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RESEARCH ARTICLE

Effect of microclimate on early and total yield of bottle gourd

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ABSTRACT: Bottle gourd **(***Lagenaria siceraria* (Mol) Standl.**), c***ucurbitaceae* crops normally cultivated during summer and rainy season. The effect of plastic mulch and plastic low tunnel alone and plastic mulch with plastic low tunnel on soil and air temperature was studied. The effect of plasticulture technologies on early and total yield of bottle gourd were evaluated for BSS 951 (Semal) and ES 330 (Sunder). The increase in air and soil temperature was 1-17^{0}C and 3-8^{0}C, respectively open field condition. The highest yield of bottle gourd for BSS-951 (Semal) was 24.16 t/ha under low tunnel and for ES-330 (Sunder) was 22.16 t/ha under mulch with low tunnel and significantly superior to other treatments. The highest net BC ratio was 2.73 (BSS 951) and 1.72 (ES 330) respectively for low tunnel and mulch with low tunnel condition.

INTRODUCTION

Bottle gourd **(***Lagenaria siceraria* (Mol) Standl.**)** is an important vegetable belongs to *Cucurbitaceae* family and largely cultivated in the tropics and subtropics areas. It is having a wide range of uses, edible fruits are good source of carbohydrates and calcium and the pulp and leaves have medicinal properties (Decker-Walter, 2004). There is always a high demand of fresh bottle gourd in local and export market but due to unfavorable climatic conditions during winter season, farmers' starts cultivation after end of winter season i.e. after 15th February. The optimum yield of bottle gourd requires warm climate and sunny days and a constant temperature of 30^{0}C is ideal for optimum seed germination (Singh *et al*., 1973). The broad temperature range required for its proper growth and high fruit set are 18-22°C and 30-35^{0}C respectively during night and day time. But the early and off season cultivation of bottle guard gives better price realization for farmers' and can be cultivated under low and high poly tunnel and green house due to favorable soil and air temperature (Lodhi *et al*., 2015).

The structure of low tunnel, low arch tunnel hoops (typically less than 0.75 m centre height) can be constructed using iron rode/bamboo/plastic pipe and round the year cultivation or nursery growing can be done using different cladding materials such as UV stabilized plastic film (50 micron), insect proof net material (40 mesh) and shade net material (Green and 35-50%). The plastic low tunnels with transparent film can be used during winter season to enhance the growth, productivity and quality of most vegetable crops (Wells and Loy, 1993). Due to increase in soil and air temperatures, reduction in wind damage and protection from frost, it accelerates the crop development and extends the growing season (Waterer, 1992).

The low tunnels with transparent plastic film is advance form of plastic mulch with greenhouse effect suitable for early or off season cultivation of cucurbits like muskmelon, round melon, long melon, bitter grand, bottle gourd and summer squash etc. (Singh et al., 2005). Helbacka (2002) cultivated cucurbits (squash, cucumber, and melons) under row covers and cucurbits responded well under row covers with increase in yield of about 25%. Joublan and Vergara (2003) reported that the use of row covers increased the number of fruit and weight, yield per plant and sugar concentration of strawberry crop compared to the conventional treatments.

Plastic mulches can reflect, absorb and transmit incoming sunlight, the extent of which depends on the type of mulch. The black plastic mulch (25 micron) found to be effective during winter because it increases the soil temperature by 1-3^{0}C in comparison to open field condition. The

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transparent plastic mulch is more effective in enhancing the soil temperature than black plastic mulch but the major issue is weed control (Haynes, 1987). The use of row covers with plastic mulch has been shown to generate earlier and increased yields than row covers and plastic mulch used separately (Powell, 2000). The plastic mulch is generally used in combination with plastic low tunnel (Ibarra *et al.,* 2001).

