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Effect of fertigation scheduling under drip irrigation with different black polyethylene mulching in Capsicum crop under polyhouse and open field conditions

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Abstract
The experiments were conducted (Field No. NA5) in naturally ventilated polyhouse and open field conditions at PFDC farm, TNAU, Coimbatore to study the effect of drip fertigation with different polyethylene mulches in Capsicum crop under polyhouse and open field conditions. The experiments were laid out in completely randomized design with six treatments which included three mulching levels, viz. 25 micron black plastic mulch, 50 micron black plastic mulch and no mulch, two fertigation levels, viz. 100 and 80% of recommended N and K fertigation through drip irrigation and replicated thrice. In polyhouse, the higher yield was obtained in the treatment of 25 micron thickness with 100 per cent RDF and the minimum yield was obtained in treatment T_5. In open field conditions, the higher yield was obtained in the treatment of 25 micron thickness with 100 per cent RDF and minimum yield was obtained in treatment T_5. Drip irrigation with fertigation, water use is reduced, nutrient application is precise and yields of crops also increased. With fertigation, nutrient use efficiency is increased and the risk of loss of nutrients to the ground water is reduced. Hence the research was conducted to study the effect of fertigation with plastic mulching in polyhouse and open field.

Keywords: drip irrigation, fertigation scheduling, polyethylene mulch, fertilizer use efficiency and biometric observation

Introduction
Fertigation is the application of soluble nutrients with irrigation water, its use in vegetable production has increased with the introduction of polyethylene mulch with drip irrigation and fertigation for efficient use of applying fertilizer to the root zone. Polyethylene mulch was introduced in 1950's and its use drastically changed vegetable fertilization practices. Nowadays it is called as plasticulture, nutrient leaching is reduced, soil temperatures can be increased by the use of black mulch, most weeds are controlled and yields are generally increased (Lamont, 2005) [4].

Fertigation has the potential to supply a right mixture of water and nutrients to the root zone and thus meeting plants water and nutrient requirements in most efficient possible manner (Patel *et al.* 2001) [9]. Fertigation allows an accurate and uniform application of nutrients to the wetted area where most active roots are concentrated. Therefore, it is possible to dispense adequate nutrient quantity at an appropriate concentration to meet the crop demand during a growing season. Since fertigation was first used in Israel in 1969 for tomato grown on sand dunes in a field experiment (Sagiv *et al.* 1976) [11], since then the area under fertigation has increased rapidly worldwide. With fertigation, water use efficiency of the crops has to be increased in order to reduce the water loss from the fields and nutrients use efficiency is increased and the loss of nutrients to the groundwater is reduced.

With drip fertigation, nutrient use efficiency is increased and the loss of nutrients to the ground water is reduced. Soluble chemicals and nutrients move with the wetting front. Hence a precise scheduling of irrigation and fertilizer applications is essential for sustainable crop production.

Materials and Methods
The experiments were conducted at Precision Farming Development Centre, Tamil Nadu Agricultural University, Coimbatore during 2015-16 in naturally ventilated polyhouse and open field conditions. The field is located at 11^0 N latitude and 77^0 E longitude with mean altitude of 426 m above the mean sea level. Capsicum crop (Orobelle) were grown in naturally ventilated polyhouse and open field conditions.

Design and treatments
The experiment was laid out in a Completely randomized design. Design with six treatments which included two factors such as mulching and fertigation level and replicated thrice.

Treatment details

T_1	Black Polythene mulch of 25 micron thickness, fertigation with 80 per cent RDF.
T_2	Black Polythene mulch of 25 micron thickness, fertigation with 100 per cent RDF.
T_3	Black Polythene mulch of 50 micron thickness, fertigation with 80 per cent RDF.
T_4	Black Polythene mulch of 50 micron thickness, fertigation with 100 per cent RDF.
T_5	No mulch, fertigation with 80 per cent RDF.
T_6	No mulch, fertigation with 100 per cent RDF.

Irrigation scheduling
Irrigations were scheduled on the daily climatological data for calculating the water requirement. The daily water requirement was calculated using this equation.

