5.3^{b}	4.7^{c}	1.5^{ab}	0.5
VLTomato-4	135.7^{ab}	68.7^{ab}	31.7^{d}	2.2^{b}	2.17^{b}	69.4^{c}	78.8^{b}	23.9^{a}	5.6^{ab}	4.5^{c}	1.2^{c}	0.6
MT-2	125.3^{cd}	71.2^{a}	33.0^{cd}	2.4^{b}	2.35^{b}	76.2^{b}	77.6^{b}	17.8^{cd}	5.6^{ab}	7.4^{ab}	1.1^{c}	0.6
Sel-9A	140.1^{a}	45.4^{c}	34.3^{bc}	1.6^{c}	1.55^{c}	54.3^{d}	51.2^{d}	21.0^{b}	4.7^{c}	7.9^{ab}	1.6^{a}	0.5
Pusa Rohini	103.3^{f}	41.4^{c}	36.5^{b}	1.5^{c}	1.51^{c}	45.3^{e}	57.5^{c}	16.9^{d}	4.6^{c}	7.1^{b}	1.7^{a}	0.6
CV (%)	3.76	7.49	4.28	5.69	5.50	5.35	4.24	5.93	5.03	11.17	9.66	9.90
LSD (*P*<0.05)	8.27	7.80	2.54	0.20	0.22	6.12	5.17	1.99	0.46	1.39	0.24	NS

*Means with the same letter in column are not significantly different at *P*<0.05 level.

and all were statistically at par. However, minimum fruit weight was in Pusa Rohini (41.4 g). The highest number of fruits (42.5) and fruit yield per plant (2.8 kg) was also recorded from the Megha Tomato 3 followed by Megha Tomato 2 (34.3 fruits, and 2.4 kg/plant). Similarly, the highest yield during both the crop season was recorded from the cultivar Megha Tomato 3. From pooled analysis the highest fruit yield was (84.8 t/ha) from Megha Tomato 3 followed by Megha Tomato 2 (76.9 t/ha) and VL Tomato 4 (74.1 t/ha) which were statistically at par. Cheema *et al*. (3) also observed the fruit yield of 2.87 kg/plant from cultivar Naveen of tomato under protected condition. The results have also shown higher yield (70.96%) over the open condition as Verma *et al*. (12) observed 49.6 t/ha yield from Megha Tomato 3 under open condition in the mid-hills of Meghalaya.

Among the quality traits, the highest vitamin-C content was recorded in VL Tomato 4 (23.9 mg/100g) followed by Sel 11 (21.0 mg/100g) and Sel-9A (20.4 mg/100g). However, highest TSS (5.8°B) was recorded from the Megha Tomato 3 followed by Megha Tomato 2 and VL Tomato 4 as 5.6 each. The highest lycopene content was recorded from MCTR- 4B and Megha Tomato 3 (8.8 mg/100g each) followed by Sel-9A (7.9 mg/100g) and Megha Tomato 2 (7.6 mg/100g) which were statistically at par. Likewise, the highest total sugar was recorded from Megha Tomato 3 and Pusa Rohini (1.7% each) followed by Sel-9A (1.6%). There was no significant difference for acidity. From above findings, Megha Tomato 3 was found high yielding variety followed by Megha Tomato 2 and VL Tomato 4 under naturally ventilated low-cost polyhouse.

Out of 4 genotypes of capsicum (*Capsicum annuum* L.), highest plant height was recorded from hybrid Pusa Deepti (80.21 cm) followed by Mahabharat (74.33 cm) and California Wonder (71.12 cm). Similarly, the highest fruit length was observed from Capsicum Long (12.0 cm) followed by Pusa Deepti (8.4 cm). However, highest fruit diameter (6.03 cm) and fruit weight (70 g) was observed in hybrid Mahabharat. The maximum number of fruits and fruit yield per plant was recorded from hybrid Pusa Deepti (Table 2). The yield per hectare was also highest in Pusa Deepti followed by Mahabharat and California Wonder during both the years. From pooled data hybrid Pusa Deepti was found to be superior with highest yield (59.31t/ha) over Mahabharata and California Wonder and both were statistically at par**.** Among the genotypes vitamin-C content were highest (106.8 mg/100g) in California Wonder over other genotypes. Similar findings were also observed by Aruna *et al*. (1) and Kumar *et al*. (4). From the above findings, hybrids were found to be superior for the protected cultivation over the variety and hybrid Pusa Deepti was found to be best for the production in the region. The results also indicated higher yield (45.74 t/ha) under protected condition in California Wonder over the open condition as Verma *et al*. (12) observed 9.5 t/ha fruit yield of capsicum from same variety under open condition in the mid-hills of Meghalaya.