Reghin et al. (2005) used transparent and black plastic mulch under row cover with transparent plastic film for cultivation of lettuce and found that row cover produced positive results on yield, early harvest and quality, even with the occurrence of frost and frost damage in uncovered plots reduced the plant weight by 34.62%. On the other hand black plastic mulch controlled weeds and resulted in 22.12% increase in plant weight. Rai and Dinmani (2018) conducted study to find out the effect of plastic mulch [black (25 micron)/transparent (50 micron)] alone, plastic low tunnel and black plastic mulch with plastic low tunnel on earliness production of bottle gourd. The germination and number of fruits were found highest under transparent plastic mulch for Tulsi variety whereas for Warad variety it found to be under black plastic mulch with plastic low tunnel.

The main aim of this work was to study the effect of increase in soil and air temperature induced by plastic mulch and plastic low tunnel alone and plastic mulch combined with plastic low tunnel on early and total yield of bottle gourds.

MATERIALS AND METHODS

The research was conducted at PET farm, Birsa Agricultural University, Ranchi, Jharkhand. The soil was sandy loam and bottle gourd was irrigated using drip irrigation system. The bottle gourd seeds used for cultivation were BSS 951 Semal (Kalash Seeds Pvt. Ltd.) and ES 330 Sunder (Eastern Seeds). The study was conducted for two years during December 2017 to April 2019 and total area of experimentation was 200 m^2. The wire hoop of iron rode (8.02 mm) was used to construct low tunnel with radius of 40 cm and both end of wire hoop was put into soil for 5 cm. The plastic mulches were used of transparent (50 micron) and the clear plastic film (transparent) of 50 micron for cladding the low tunnel. The geometry and isometric view of plastic low tunnel was designed 3D using Solid works 2016 (Fig. 1). The raised bed of 80 cm width, crop spacing of 1 m × 1.5 m and fertilizer dose of 87:52:139 kg/ha were used for experiments. The seeds of bottle gourd were sown on the raised bed, thereafter transparent plastic mulch

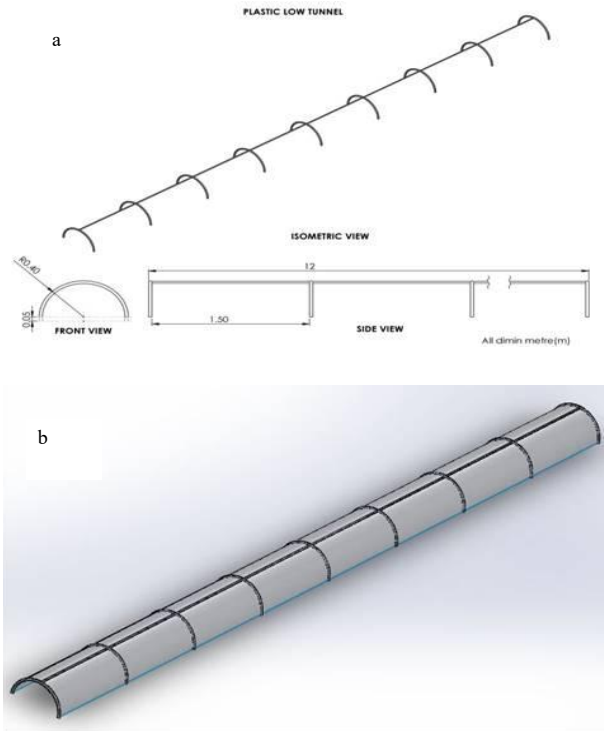

Fig. 1. (a) Geometry, and (b) Isometric view of plastic low tunnel

was laid over. Circular holes in the mulch were cut after germination of seeds. The transparent cladding material used over low tunnel was removed by the end of February due to rise in air temperature.

The experiment was laid out in a randomized block design (RBD) with five treatments and four replications were taken. The treatments were: T_1- control (without drip irrigation, plastic mulch and plastic low tunnel), T_2- drip irrigation, T_3- drip irrigation + plastic mulch, T_4- drip irrigation + plastic low tunnel, T_5- drip irrigation + plastic mulch + plastic low tunnel. The maximum and minimum temperature in open field and under low tunnel was measured using maximum and minimum thermometer (ZEAL, UK). The soil temperature in open field and under low tunnel was recorded daily on 10 A.M. and 2.30 P.M with the help of soil thermometer at the depth of 5 cm and 10 cm. The other data recorded were seed germination, number of fruits and yield of bottle gourd. Statistical parameters such as Standard Error of mean value (SEm), Critical Difference (CD) with 95% confidence interval (p value < 0.05), and Coefficient of Variance (CV) were calculated for total yield of bottle guard. The photographs of bottle gourd under various treatments are given in Fig. 2.

