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Short Communication

Effect of polyethylene mulches and low tunnel on performance of brinjal under net-house vis-à-vis open field in a composite climate

Ajmer Singh Dhatt[1], Naveen Garg[2*], Rajinder Singh[1] and Iqbal Singh Aujla[1]

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India contributes about 25% to world's total brinjal production (48.42 mt) and occupies second position after China (28.82 mt). In India, the crop is cultivated on 0.70 mha and occupies fourth position in area after potato (1.91 mha), tomato (0.87 mha) and chilli pepper (0.79 mha) (FAO 2014). In north-western plain zone of India, the crop productivity is affected severely due to low temperature and frost during mid-December to mid-February (Singh and Kalda 2001) resulting in high market price in spring and early summer. Although agro-net house cultivation has been adopted for reducing the incidence of shoot and fruit borer and countering low temperature injury, but the plant growth remain restricted during winter as the perforations (40 × 40 mesh) in the net house do not allow the inside air temperature to rise above the open field air temperature (Sethi *et al.* 2009); resulting in the need to try and standardize other protected cultivation measures for successful cultivation of a spring summer crop of eggplant. Low tunnels, also known as row covers, are small structures generally of plastic that provide temporary crop protection against unfavourable climatic variables and their use enhances early and total yield (Wittwer and Castilla, 1995). Sethi *et al.* (2009) have also advocated the use of polyethylene low tunnels over the plant rows in net house to generate localized greenhouse effect for faster plant growth, earliness and higher total yield of brinjal. Secondly, mulching is the application of a soil cover of some organic or plastic material that acts as a barrier to the transfer of heat or vapour. The most extensive use of plastic for protected cultivation is as soil mulching (Wittwer and Castilla, 1995). These mulches creates microclimate around the plant by modifying the radiation budget of the surface and decreasing the soil water loss. These mulches are available in various colours including black, transparent (clear), silver, white, gray, red, blue, etc. In brinjal, plastic mulches have been reported to promote growth, increase early and total yield, and reduce incidence of *Verticillium* wilt (Mooran 1982, Singh *et al.* 2005). However, the influence of mulch colour on crop growth and productivity has been postulated to be highly specific, and may vary with plant taxa, climate and seasonal conditions (Mahmoudpour and Stapleton 1997). The objectives of the present study was to assess the effect of polyethylene mulch (black and transparent) and low tunnel on plant growth parameters, earliness, total yield, incidence of frost injury, shoot and fruit borer, and *Sclerotinia* rot in brinjal in both net house and open field conditions.

The present study was conducted on a loamy sand soil having low available nitrogen and organic matter, medium available phosphorus and high available potassium at Vegetable Research Farm, PAU, Ludhiana (30° 55' N latitude, 75° 51' E longitude, 247 m altitude). Two experiments were conducted during *rabi* (over winter) seasons of 2009-10 (E_1) and 2010-11 (E_2) to compare the performance of brinjal hybrid BH-2, recommended for cultivation in north-western plain zone by All India Coordinated Research Project on Vegetable Crops, using transparent polyethylene mulch (TPM), black polyethylene mulch (BPM), polyethylene low tunnel (PLT) and bare soil (BS) (control) in both net-house (40 mesh size) and open field. The thickness of plastic sheet was 25µm. The seeds were sown in end-September in net-house, and the seedlings having 3-4 mature leaves (4-5 weeks old) were transplanted in early-November in both net-house and open field. Transplanting was done on 0.90 m wide beds which were raised 0.15 m above ground. For each treatment, two rows of seven plants each were maintained at an intra row spacing of 0.30 m. The beds were covered with different mulch materials in end-November and were removed in early-March.

[1]Department of Vegetable Science, Punjab Agricultural University, Ludhiana 141004, Punjab
[2]Regional Research Station, Punjab Agricultural University, Bathinda 151001, Punjab
*Cirresponding author, E-mail: naveen@pau.edu

The plants were covered with plastic low tunnels from first week of December to third week of February. The tunnels were made by stretching and fixing the plastic sheet over iron arches of 1.8 m length. The observations were recorded on ten competitive plants on plant height (during first week of March and fourth week of May), number of leaves/plant (in first week of March), plant spread (average of two values taken in two directions at 90^0 to each other), number of fruits/plant, total yield (t/ha), early yield (from first two pickings) (t/ha), number of days taken from transplanting to first picking, plant mortality (%), incidence of shoot and fruit borer (%). The data were subjected to analysis of variance (ANOVA) and least significant difference ($P < 0.05$) was used to compare treatment means (Gomez and Gomez 1984).

The various plasticulture treatments influenced the growth parameters of brinjal both in net house and open field. Plant height, plant spread and number of leaves plant^{-1} were significantly higher under net house than open field for all the treatments during both the years (Table 1, 2), depicting better growth of plants under controlled conditions. This may be due to a little higher temperature in net house than in open field. The PLT produced the highest plant height (at both crop stages) in both net house and open field, and was significantly better than other treatments. The TPM, BPM and PLT treatments produced maximum plant spread and number of leaves plant^{-1} in net house and these treatments were *at par* with each other during both the years, however, in open field, the highest values for these two growth parameters were exhibited by PLT which was significantly better than other treatments and control (Table 2). Awasthi *et al.* (2006) have also reported an increase of 146.6% & 95.7% in plant height, and 70.2% & 41.7% in plant spread using black and white plastic mulches, respectively in brinjal grown under semi-arid conditions.