King chilli (*Capsicum chinense*) is an important high value crop of the region, grown widely in the backyard and commercially in the fields. It prefers warm and humid weather for better growth and development. In mid-hills, the yield is low due to short warm and humid period and under protected condition the ideal climate could be met for longer period and resulting into higher yield. In the present

Table 2. Performance of capsicum varieties/hybrids under low cost polyhouse.

Variety	Plant height (cm)	Fruit length (cm)	Fruit dia. (cm)	No of fruits / plant	Fruit wt. (g)	Yield (kg/plant)		Yield (t/ha)		Vitamin-C (mg/100 g)
						2011-12	2012-13	2011-12	2012-13	
Capsicum Long	74.33^{b}	12.06^{a}	3.03^{d}	17.11^{b}	40.00^{c}	0.67^{bc}	0.78^{b}	36.04^{c}	42.19^{b}	70.6^{b}
California Wonder	71.12^{bc}	5.41^{d}	4.62^{b}	13.33^{c}	67.33^{a}	0.92^{b}	0.84^{b}	49.82^{b}	45.45^{b}	106.8^{a}
Pusa Deepti	80.21^{a}	8.41^{b}	4.19^{c}	23.33^{a}	47.00^{b}	1.01^{a}	1.12^{a}	58.27^{a}	60.35^{a}	71.8^{b}
Mahabharat	69.61^{c}	6.35^{c}	6.03^{a}	13.00^{c}	70.00^{a}	0.93^{b}	0.77^{b}	50.33^{ab}	41.65^{b}	72.0^{b}
CV (%)	4.73	2.70	2.66	10.42	4.24	7.78	11.82	8.38	11.82	7.95
LSD(*P*<0.05)	4.67	0.44	0.23	3.47	4.75	0.15	0.21	8.13	11.18	12.76

*Means with the same letter in column are not significantly different at *P*<0.05 level.

investigation, significant variability was observed for all the plant and fruit characteristics. The crop is perennial in nature and four landraces (collected from Nagaland and Manipur) were evaluated during March to December (10 months) for their growth and yield attributes under low-cost polyhouse. The plant height ranged from 128.3 cm (Chocolate Small) to 161.7 cm (Red Long). The number of fruits per plant ranged from 154.0 to 190.8 and it was maximum in the line, Chocolate Small. The fruit characteristics i.e., pod length and pod diameter was maximum in line Red Long (Table 3). Similarly, yield per plant and estimated yield per hectare was also highest in the line Red Long over the other genotypes during both the years of evaluation (Table 3). Landrace of red fruit type were high yielding over chocolate fruit type and they need to be promoted for the protected cultivation.

Chilli (*Capsicum annuum*) is another important commercial crop of the region and its cultivation is limited to short period (February to September) and particularly in open condition. The yield is very low with poor quality due to heavy rains leading to severe incidence of soft rot and anthracnose during the cropping season. The long fruited genotypes are in great demand due to multipurpose use and fetch premium price. Two F_1 hybrids viz., Fungale and Angel grown during off-season (July to December) under low-cost polyhouse for two years with 10 replications each showed wider variability for different yield attributes. Of these two hybrids, maximum plant height (86.3 cm) and fruit length (19.67 cm) was recorded from the hybrid Fungale, however the fruit diameter and fruit weight was maximum in hybrid Angel. Similarly, the maximum number of fruits, fruit yield per plant and estimated yield per hectare was recorded from the hybrid Fungale. Vitamin - C content was highest in hybrid Angel (Table 4). These findings also indicated production potential of long fruited hybrid chilli under the protected condition.