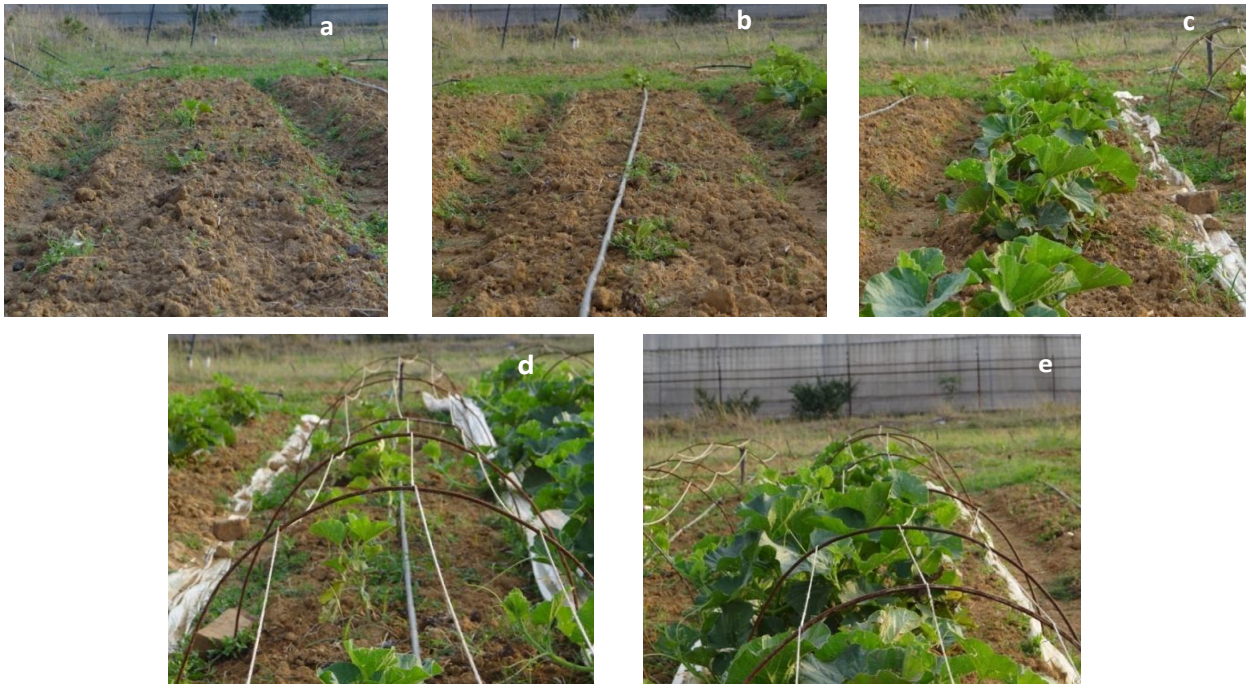

Fig. 2. Bottle gourd cultivation under (a) open field, (b) with drip irrigation, (c) plastic mulch, (d) plastic low tunnel, and (e) plastic mulch with low tunnel

RESULTS AND DISCUSSION

Microclimatic parameters

The minimum and maximum air temperature measured on daily basis from 1st week to 7th week is shown in Fig. 3 and 4, respectively. The increase in minimum air temperature under low tunnel and mulch with low tunnel is 0.3-3.8^{0}C and 0.8-4.2^{0}C over open field condition respectively (*Fig. 3*). The increase in maximum air temperature under low tunnel and mulch with low tunnel is 8-17.8^{0}C and 8.9-16.8 ^{0}C over open field condition respectively (*Fig. 4*). Minimum temperature was experienced in low tunnel at the beginning of experiment due to slow response of tunnel toward thermal radiation as compared to mulch with low tunnel. The high air temperature under low tunnel and mulch with low tunnel is due to greenhouse effect, because of two different effects i.e. (i) a confinement effect and (ii) an effect caused by the existence of a cover characterized by its low transparency to far infrared radiation (emitted by the crop and soil), but its high transparency to sunlight (Baudoin et al. 2003).