Daily Water Requirement (DWR) = Ep x Kp x Kc x Wp x A ……. (1)

Where,

DWR = Computed daily water requirement (lit plant^{-1})
Ep = Average pan evaporation of the day (mm)
Kp = Pan factor (0.8)
Kc = Crop factor
Wp = Wetted percentage (80 per cent)
A = Area per plant

The water was supplied to the plant daily as per the treatments. Time of operation of drip system to deliver the required volume of water per treatment was calculated using the equation.

$$\text{Time of operation (min)} = \frac{\text{Volume of water required}}{\text{Emitter discharge x No. of emitters}} \quad \ldots\ldots (2)$$

Fustigation
Water soluble N and K fertilizers through drip irrigation were used in this experiment. Phosphorous was applied as a basal dose. The recommended soluble fertilizers were applied simultaneously to the plant root zone. Urea, NPK 19:19:19 and Sulphate of potash were applied through venturi. The fertilizers were dissolved in water in the ratio of 1:5 and the solution was diluted in fertigation tank. With venturi injectors, water is extracted from the main line, pressure difference is created by a valve in the mainline forcing water through the injector at high velocity. The high velocity water passing through the throat of the venturi creates a vacuum or negative pressure, generating suction to draw chemicals into the injector from the chemical tank. The 80 per cent, 100 per cent recommended N and K water soluble fertilizers were regulated by operating the tap connected at the starting end of each lateral.

Fertilizer scheduling
Drip laterals were laid along the length of each raised bed at the centre with the spacing kept at 0.85 m between two adjacent laterals. Fertigation to individual plot in each replication was controlled by a manual regulating valve fixed to each lateral lines. A dosage of 250: 150: 150 NPK kg ha^{-1} was taken as 100 per cent recommended dose of fertilizer (RDF) and 75 per cent of RDF phosphorous was applied as basal dose. Table 1 shows the fertigation scheduling are applied through drip fertigation at various growth stages.

Table 1: Details of quantity of fertilizers applied for the plot area of 4.25 m^2 (Kg) in polyhouse and open field

Basal Dose			
75 per cent of RDF- Phosphorous (Super Phosphate) applied as basal dose = 703 kg ha^{-1}			
Top dressing			
Stage	**Name**	**80 per cent RDF**	**100 per cent RDF**
Transplanting to plant establishment stage (1-10 days)	NPK 19:19:19	0.25	0.31
	13:00:45	0.12	0.13
	Urea	0.21	0.26
Flower initiation to flowering (10 - 40 days)	12:61:0	0.15	0.19
	13:00:45	0.82	1.19
	Urea	1.1	1.32
Flowering to fruit set (40 - 70 days)	NPK 19:19:19	0.25	0.31
	13:00:45	0.52	0.63
	Urea	0.76	0.94
Alternate day from picking (70 - 160 days)	12:61:0	0.075	0.09
	13:00:45	0.41	0.51
	Urea	0.53	0.66

Soil temperature
Soil temperature was taken during the experiment in polyhouse and open field with the help of digital soil thermometer. Soil temperature was taken at 5 cm, 10 cm and 20 cm depth by inserting sensor rod of digital soil thermometer below the soil surface at different depth. Soil temperature was taken from the plot covered with black polythene mulch (25µ and 50µ) and without mulch. Observation was recorded to know the effect of mulch and without mulch on soil temperature in polyhouse and open field which indirectly affect the crop production. The daily records of soil temperature were taken at 8:00 am and 2:00 pm in each treatment.

Collection of biometric data - Growth parameters
Plant height (cm)
The plant height was measured at 30, 60, 90 and 120 DAT and at harvest from base of the plant to the tip of the growing point in polyhouse and open field conditions..

Yield per plant (kg)

The yield per plant in polyhouse and open field were estimated based on yield per plant and expressed in kilogram.

Yield per hectare

The yield per hectare in polyhouse and open field were estimated for the cropped area based on yield per plot and expressed in tons per hectare.

Determination of Fertilizer Use Efficiency

Fertilizer Use Efficiency (FUE) was calculated separately for N. P and K for each treatment, which is the ratio of yield of the crop in kg ha^{-1} and total nitrogen, potassium and phosphorus applied in kg ha^{-1}.

$$FUE = \frac{Y}{F.A} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,

FUE - Fertilizer Use Efficiency
Y - Yield of the crops, kg ha^{-1}
F.A - Total fertilizer applied, kg

Results and Discussions

Effect of different thickness black plastic mulch and without mulch on soil temperature and yield of crop under different level of fertigation were recorded and are presented in the form of tables.