Cucumber (*Cucumis sativus* L.) being an indigenous crop, it is grown widely during March-October in *Jhum* land as well as backyard. Due to open-pollination, there is a wider variability in fruit and quality characteristics. The four popular land races from Nagaland (two each from Wokha and Mockochong) were evaluated along with two popular varieties viz., Japanese Long Green and Kalayapur Hara. The significant variation was observed for the different growth, yield and quality attributes (Table 5). Among the genotypes, the highest yield was recorded from the RCC 2 (32.1 t/ha) followed by Kalayanpur Hara (30.68 t/ha) and both were statistically at par. However, the highest TSS was observed in RCC 3 (3.6°B), a collection from Mokokchung of

Table 3. Performance of king-chilli landraces grown under low cost polyhouse.

Variety	Plant height (cm)	Number of fruits/plant	Fruit length (cm)	Fruit dia. (cm)	Yield (kg/plant)		Yield (t/ha)	
					2012	2013	2012	2013
Red -Long	161.67^{a}	154.00^{b}	5.97^{a}	3.70^{a}	0.97^{a}	1.00^{a}	13.82^{a}	13.39^{a}
Red -Small	140.00^{b}	167.50^{b}	4.00^{b}	3.23^{b}	0.70^{c}	0.80^{b}	9.40^{c}	9.73^{c}
Choclate Long	152.33^{a}	170.00^{b}	5.43^{a}	3.60^{a}	0.84^{b}	0.88^{b}	11.45^{b}	11.34^{b}
Choclate Small	128.33^{b}	198.75^{a}	4.33^{b}	2.67^{c}	0.67^{c}	0.78^{b}	9.01^{c}	9.38^{c}
CV (%)	4.04	6.56	7.62	2.99	5.16	6.32	5.46	4.61
LSD (*P*<0.05)	11.75	18.52	0.75	0.19	0.07	0.09	0.99	0.84

*Means with the same letter in column are not significantly different at *P*<0.05 level.

Table 4. Performance of chilli (long type) grown under low cost polyhouse.

Genotype	Plant height (cm)	Fruit length (cm)	Fruit dia. (cm)	Fruit wt (g)	No of fruits/ plant	Yield (g/plant)		Yield (t/ha)		Vitamin-c (mg/100 g)
						2012	2013	2012	2013	
Fungale (F1)	86.3[a]	19.67[a]	2.10[b]	12.33[b]	76.00[a]	987.00[a]	1001.0[a]	43.8[a]	44.6[a]	105.0[b]
Angel (F1)	75.9[b]	15.10[b]	2.90[a]	18.33[a]	33.00[b]	733.33[b]	730.67[b]	33.0[b]	32.0[b]	117.20[a]
LSD (P<0.05)	5.50	1.23	0.2	3.56	12.6	88.17	56.23	2.66	3.45	5.17

*Means with the same letter in column are not significantly different at *P*<0.05 level.

Nagaland. Similar findings from off-season production of cucumber under low-cost polyhouse were also observed by Saikia *et al*. (6).

The results of economic analysis from the yield (pooled) of the crops and varieties have shown wide variability in per hectare income and benefit: cost ratio. All the factors of production were estimated based on payment basis including manpower. The cost of production for tomato was ₹ 3,88,303/ ha. The cost of polyhouse contributed maximum (51.51%) to the total cost of production followed by operation expenses (40.17%). The highest net income (₹ 8,07,196/ha) and benefit cost ratio (3.3) was recorded from the tomato cultivar Megha Tomato 3 followed by VL Tomato 4 and Megha Tomato 2 and these two were statistically at par. Likewise, in capsicum the estimated cost of production was ₹ 3,87,902/ha. Hybrids were found to be superior over varieties and the highest yield (59.3 t/ha) with net income of ₹ 10,94,847/ha and benefit: cost ratio of 3.8 was recorded from the hybrid Pusa Deepti followed by Mahabharat and California Wonder (Table 6). Similarly, the production cost of chilli was calculated as ₹ 3,57,407/ha with highest yield of 44.42 t/ha, net income of ₹ 7,52,967 and benefit cost ratio of 3.1 was recorded from the hybrid Fungale (Table 7). However in case of cucumber the cost of production was ₹ 3,73,992/ha with highest yield of 32.1 t/ha, net income of ₹ 2,93,007 and benefit: cost ratio of 1.8 was recorded from the collection RCC 2 followed by variety Kalayanpur Hara. Among the seasonal crops, the highest net income was observed from the capsicum hybrid Pusa Deepti and Mahabharat followed by tomato cultivar Megha Tomato 3 and chilli hybrid Fungale. The lowest income was recorded from the crop cucumber. Similarly, the highest benefit: cost ratio was from king chilli (4.2) followed by capsicum (3.8), tomato (3.3), chilli (3.1) and cucumber (1.8). Chakraborty *et al.* (2) also observed the B: C ratio of 2.29:1 from the vegetable crops under the low-cost polyhouse. Similarly, Sreedhara *et al*. (10) also observed higher (3.92) BC ratio from capsicum grown under protected condition.