The increase in soil temperature (5 cm at 10.30 AM) under mulch, low tunnel and mulch with low tunnel is 2.9-5.04^{0}C, 3-8.12^{0}C and 2.9-7.04^{0}C over open field condition respectively (Fig 5a). The increase in soil temperature (5 cm at 2.30 PM) under mulch, low tunnel and mulch with low tunnel is 2.6-7.61^{0}C, 2.5-7.96^{0}C and 3.4-9.2^{0}C over

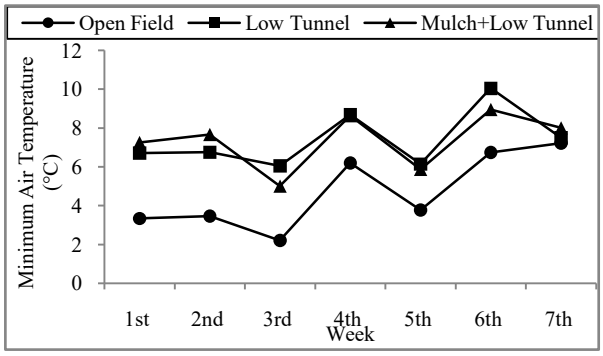

Fig. 3. Average minimum air temperatures (°C)

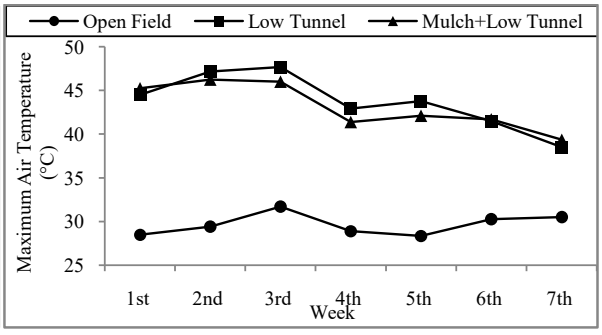

Fig. 4. Average maximum air temperatures (°C)

open field condition respectively (Fig 5b). The increase in soil temperature (10 cm at 10.30 AM) under mulch, low tunnel and mulch with low tunnel is 0.75-3.8^{0}C,

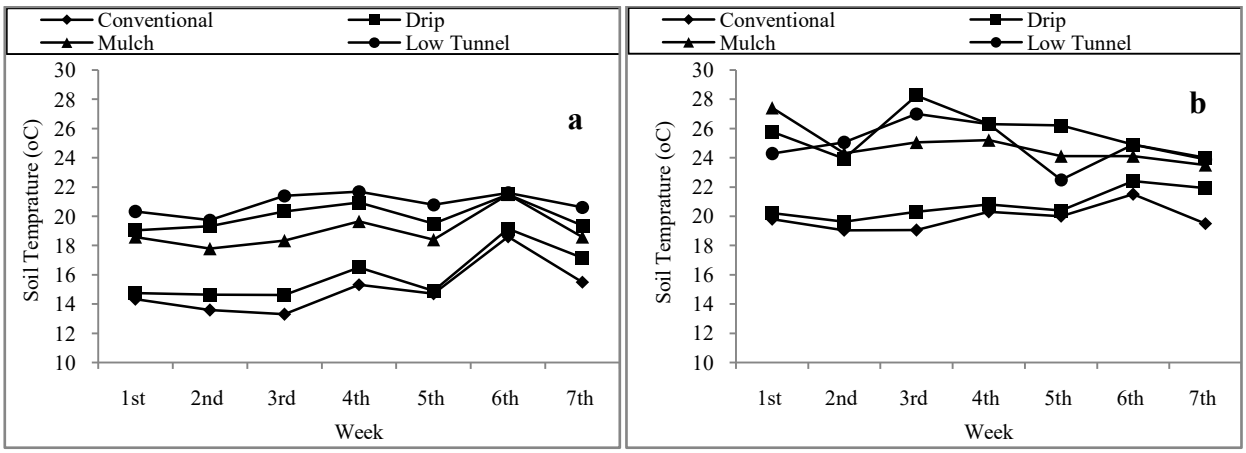

Fig. 5. Average soil temperature (^{0}C) at (a) 10.30 AM and (b) 2.30 PM at 5 cm depth