Effect of different mulching and fertigation scheduling on soil temperature in polyhouse and open field

Soil temperature were recorded at 8:00 AM and 2:00 PM from December 2015 to May 2016. The average of daily recorded soil temperature at 5 cm, 10 cm and 20 cm depth is presented in Table 2 &3.

Table 2: Effect of different mulching and fertigation scheduling on mean soil temperature in polyhouse

Treatments	8.00 am			2.00 pm		
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm
T_1	32.3	34.3	37.0	42.9	41.5	37.8
T_2	32.2	34.2	36.8	42.9	41.6	37.7
T_3	31.4	33.4	36.1	42.0	40.6	36.9
T_4	31.3	33.3	35.9	42.0	40.7	36.8
T_5	29.2	31.2	33.9	39.8	38.4	34.7
T_6	29.1	31.1	33.7	39.8	38.5	34.6
Mean	30.9	32.9	35.6	41.6	40.2	36.4

Table 3: Effect of different mulching and fertigation scheduling on mean soil temperature in open field

Treatments	8.00 am			2.00 pm		
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm
T_1	29.0	30.8	33.5	39.3	38.2	34.4
T_2	28.9	30.7	33.6	39.2	38.2	34.3
T_3	28.2	30.0	32.7	38.5	37.4	33.6
T_4	28.1	29.9	32.8	38.4	37.4	33.5
T_5	26.2	28.0	30.7	36.5	35.4	31.6
T_6	26.1	27.9	30.8	36.4	35.4	31.5
Mean	27.8	29.6	32.4	38.1	37.0	33.2

From table, it can be seen that soil temperature under polyhouse always maintained a 2 – 4ºC higher temperature as compared to the temperature at the outside soil at all growth stages of crop. The similar findings showed that Soil under polyhouse always maintained a 2 - 3ºC higher temperature as compared to the temperature at the outside soil at all growth stages of crop (Parvej *et al.,* (2010) [8], Montero and Anton (2003) [6] and Bini Sam and Regeena (2015) [3].

In polyhouse and open field, the average soil temperature at 8.00 am in 5 cm depth was lower as compared to 10 cm and 20 cm depth under 25 micron, 50 micron black plastic mulch and without mulch. At the same time soil temperature has been found maximum under 25 micron black plastic mulch followed by 50 micron black plastic mulch and then without mulch at 5 cm, 10 cm and 20 cm depth. The result revealed that during forenoon soil temperature increases with increasing depth. Based on the recorded data at 2.00 pm the average soil temperature at 5cm depth is higher compared to 10 and 20 cm depth under 25 micron black plastic mulch followed by 50 micron black plastic mulch and without mulch. At the same time soil temperature has been found maximum under black plastic mulch followed by without mulch. The result revealed that at afternoon soil temperature decreases with increasing depth. Increasing and decreasing trend of soil temperature under black plastic mulch depends on daily atmospheric temperature.

The result concluded that at 8.00 am the average soil temperature in the treatment T_1 (Black Polythene mulch of 25 micron thickness with fertigation with 80 per cent RDF) was 32.3°C and 0.9°C higher than 50 micron black plastic mulch and 3.2°C in without mulch at 5 cm depth respectively. Similarly the soil temperature difference shown, at 10 cm depth and 20 cm depth. At 2:00 pm the average soil temperature under 25 micron black plastic mulch is 0.8°C higher than 50 micron black plastic mulch and 2.8°C in without mulch at 5 cm depth respectively. Similarly at 10 and 20 cm depth soil temperature under 25 micron black plastic mulch is 1.0 to 1.1°C higher than 50 micron black plastic mulch followed by 2.8 to 3.2°C more than without mulch respectively.

Likewise, in open field, the average soil temperature was higher under 25 micron black plastic mulch at 8.00 am and 2.00 pm in 5 cm, 10 cm and 20 cm depth followed by 50 micron black plastic mulch and without mulch respectively.

Data regarding soil temperature under different mulch treatments revealed that plastic mulches increased soil temperature significantly than without mulched plots. Higher soil temperature under plastic mulch may be due to increased radiation absorption and better thermal conductivity between soil surface and the plastic mulch. Plastic mulches are commonly used to modify the soil temperature, moisture regimes, control weeds and increase the crop yield.

The results are in conformity with the findings as reported by Singh and Kamal (2012), Mehta *et al,* (2010) [5] that black plastic much is effective in soil temperature, weed control and conservation of soil moisture.