King chilli, an indigenous perennial high value crop (market price ranged from (₹ 150-400/kg) is extensively grown in the region. Being a long duration crop, it was evaluated under low-cost polyhouse for 10 months (March-December) by raising the nursery in February. The estimated cost of production was ₹ 5,71,317/ha and the highest yield (13.61 t/ha), net income (₹ 18,10,082) and benefit cost ratio (4.2) was recorded from the collection Red Long of Nagaland. The cost of polyhouse contributed maximum (70.1%) to the total cost of production followed by

Table 5. Performance of cucumber genotype grown under low cost polyhouse.

Varieties	No of fruits/plant	Fruit length (cm)	Fruit dia. (cm)	Fruit wt. (g)	TSS (°B)	Yield (kg/plant)		Yield (t/ha)	
						2011-12	2012-13	2011-12	2012-13
RCC-1	11.50[b]	22.2[b]	4.5[bc]	406.7[a]	2.4[c]	3.52[b]	2.21[cd]	26.40[bc]	16.57[d]
RCC-2	14.67[a]	25.9[a]	4.4[c]	396.7[a]	2.6[bc]	4.41[a]	4.15[a]	33.08[a]	31.12[a]
RCC-3	11.17[b]	22.7[b]	4.6[bc]	248.3[b]	3.6[a]	3.08[bc]	2.42[c]	23.10[c]	18.15[cd]
RCC-4	11.84[b]	18.6[bc]	4.9[b]	241.7[b]	2.8[abc]	3.4[b]	2.84[c]	25.50[bc]	21.30[c]
Long Green	9.83[c]	17.7[c]	4.9[b]	233.3[b]	2.7[b]	4.01[a]	3.5[b]	30.08[ab]	26.25[b]
Kalyanpur Hara	10.50[bc]	23.2[b]	5.8[a]	386.7[a]	2.4[c]	4.13[a]	4.05[a]	30.98[ab]	30.37[ab]
CV (%)	7.12	14.48	2.79	11.37	10.45	7.45	8.40	10.45	8.80
LSD (P <0.05)	1.37	2.60	0.38	124.30	0.85	0.45	1.08	3.80	3.30

*Means with the same letter in column are not significantly different at *P*<0.05 level.

Table 6: Production cost and returns from tomato and capsicum under low-cost polyhouse.

Tomato			(Value in ₹)		Capsicum			(Value in ₹)	
Cost of polyhouse (EMI based):			200000.0 (51.51)		Cost of polyhouse (EMI based):			200000.0 (51.56)	
Land rent (Rs. 30000 per annum):			15000.0 (3.86)		Land rent (Rs. 30000 per annum):			15000.0 (3.87)	
Operational cost:			155985.0 (40.17)		Operational cost:			155610.0 (40.12)	
Depreciation (Lump sum):			5000.0 (1.29)		Depreciation (Lump sum):			5000.0 (1.29)	
Interest on working capital:			12318.9 (3.17)		Interest on working capital:			12292.7 (3.17)	
Total cost of production per ha area:			388303.9 (100)		Total cost of production per ha area:			387902.7 (100)	
Variety	Yield (t/ha)	Goss income (₹)	Net income (₹)	B:C ratio	Variety	Yield (t/ha)	Goss income (₹)	Net income (₹)	B:C ratio
MCTR-4B	57.8	867000	478696.0	2.4	Capsicum Long	39.12	977875.0	589972.3	2.5
Megha Tomato-3	79.7	1195500	807196.0	3.3	California Wonder	45.74	1143375.0	755472.3	2.9
Sel-11	57.3	859500	471196.0	2.4	Pusa Deepti	59.31	1482750.0	1094847.0	3.8
VLTamato - 4	71.8	1077000	688696.0	2.9	Mahabharat	47.89	1197250.0	809347.3	3.1
Megha Tomato-2	70.6	1059000	670696.0	2.9					
Sel-9A	51.2	768000	379696.0	2.1					
Pusa Rohini	57.5	862500	474196.0	2.4					