2.71-7.54^{0}C and 1.71-6.66^{0}C over open field condition (Fig 6a). The increase in soil temperature (10 cm at 2.30 PM) under mulch, low tunnel and mulch with low tunnel is 1.8-4.4^{0}C, 2.0-8.75^{0}C and 3.5-8.8^{0}C over open field condition respectively (Fig 6b).

The soil temperature under plastic mulch depends on the thermal properties (reflectivity, absorptivity, or transmittance) of a material in relation to incoming solar radiation. In this study transparent plastic mulch was used, which absorbs little solar radiation and transmits 85% to 95% of incoming radiation, with relative transmission depending on the thickness and degree of opacity of the plastic film. The under surface of transparent plastic mulch is usually covered with condensed water droplets, it is transparent to incoming shortwave radiation but is opaque to outgoing long wave infrared radiation; so much of the heat lost to the atmosphere from a bare soil by infrared radiation is retained by transparent plastic mulch (Lodhi et al. 2015). So most of the solar radiation was transmitted by the film was absorbed by the soil which helped in increasing the soil temperature both at 5 cm and 10 cm depth. The high soil temperature under low tunnel is due to greenhouse effect and under mulch with low tunnel because of combined effect of absorption of soil radiation by soil and greenhouse effect.

The soil temperature both at 5 cm and 10 cm depth was higher for plastic mulch, low tunnel and plastic mulch with low tunnel with slight variation as compared to open field. The plastic mulch, low tunnel and mulch with low tunnel provided desirable soil temperature for bottle guard germination and plant growth.

Agronomical parameters

The germination of bottle gourd under various treatments i.e. T_1- control (without drip irrigation, plastic mulch and plastic low tunnel), T_2- drip irrigation, T_3- drip irrigation + plastic mulch, T_4- drip irrigation + plastic low tunnel, T_5- drip irrigation + plastic mulch + plastic low tunnel is given in Table 1. The germination for two varieties BSS 951 (Semal) and ES 330 (Sunder) is varied from 0%

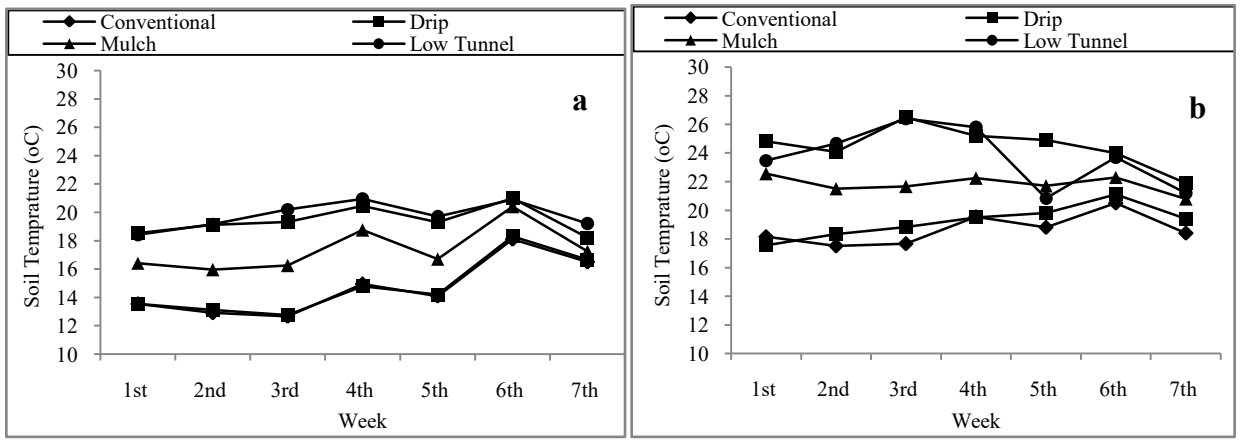

Fig. 6. Average soil temperature (^{0}C) at (a) 10.30 AM, and (b) 2.30 PM at 10 cm depth of soil