In comparison with open field, the crop raised in net house took less number of days to first picking, produced higher early and total yield along with more number of fruits/plant in all the treatments except PLT during both the years (Table 3, 4). This could be due to a little higher temperature in net house than in open field. The previous studies conducted on tomato (Cheema *et al.* 2004), bell pepper (Singh *et al.* 2004), and brinjal (Sidhu and Dhatt 2007) have also reported considerable increase in early, total and marketable fruit yield under net house than in open field. However, the PLT treatment produced significantly higher early and total yield in open

Table 1: Plant height of autumn planted brinjal as influenced by polyethylene mulches and low tunnel in net house (NH) and open field (OF) for two consecutive seasons

	Plant height (1st week of March) (cm)						Plant height (4th week of May) (cm)					
	2009-10			2010-11			2009-10			2010-11		
Treatments	NH	OF	Mean	NH	OF	Mean	NH	OF	Mean	NH	OF	Mean
TPM	56.3	38.7	47.5	52.0	41.4	46.7	95.7	94.5	95.1	98.9	91.9	95.4
BPM	55.3	39.3	47.3	52.1	40.7	46.4	95.1	94.9	95.0	100.3	92.5	96.4
PLT	60.2	46.2	53.2	57.3	47.9	52.6	110.2	105.6	107.9	102.9	93.3	98.1
BS	45.5	28.3	36.9	44.0	31.2	37.6	101.3	88.1	94.7	104.0	82.8	93.4
Mean	54.4	38.1		51.3	40.3		100.6	95.7		101.5	90.1	
LSD ($P < 0.05$)												
NH vs OF	2.9			1.2			2.4			1.7		
Mulch	4.1			1.9			3.4			2.7		
Interaction	NS			NS			NS			3.8		

TPM = Transparent polyethylene mulch, BPM = Black polyethylene mulch, PLT = Polyethylene low tunnel, BS = Bare soil (Control)

Table 2: Plant spread and number of leaves plant^{-1} of autumn planted brinjal as influenced by polyethylene mulches and low tunnel in net house (NH) and open field (OF) for two consecutive seasons

	Plant spread (cm)						Number of leaves plant^{-1}					
	2009-10			2010-11			2009-10			2010-11		
Treatments	NH	OF	Mean	NH	OF	Mean	NH	OF	Mean	NH	OF	Mean
TPM	91.7	75.3	83.5	92.1	78.7	85.4	72.2	57.2	64.7	66.1	46.5	56.3
BPM	90.9	76.7	83.8	90.5	77.3	83.9	72.2	59.4	65.8	65.9	49.9	57.9
PLT	89.6	92.6	91.2	88.4	84.6	86.5	73.3	63.5	68.4	66.1	55.7	60.9
BS	87.3	73.7	80.5	84.2	73.8	79.0	42.4	38.8	40.6	36.3	31.7	34.0
Mean	89.9	79.6		88.8	78.6		65.0	55.2		58.6	46.0	
LSD ($P < 0.05$)												
NH vs OF	1.7			2.0			3.0			2.1		
Mulch	2.4			3.1			4.2			3.3		
Interaction	3.4			4.4			NS			4.6		

TPM = Transparent polyethylene mulch, BPM = Black polyethylene mulch, PLT = Polyethylene low tunnel, BS = Bare soil (Control)

field than in net house. This may be due to high plant mortality due to *Sclerotinia* rot in PLT under net house.

In net house, all the treatments were significantly better than control in respect of days to first picking, early yield, number of fruits/plant and total yield (Table 3, 4). The PLT, TPM and BPM treatments took statistically equal number of days to first picking in net house. However, BPM and TPM were significantly better than PLT in producing higher early and total yield. Like net house, in open field, all the treatments were significantly superior to bare soil in respect of days to first picking, early yield, number of fruits/plant and total yield (Table 3, 4). However, the PLT was significantly better than TPM and BPM, and took minimum days to first picking, and produced highest early yield, number of fruits/plant and total yield during both the years. Awasthi *et al.* (2006) have also reported an increase of 560% & 380% in fruit number, 516.3% & 341.5% in fruit yield over control with black and white plastic mulches, respectively. This improvement in plant growth, earliness, and yield attributes of eggplant due to BPM, TPM and PLT in net house and PLT in open field may be attributed to modification in root-zone temperature which is important for plant growth and development as it affects physiological processes in roots such as uptake of water and mineral nutrients (Diaz-Perez and Batal 2002). The other reasons could be less weed population due to mulches resulting in reduced competition for nutrients and water and conserving soil moisture which is also beneficial for uptake of nutrients from soil (Lamont 1993). In open field, low tunnel was better than mulches as it protects tender plants from cold winds and frost and provides warmer growing temperatures inside the tunnel.