*Figures in parenthesis are percentage share in total cost of production

Table 7: Cost and returns from king-chilli and chilli (long type) under low-cost polyhouse.

King-chilli			(Value in ₹)		Chilli			(Value in ₹)	
Cost of polyhouse (EMI based):			400000.0 (70.01)		Cost of polyhouse (EMI based):			200000.0 (55.96)	
Land rent (₹ 30000 per annum):			15000.0 (2.63)		Land rent (₹ 30000 per annum):			15000.0 (4.20)	
Operational cost:			140110.0 (24.52)		Operational cost:			127110.0 (35.56)	
Depreciation (Lump sum):			5000.0 (0.88)		Depreciation (Lump sum):			5000.0 (1.40)	
Interest on working capital:			11207.7 (1.96)		Interest on working capital:			10297.7 (2.88)	
Total cost of production:			571317.7(100)		Total cost of production per ha area:			357407.7 (100)	
Variety	Yield (t/ha)	Goss income (₹)	Net income (₹)	B:C ratio	F_1 hybrids	Yield (t/ha)	Goss income (₹)	Net income (₹)	B:C ratio
Red Long	13.61	2381400	1810082	4.2	Fungale	44.42	1110375	752967.3	3.1
Red Small	9.56	1673700	1102382	2.9	Angel	33.00	825000	467592.3	2.3
Chocolate Long	11.39	1993950	1422632	3.5					
Chocolate Small	9.20	1609650	1038332	2.8					

*Figures in parenthesis are percentage share in total cost of production

operation expenses (24.52%). Among the crops, based on economic analysis the highest income was recorded from King chilli with the cropping period of 10 month.

From the analysis of cropping sequence, the highest per annum net income (₹ 19,02,043.4/ha) was recorded from the tomato (variety Megha Tomato 3) – capsicum (hybrid Pusa Deepti) followed by ₹ 18,10,082/ha from King-chilli sole cropping and ₹ 15,60,163/ha from tomato (variety Megha Tomato 3) – chilli (hybrid Fungale) cropping sequence. However, the highest benefit: cost ratio (4.2) was observed from the King chilli sole cropping followed by tomato – capsicum cropping sequence (Table 8).

The results of yield and economic analysis have indicated the potential of protected cultivation of these high value crops in the region. For getting higher yield and income of the crop capsicum (hybrid Pusa Deepti) was found to be most economical followed by tomato (variety Megha Tomato 3) and Chilli (hybrid Fungale). However, cucumber was found least economical. From cropping sequence

Table 8: Cost and returns from cucumber and cropping sequences under low-cost polyhouse.

Cucumber	(Value in ₹)	Economical Cropping Sequence					
Cost of polyhouse (EMI based):	200000.0 (53.48)	S. No.	Cropping Sequence	Total Cost (₹)	Goss income (₹)	Net income (₹)	B:C ratio
Land rent (Rs. 30000 per annum):	15000.0 (4.01)	C_1	Tomato (MT 3) – Capsicum (Pusa Deepti)	776206.7	2678250.0	1902043.4	3.5
Operational cost:	142610.0 (38.13)	C_2	Tomato (MT 3) – Cucumber (RCC-2)	737296.7	1837500.0	1100203.4	2.5
Depreciation (Lump sum):	5000.0 (1.34)	C_3	Capsicum (Pusa Deepti) – Cucumber (RCC 2)	736895.4	2124750.0	1387854.6	2.9
Interest on working capital:	11382.7 (3.04)	C_4	Tomato (MT 3) – Chilli (Fungale)	745711.7	2305875.0	1560163.4	3.1
Total cost of production:	373992.7 (100)	C_5	King chilli (Long Red)	571317.7	2381400.0	1810082.0	4.2