Effect of different mulching level and fertigation scheduling on growth parameters

The growth parameters like height of the plant, yield per plant and total yield were recorded in polyhouse & open field and analysed for their significance on the treatment.

Plant height

The data on plant height as influenced by mulching and fertigation levels in polyhouse and open field are presented in Table 4 and 5.

Table 4: Effect of plant height (cm) for different treatments in polyhouse

Treatments	30 DAT		60 DAT		90 DAT		120 DAT	
T_1	27.9		58.42		85.77		97.53	
T_2	28.0		58.43		85.60		93.70	
T_3	28.04		58.03		78.40		95.10	
T_4	28.56		57.13		78.07		95.11	
T_5	26.25		51.60		61.83		72.83	
T_6	27.22		52.67		63.80		75.03	
Mean	27.66		56.05		75.58		88.22	
Effect	S.E(d)	CD(0.05)	S.E(d)	CD(0.05)	S.E(d)	CD(0.05)	S.E(d)	CD(0.05)
M	0.074	0.162	0.054	0.116	0.047	0.103	0.053	0.115
F	0.060	0.132	0.043	0.095	0.038	0.084	0.043	0.094
M x F	0.105	0.229	0.075	0.164	0.067	0.146	0.075	0.163

Table 5: Effect of plant height (cm) for different treatments in open field

Treatments	30 DAT		60 DAT		90 DAT		120 DAT	
T_1	29.16		45.96		58.80		77.63	
T_2	28.67		46.03		58.83		77.23	
T_3	27.43		45.26		58.53		76.40	
T_4	28.46		44.70		57.67		76.03	
T_5	24.80		39.53		52.57		68.40	
T_6	25.70		40.30		53.73		69.67	
Mean	27.37		43.63		56.68		74.22	
Effect	S.E(d)	CD(0.05)	S.E(d)	CD(0.05)	S.E(d)	CD(0.05)	S.E(d)	CD(0.05)
M	0.057	0.125	0.047	0.103	0.034	0.074	0.047	0.103
F	0.047	0.102	0.038	0.084	0.028	0.061	0.038	0.084
M x F	0.081	0.177	0.067	0.145	0.048	0.106	0.067	0.146

In polyhouse cultivation, the maximum plant height of 120 DAT was recorded 97.53 cm, under the treatment T_1 (Black Polythene mulch of 25 micron thickness, fertigation with 80 per cent RDF) and the lowest plant height of was recorded under the treatment T_5 (No mulch, fertigation with 80 per cent RDF). The interaction effect of 25 micron, 50 micron mulching and without mulching and fertigation levels were significant on the plant height of Capsicum (Orobelle) at 30, 60, 90 and 120 DAT.

In open field, the maximum plant height of 120 DAT was recorded 77.63 cm, under the treatment T_1 (Black Polythene mulch of 25 micron thickness, fertigation with 80 per cent RDF) and the lowest plant height of was recorded under the treatment T_5 (No mulch, fertigation with 80 per cent RDF). The interaction effect of 25 micron, 50 micron mulching and without mulching and fertigation levels were significant on the plant height of Capsicum (Orobelle) at 30, 60, 90 and 120 DAT.

The similar results were reported by Qumer Iqbal *et al.* (2009) [10] had reported that plastic mulches had significant effect on plant height of hot pepper. Plants grown on black plastic mulch produced taller plants as compared to bare soil plants.

From the results, showed that maximum plant height was recorded under polyhouse in the treatment T_1 (Black Polythene mulch of 25 micron thickness, fertigation with 80 per cent RDF) when compared to open field.

Yield per plant

The yield per plant were observed for capsicum crop in polyhouse and open field and the data recorded is given in Table 6. The maximum yield per plant of polyhouse and open field were 1.66 and 1.10 kg were recorded under the treatment T_2 (Black Polythene mulch of 25 micron thickness, fertigation with 100 per cent RDF) and minimum yield per plant was recorded in the treatment T_5 (No mulch and fertigation with 80 per cent RDF) were 1.13 and 0.85 kg respectively. Similar result was obtained in Awani kumar *et al.* (2011) [1] had reported that protected technology enhanced crop duration in capsicum. Yield per plant was higher in polyhouse conditions with mulching at 1.57 kg plant^{-1} as compared to 0.9 kg plant^{-1} under open field conditions.

On comparing polyhouse and open field, the maximum yield was obtained in the treatment T_2 (Black Polythene mulch of 25 micron thickness and fertigation with 100 per cent RDF) under polyhouse.