In net house, there was no plant mortality due to frost for all the treatments during both the years. In open field, BPM and PLT did not show any plant mortality due to frost during both the years, however, BS showed mortality of 2.39 and 47.22%, and TPM exhibited zero and 2.78% mortality due to frost during 2009-10 and 2010-11, respectively. The probable reason for plastic low tunnel providing protection against frost is that transparent plastic covers allow sunlight to pass through during the day and slow heat loss from the surface at night. The downward radiation from the sky at night is enhanced by covering the plants. The condensation, which forms underneath the polyethylene, releases latent heat, warms the plastic and provides even more protection. In addition, under advection frost conditions, the plastic row covers also block the wind and provide

Table 3: Days to first picking and early yield of autumn planted brinjal as influenced by polyethylene mulches and low tunnel in net house (NH) and open field (OF) for two consecutive seasons

	Early yield (t ha^{-1})						Days to first picking					
	2009-10			2010-11			2009-10			2010-11		
Treatments	NH	OF	Mean	NH	OF	Mean	NH	OF	Mean	NH	OF	Mean
TPM	7.6	5.0	6.3	7.1	3.5	5.3	128.6	138.0	133.3	133.7	149.7	141.7
BPM	7.6	5.0	6.3	6.8	3.6	5.2	128.6	138.0	133.3	134.3	154.1	144.2
PLT	5.3	7.7	6.5	6.0	6.0	6.0	128.6	125.0	126.8	132.3	131.3	131.8
BS	2.8	0.8	1.8	2.1	0.5	1.3	135.0	150.6	142.8	137.0	160.0	148.5
Mean	5.8	4.6		5.5	3.4		130.2	137.9		134.3	148.7	
LSD (P < 0.05)												
NH vs OF	0.4			0.4			2.1			1.2		
Mulch	0.5			0.6			2.9			1.8		
Interaction	0.7			0.9			4.1			2.6		

TPM = Transparent polyethylene mulch, BPM = Black polyethylene mulch, PLT = Polyethylene low tunnel, BS = Bare soil (Control)

Table 4: Number of fruits plant^{-1} and total yield of autumn planted brinjal as influenced by polyethylene mulches and low tunnel in net house (NH) and open field (OF) for two consecutive seasons

	Total yield (t ha^{-1})						No. of fruits plant^{-1}					
	2009-10			2010-11			2009-10			2010-11		
Treatments	NH	OF	Mean	NH	OF	Mean	NH	OF	Mean	NH	OF	Mean
TPM	72.4	55.0	63.7	75.4	38.6	57.0	15.6	14.0	14.8	17.2	10.4	13.8
BPM	75.7	50.5	63.1	72.6	40.8	56.7	16.5	14.5	15.5	17.0	10.8	13.9
PLT	62.2	81.8	72.0	64.7	73.7	69.2	15.9	17.9	18.9	16.6	15.6	16.1
BS	53.4	48.6	51.0	47.8	29.8	38.8	10.2	8.2	11.2	11.5	6.5	10.5
Mean	65.9	59.0		65.1	45.8		14.5	14.6		15.6	11.6	
LSD (P < 0.05)												
NH vs OF	2.2			3.1			0.9			0.5		
Mulch	3.1			5.0			1.2			0.8		
Interaction	4.4			7.0			1.7			1.2		

TPM = Transparent polyethylene mulch, BPM = Black polyethylene mulch, PLT = Polyethylene low tunnel, BS = Bare soil (Control)

protection. On the other hand, the beneficial effect of black and transparent polyethylene mulches against frost may be due to their effect in raising the soil temperature and increasing the transfer of heat from ground to surface soil. The plant mortality due to *Sclerotinia* rot was nil in open field during both the years, whereas in net house it was maximum for PLT (16.67% and 26.19%) followed by TPM and BPM (2.78% and 2.38%) and BS (nil and 2.38%) during 2009-10 and 2010-11, respectively. This could be attributed to high relative humidity build-up in low tunnel which along with low temperature (15.5-21.0 ^{0}C) and light is considered conducive for sclerotia germination and infection.

The incidence of shoot and fruit borer (*Leucinodes orbonalis*) was nil in net-house as compared to 17.98% and 15.89% in open field during 2009-10 and 2010-11, respectively. The previous studies have also reported reduced incidence of fruit borer under net house than in open in brinjal (Sidhu and Dhatt 2007), tomato (Cheema *et al.* 2004) and bell pepper (Singh *et al.* 2004). This may be because net house act as barrier between adults and larvae of shoot and fruit borer and inside grown plants. Further, in open field, minimum incidence (9.73% and 5.31%) was observed in PLT that was significantly lower than BS (32.56% and 15.23%) during 2009-10 and 2010-11, respectively. This could be due to protection cover of plastic tunnel from insect infestation during early phase of plant growth. The other treatments, viz., TPM (15.25% and 13.56%) and BPM (14.40% and 14.23%) exhibited moderate incidence of shoot and fruit borer.

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