Variety	Yield (t/ha)	Goss income (₹)	Net income (₹)	B:C ratio
RCC-1	21.5	429750.0	55757.3	1.1
RCC-2	32.1	642000.0	293007.3	1.8
RCC-3	20.6	412500.0	63507.3	1.2
RCC-4	23.4	468000.0	119007.3	1.3
Long Green	28.2	563250.0	214257.3	1.6
Kalynpur Hara	30.7	613500.0	264507.3	1.8

*Figures in parenthesis are percentage share in total cost of production

analysis, tomato – capsicum, King chilli sole cropping and tomato –chilli cropping sequence were best giving higher income. The farmers can double their income by adopting the identified economical crop and varieties for naturally ventilated polyhouse in the mid-hill conditions. Further, to increase income per unit area with efficient utilization of polyhouse there is also need to study the crop intensification under the protected condition by integrating of short duration crops between two major crops as well as intercropping.

ACKNOWLEDGMENT

Authors sincerely thank the Director, ICAR Research Complex for NEH Region, Umiam Meghalaya for the financial support and facilities.

REFERENCE

1. Aruna, P. and Sudagar, I.P. 2010. Evaluation of capsicum varieties under polyhouse conditions. *Asian J. Hort*. **4**: 336-37.
2. Chakraborty, H. and Sethi, L.N. 2015. Prospects of protected cultivation of vegetable crops in north eastern hilly region. *Int. J. Basic Appl. Biol.* **2**: 284-89.
3. Cheema, D.S., Kaur, P. and Kaur, S. 2004. Off-season cultivation of tomato under net house conditions. *Acta Hort*. **659**: 177-81.
4. Kumar, M. and Verma, V. 2009. Bell pepper (*Capsicum annuum* L.) production in low cost naturally-ventilated polyhouses during winters in the mid hills of India. *Acta Hort.* **807**: 389-94.
5. Ranganna, S. 1985. Manual of analysis of fruit and vegetable production. Tata McGraw hill, New Delhi.
6. Saikia, J., Baruah, H.K., and Phookan, D.B. 2001. Off-season production of cucumber inside low-cost polyhouse. *Ann. Biol.* **17**: 61-64.
7. Singh, A.K., Shrivastav, R., Gupta, M.J. and Chandra, P. 2005. Effect of protected and unprotected condition on biotic stresses, yield and economics of spring summer vegetables. *Indian J. Agri. Sci.* **75**: 485-87.
8. Singh, A.K., Singh, A.K., Gupta, M.J. and Shrivastav. R. 2003. Effect of polyhouse on insect pest incidence, fruit quality and production of vegetable and fruit crops. **In**: *Proceeding of the National Symposium on Frontier areas of Entomological Research*, 5-7 November, 2003, IARI, New Delhi, pp. 94.

9. Singh, B. and Sirohi, N.P.S. 2006. Protected cultivation of vegetable in India: Problems and future prospects. *Acta Hort*. **710**: 339-34.

10. Sreedhara, D.S., Kerutagi, M.G., Basavaraja, H., Kunnal, L.B. and Dodamani, M.T. 2013. Economics of capsicum production under protected conditions in Northern Karnataka. *Karnataka J. Agric. Sci.* **26**: 217-19.

11. Srivastava, P., Srivastava, B.K. and Singh, M.P. 2002. Effect of date of planting and growing environment on the plant survival, growth and yield of early cauliflower in rainy season. *Veg. Sci*. **29**: 157-60.

12. Verma, V.K., Jha, A.K., Chaudhuri, P, Singh, B.K. and Roy, A. 2016. Comparative analysis of production and profitability of seasonal vegetable, tuber and spice crops under the mid-hills of Meghalaya. *Veg. Sci*. **43**: 87-90.

Received : October, 2017; Revised : November, 2018;
Accepted : December, 2018