Table 1.
Germination (%) of bottle gourd at 18 DAS

Treatments	Variety: BSS-951 (Semal)	Variety: ES-330 (Sunder)
Control (without drip irrigation, plastic mulch and plastic low tunnel	11.9	-
Drip irrigation	12.5	-
Drip irrigation + plastic mulch	87.5	67.7
Drip irrigation + plastic low tunnel	84.9	56.7
Drip irrigation + plastic mulch + plastic low tunnel	92.7	81.7

to 92% for various treatments. The lowest and highest germination is recorded about 11% and 92% for open field and plastic mulch with plastic low tunnel, respectively in the case of BSS 951. For ES 330, lowest germination was found for open field and highest about 81% for plastic mulch with plastic low tunnel.

The better germination under plastic mulch, plastic low tunnel and plastic mulch with low tunnel are due to favorable soil temperature condition in comparison to open field. For the same microclimatic condition the germination was found to be more for BSS 951 (Semal) in comparison to ES 330 (Sunder), it could be due to varietal traits. The soil temperature affects various plant growth parameters such as seed germination, plant height, quality of flowers and fruits, so it is very essential to maintain the optimum temperature artificially by using plastic mulches and low tunnel for production of early or off season crop (Lodhi et al., 2015). From the other studies on plastic mulch, it is reported that due to plastic cover, soil is protected from outside environment and able to maintain soil temperature, soil moisture, nutrient etc. which lead to early germination of crop, which leads to higher yield and better product quality (Wien and Minotti, 1987; West and Peirce, 1988; Arin and Ankara 2001).

The yield for BSS 951 (Semal) and ES 330 (Sunder) is varied between 0.18 t/ha to 24.16 t/ha for various treatments undertaken and given in Table 2. There is variation in early and total yield for two varieties BSS 951(Semal) and ES 330 (Sunder). The lowest and highest yield is recorded for control condition and plastic low tunnel for BSS 951 respectively but for ES 330 it is highest under plastic mulch with plastic low tunnel. The result is due to favorable soil and air temperature condition under plastic low tunnel or plastic mulch with plastic low tunnel in comparison to open field. The beneficial effect of most plastic mulches and low tunnel is due to increase in soil temperature and it has direct effects on microbial growth and development, organic matter decay, seed germination, root development, and water and nutrient absorption by roots (Decoteau, 1998).

Value of CD and CV is 1.9 and 9.32, respectively for variety BSS-951(Semal) whereas it is 3.01 and 16.79, respectively for variety ES-330 (Sunder). A smaller CV value indicates a more consistent measurement. Critical difference (CD) shows the significant difference between the treatments which have the same replications. If the difference in the total yield of two treatments is less than CD value, it shows that there is no significant difference between them. In this study, the highest total yield for BSS 951(Semal) is found under low tunnel condition and which is statistically superior to other treatments except between treatment drip irrigation and control because it had less yield difference (0.73) than CD value (1.9). The highest total yield under low tunnel could be due to better germination and favorable air temperature during growth phase of bottle gourd.

Table 2.
Early and total yield (t/ha) of bottle gourd

Treatments	Variety: BSS-951 (Semal)		Variety: ES-330 (Sunder)	
	Early yield	Total yield	Early yield	Total yield
Control (without drip irrigation, plastic mulch and plastic low tunnel	0.69	1.10	0.02	1.34
Drip irrigation	1.42	3.54	-	0.18
Drip irrigation + plastic mulch	11.06	14.65	7.54	16.13
Drip irrigation + plastic low tunnel	24.04	24.16	13.26	17.63
Drip irrigation + plastic mulch + plastic low tunnel	21.49	22.00	15.44	22.19
SEm±		0.61		0.97
CD (P=0.05)		1.90		3.01
CV (%)		9.32		16.79

For the ES 330 (Sunder), the highest total yield is found under plastic mulch with low tunnel condition. The yield difference of drip irrigation with plastic mulch and drip irrigation with plastic low tunnel was not significant because it has a low yield difference (1.5) than CD value (3.01). But for the ES 330 (Sunder), the highest yield is found under plastic mulch with low tunnel, it could be due to varietal traits or better soil moisture under mulch condition in comparison to low tunnel condition for BSS 951 (Semal).