Table 6: Effect of drip fertigation and mulching on yield per plant (Kg)

Treatments	Yield per plant (Kg) Polyhouse		Yield per plant (Kg) Openfield	
T_1	1.21		1.06	
T_2	1.66		1.10	
T_3	1.39		1.01	
T_4	1.51		1.00	
T_5	1.13		0.85	
T_6	1.24		0.99	
Mean	1.35		1.00	
Effect	S.E(d)	CD(0.05)	S.E(d)	CD(0.05)
M	0.005	0.012	0.004	0.010
I	0.004	0.010	0.003	0.008
M x I	0.008	0.017	0.006	0.014

Yield (t/ha)

The total yield were observed for capsicum crop in polyhouse and open field and the data recorded is given in Table 7. The maximum yield of polyhouse and open field were 46 and 30.51 t ha^{-1}, recorded under the treatment T_2 (Black Polythene mulch of 25 micron thickness, fertigation with 100 per cent RDF) and minimum yield per plant was recorded in the treatment T_5 (No mulch and fertigation with 80 per cent RDF) were 31.27 and 23.52 t ha^{-1} respectively. Similar results based on investigated by Muhammad *et al.* (2015) [7] on the growth and yield of capsicum. Orobelle gets higher yield of 51 t ha^{-1} and 1.96 kg of fruit weight per plant.

The maximum yield was obtained in the treatment T_2 (Black Polythene mulch of 25 micron thickness and fertigation with 100 per cent RDF) under polyhouse when compare to open field.

Table 7: Effect of drip fertigation and mulching on yield (t/ha)

Treatments	Yield (t/ha) Polyhouse		Yield (t/ha) Openfield	
T_1	33.56		29.56	
T_2	46.00		30.51	
T_3	38.60		28.19	
T_4	41.88		27.88	
T_5	31.27		23.52	
T_6	34.35		27.55	
Mean	37.61		27.86	
Effect	S.E(d)	CD(0.05)	S.E(d)	CD(0.05)
M	0.082	0.180	0.008	0.017
I	0.067	0.147	0.006	0.014
M x I	0.117	0.255	0.011	0.025

Fertilizer use efficiency

Fertilizer Use Efficiency of Nitrogen, phosphorous and potassium are calculated by using equation 3. for each treatment and are depicted in Table 8 & 9. Increased fertilizer use efficiency with the decreased level of fertilizer dose through drip was observed. In polyhouse, The highest N, P and K fertilizer use efficiency of 193.0 kg $ha^{-1}.kg^{-1}$ of N, 321.7 kg $ha^{-1}.kg^{-1}$ of P and 321.7 kg $ha^{-1}.kg^{-1}$ of K were recorded in T_3 (Black Polythene mulch of 50 micron thickness, fertigation with 80 per cent RDF) and the lowest N, P and K fertilizer use efficiency of 137.4 kg $ha^{-1}.kg^{-1}$ of N, 229.0 kg $ha^{-1}.kg^{-1}$ of P and 229.0 kg $ha^{-1}.kg^{-1}$ of K were recorded in T_6 (No mulch, fertigation with 100 per cent RDF). Likewise, in open field, the highest N, P and K fertilizer use efficiency of 147.9 kg $ha^{-1}.kg^{-1}$ of N, 246.5 kg $ha^{-1}.kg^{-1}$ of P and 246.5 kg ha^{-1}. kg^{-1} of K were recorded in T_1 (Black Polythene mulch of 25 micron thickness, fertigation with 80 per cent RDF) and the lowest N, P and K fertilizer use efficiency of 92.9 kg $ha^{-1}.kg^{-1}$ of N, 154.9 kg $ha^{-1}.kg^{-1}$ of P and 154.9 kg $ha^{-1}.kg^{-1}$ of K were recorded in T_4 (Black Polythene mulch of 50 micron thickness, fertigation with 100 per cent RDF).

This results are in accordance with Bharambe *et al*. 1997 [2] who reported that N use efficiency increased considerably increased with the application of N through drip over soil application and was highest at 75 kg N ha^{-1} applied through drip application in a parbhani clayey soil at Maharastra.