Economics

A detailed cost economics of bottle guard cultivation for one hectare area is given in Table 3. The initial investment for the cultivation of the bottle guard are Rs. 82,544 for the control condition, Rs. 97,544 for drip irrigation, Rs. 3, 15, 984 for plastic mulch, Rs.1,94,394 for plastic low tunnel, and Rs. 4,12,834 for the plastic mulch with plastic low tunnel. The cost of plastic materials is around 65.9%, 44.7% and 71.5% of total cost of cultivation respectively for plastic mulch, plastic low tunnel and plastic mulch with plastic low tunnel. The initial investment was higher for plastic mulch with plastic low tunnel among all the treatments due to cost involved in plastic mulching as well as plastic material required for low tunnel. The highest net BC ratio is 2.73 (BSS-951) and 1.72 (ES-330) is found for treatment plastic low tunnel and plastic mulch with plastic low tunnel respectively. Even though yield was highest under plastic mulch with low tunnel for ES-330, but due to high initial investment in plastic mulching and low tunnel film, net BC ratio is low in comparison to BC ratio of 2.73 for BSS-951 under plastic low tunnel condition. The plastic film used for mulching can be used only once but the plastic film used for low tunnel can be used for three season's i.e. three crops of bottle gourd. So from the Table 3, it is concluded that bottle gourd cultivation under plastic low tunnel is more profitable than other treatments taken under study.

CONCLUSION

The increase in minimum and maximum air temperature respectively under low tunnel condition was around 1-4^{0}C and 8-17^{0}C over open field condition. The increase in soil temperature (5 cm at 10.30 AM) under mulch, low tunnel and mulch with low tunnel were respectively 2.9-5.04^{0}C, 3-8.12^{0}C and 2.9-7.04^{0}C over open field condition. Due to conducive soil temperature conditions germination of bottle gourd was better under plastic mulch, low tunnel and plastic mulch with low tunnel condition in comparison to open field. The highest yield for BSS-951 (Semal) was 24.16 t/ha under low tunnel and for ES-330 (Sunder) was 22.16 t/ha under mulch with low tunnel and significantly superior to other treatments. The highest net BC ratio was 2.73 (BSS-951) and 1.72 (ES-330) respectively for low tunnel and mulch with low tunnel condition. Due to favorable soil and air temperature under plastic low tunnel, the early and total yield of bottle gourd was obtained, which helped in getting better price of bottle gourd.

Table 3.
Cost economics of bottle guard cultivation

S. N.	Particulars		Treatments				
			T1	T2	T3	T4	T5
1.	Field preparation and bed formation		6750	6750	6750	6750	6750
2.	Drip irrigation system		00	15000	15000	15000	15000
3.	Seed		13000	13000	13000	13000	13000
4.	Fertilizers		9044	9044	9044	9044	9044
5.	Plastic materials		0	0	208440	86850	295290
6.	Insecticides		5000	5000	5000	5000	5000
7.	Labour charge		48750	48750	58750	58750	68750
8.	Total cost		82544	97544	315984	194394	412834
9.	Plastic materials/total cost (%)		0	0	65.9	44.7	71.5
10.	Income	(BSS951)	33000	106200	439500	724800	660000
		(ES330)	40200	5400	483900	528900	665700
11.	Net income	(BSS951)	-49544	8656	123516	530406	247166
		(ES330)	-42344	-92144	167916	334506	252866
12.	Gross BC Ratio	(BSS951)	0.40	1.09	1.39	3.73	1.60
		(ES330)	0.49	0.06	1.53	2.72	1.61
13.	Net BC Ratio	(BSS951)	-0.60	0.09	0.39	2.73	0.60
		(ES330)	-0.51	-0.94	0.53	1.72	0.61

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