Table 8: Fertilizer use efficiency for different treatments in polyhouse

Treatments	Yield per hectare (kg)	FUE (kg $ha^{-1}.kg^{-1}$ of N)	FUE (kg $ha^{-1}.kg^{-1}$ of P)	FUE (kg $ha^{-1}. kg^{-1}$ of K)
T_1	33557	167.8	279.6	279.6
T_2	46003	184.0	306.7	306.7
T_3	38599	193.0	321.7	321.7
T_4	41883	167.5	279.2	279.2
T_5	31267	156.3	260.6	260.6
T_6	34349	137.4	229.0	229.0

Table 9: Fertilizer use efficiency for different treatments in open field

Treatments	Yield per hectare (kg)	FUE (kg $ha^{-1}.kg^{-1}$ of N)	FUE (kg $ha^{-1}.kg^{-1}$ of P)	FUE (kg $ha^{-1}. kg^{-1}$ of K)
T_1	29577	147.9	246.5	246.5
T_2	30510	122.0	203.4	203.4
T_3	29565	147.8	246.4	246.4
T_4	27876	92.9	154.9	154.9
T_5	23518	117.6	196.0	196.0
T_6	27551	110.2	183.7	183.7

Conclusion

In polyhouse, the maximum yield were obtained in the treatment of 25 micron thickness with 100 per cent RDF (T2) followed by 50 micron thickness with 100 per cent RDF (T4) and the minimum yield was recorded in treatment T5. In open field, the maximum yield were obtained in the treatment of 25 micron thickness with 100 per cent RDF (T2) followed by 25 micron thickness with 80 per cent RDF (T1) and the minimum yield was recorded in treatment T5. The result concluded that maximum yield obtained in polyhouse when compare to open field. Mulches increase the soil temperature, retard the loss of soil moisture and check the weed growth. The experiment concluded that 25 micron plastic mulch increased the soil temperature that prevent soil water evaporation and retains soil moisture, which leads to maximize the crop yield.

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Reference

1. Awani Kumar Singh, Balraj Singh, Ramwant Gupta. Performance of sweet pepper (*Capsicum annum*) varieties and economics under protected and open field conditions in Uttarakhand. Indian J Agric. Sci. 2011; 81(10):973-5.
2. Bharambe PR, Mungal MS, Shelke DK, Oza SR, Vaishnava VG. Sondge VD. Effect of soil moisture regime with drip on spatial distribution of moisture, salts, nutrient availability and water use efficiency of banana J Indian Soc. Soil Sci. 2001; 49(4):658-665.
3. Bini Sam, Regeena. Comparative Performance Evaluation of Cool Season Vegetables under Poly house Structure and in Open field. Intl J Eng. Res. Develop. 2015; 11(12):13-18.
4. Lamont Jr WJ. Plastics: Modifying microclimate for the production of vegetable crops. Hort. Tech. 2005; 15(3):477-481.
5. Mehta DK, Kaith NS, Kanwar HS. Effect of training methods and mulching on growth, yield and fruit rot incidence in tomato (*Solanum lycopersicum*). Indian J Agric. Sci. 2010; 80:829-31.
6. Montero JJ, Anton A. Greenhouse characteristics and microclimatic conditions. Acta Hort. 2003; 614:323-333.
7. Muhammad Farooq, Aasia Ramzan M, Riaz Chattha, Uzair Qasim. Nawab NN, Hidyatulllah. Studies on the

Performance of Sweet Pepper (*Capsicum annum* L.) Hybrids under Plastic Tunnel. Sci. Tech. Develop. 2015; 34(3):155-157.

8. Parvej MR, Khan MAH, Awal MA. Phenological development and production potentials of tomato under polyhouse climate. The J Agric. Sci. 2010; 5(1):19-31.
9. Patel N, Rajput TBS. Effect of fertigation on growth and yield of onion. Micro Irrigation, CBIP Publication. 2001; 282:451.
10. Qumer Iqbal, Muhammad Amjad, Muhammad Rafique Asi, Muhammad Asif Ali, Riaz Ahmad. Vegetative and reproductive evaluation of hot peppers under different plastic mulches in poly/plastic tunnel. Pak J Agri. Sci. 2009; 46(2):113-119.
11. Sagiv B, Kafkafi U. Fertilization and manuring of pepper plants in sandy soils. Hassadeh. 1976; 56(10):1726-1730.
12. Singh AK, Singh AK, Gupta MJ, Shrivastav R. Study of spacing, training-pruning and varieties of *Capsicum* under polyhouse condition. Prog. Hort. 2003; 7:212-216.