PLASTIC TUNNEL PRODUCTION ON BELL PEPPER GROWN DURING WET AND DRY SEASON

Clemencia L. Sumagaysay, Ph.D.
Head, Research and Development
Surigao del Sur State University-Tagbina Campus
Tagbina, Surigao del Sur, Philippines
Email: csumagaysay17@gmail.com

ABSTRACT

Responses of sweet bell pepper grown inside and outside plastic tunnel during wet and dry seasons manifested highly significant differences in the number of days to senescence, number of flowers, number of fruits, fruit size, fruit weight and fruit yield. Sweet bell pepper grown inside plastic tunnel performed best in most parameters particularly when planted during wet season and also earned the highest return with the amount of P 0.19 for every peso invested. Based on the financial analysis, this research study can pay back the production cost for about two years (four cropping) both inside plastic tunnel and outside plastic tunnel/ growing structure.

Keywords: Plastic tunnel, Bagging, Variety, Yield, Senescence

INTRODUCTION

During rainy season the production of vegetables is declining because of excessive rain on plants which cause diseases often evidenced in stunting, spots on foliage, decay on leaves, stems or fruit, wilting and in severe cases, death of the entire plant. Extreme wet weather also keeps pollinators at bay affecting bloom and fruiting and most of the flowers failed to undergo fertilization due to the droplets that strike the petals of the flowers that causes abortion/removal of flowers from the plant especially on sweet bell pepper plants.

Problems of sweet bell pepper production during wet season can be resolved using plastic tunnels, which are usually done to protect low-growing plants from extreme weather conditions and are made into a mini greenhouse. Polyethylene films are ideal in making greenhouses because its tunnel is low and has passages. Rusell (2011) said lightweight and flexibility would save construction expenses thus vegetables in plastic tunnel are best for money. A high tunnel is solar heated and its manually vented plastic covers the cold frame to lengthen the traditional growing season for many horticulture crops. Wikipedia (2013) disclosed that high tunnels, often called hoophouses can significantly increase the average daily temperature and protect the crop from wind, rain, snow, hail, insects and diseases.

Problems and solutions of plastic tunnels are rarely read and circulated. Hence, this study was conducted to evaluate the performance of sweet bell pepper grown under plastic tunnel during rainy and dry season.

Objectives of the Study

1. Compare the growth and yield performance of sweet bell pepper grown inside and outside plastic tunnel,
2. Determine the effects of plastic tunnel on sweet bell pepper during wet and dry season,
3. Evaluate the profitability of growing sweet bell pepper varieties in plastic tunnel and open field.

MATERIALS AND METHODS

The soil samples were collected in the area and submitted to the Regional Soil Testing Laboratory, Region XIII Butuan City for soil analysis to determine the recommended rate of fertilizer application.

Experimental Design and Treatment

The experimental plots were laid out in Split – Split Plot arranged in Randomized Block Design (RCBD) with three blocks/replications. The total area was 2,112 sq.m. An alley of one meter wide was provided between blocks to facilitate care and management of the plant. The treatments were designated as follows:

Growing Structure (GS)

$\mathbf{GS_1}$ = Plastic tunnel
$\mathbf{GS_2}$ = Open space (outside plastic tunnel)

Season (S)

$\mathbf{S_1}$ = Wet
$\mathbf{S_2}$ = Dry

Cultural and Management Practice

1.1 Land Preparation

An area of 2,112 sq. m. was prepared thoroughly before planting. It was plowed and harrowed two times on weekly intervals to allow the weed seeds to germinate and stubbles to decompose. After the last harrowing, two blocks were laid out.

1.2 Construction of Plastic Tunnel

Plastic tunnel was constructed (15 m wide x 45 m long x 7 ft. high) in accordance with the design using bamboo poles and woods. The top of the tunnel and all sides were covered with polyethylene plastic.

Figure 1. Plastic tunnel structure

1.3 Drainage System

Canal with a depth of 60 cm and 30 cm wide was constructed around the experimental area to prevent flooding during rainy days.

1.4 Seed Box Preparation

The sweet bell pepper seeds were germinated in seed boxes. Before seeding, germination medium was sterilized by baking the soil for one hour to reduce the incidence of soil-borne pathogens and other pests. Seed boxes were watered well every morning after sowing.

1.5 Seedlings Selection and Preparation

Sweet Bell Pepper seedlings were carefully selected from the seedbed 16 days after sowing. Selected seedlings were placed in a basin/banana bract to prevent wilting and root damage.

1.6 Pricking and Bagging

Only those classified healthy sweet bell pepper seedlings in 16 days after sowing were pricked and bagged with the use of banana leaf bags regardless of height and diameter sizes.

1.7 Hardening

Before transplanting, the bagged seedlings were hardened by reducing the amount of water and by gradual exposure to 25 %, 50 %, 75 % until full sunlight for one to two weeks.

1.8 Transplanting

Transplanting of sweet bell pepper seedlings was done after one or two weeks of hardening or when seedlings height is 8-10 cm. Strongest and healthiest seedlings were selected for transplanting. To reduce root damage, the seedlings were watered before digging up. Seedlings were transplanted in the afternoon or cloudy days with a distanced of 50 cm between hills and 75 cm between rows.

1.9 Fertilizer Management

The result of soil analysis was the basis of determining the fertilizer treatments applied on the experimental plots. One-half of the fertilizer treatments were applied in the furrows during planting and the other half was applied 2 weeks after planting.

2. Care and Management

Growing sweet bell peppers were regularly sprinkled with water. Watering, Integrated Pest Management (IPM) and a recommended chemical spray to control and prevent plants from attack of insect pest and disease like aphids, mites, bacterial wilt, cutworm and anthracnose were the uniform management practices given to all treatment plots.

Weeds were controlled by hand weeding three (3) weeks after transplanting and as the need arises, thereafter.

2.1 Harvesting

Fruits were ready for harvest two (2) to three (3) months after transplanting or three (3) to six (6) weeks after flowering. Fruit samples were harvested at green breaker or at ripening phase.

Harvesting was done early morning to minimize weight loss and deterioration.

RESULTS AND DISCUSSION

A. Agronomic Characteristics

1. Plant Heights

Sweet bell pepper grown inside the plastic tunnel produced the tallest in the plant height mean of 21.25 cm, outside plastic tunnel was observed to have recorded the shortest height which explained the requirement of the heat effect of tunnel at seedlings stage as manifested in the height of sweet bell pepper grown inside plastic tunnel and as supported by the findings of Gerber et. al (1988) who claimed that crop development increased by the increase of soil temperature due to tunnel effect.

While Table 1.0 revealed that there were no significant effects of the growing structure, the season and its combination on the bell pepper heights 60 days after transplanting. This explains that the growing structure and the season did not interfere the plant growth or height on this particular stage.

Table 1.0 Plant height (cm) of sweet bell pepper as affected by growing structure and season measured 30 and 60 days after planting.

	30 DAP			60 DAP		
	SEASON			SEASON		
GROWING STRUCTURE	**Wet**	**Dry**	**Mean** ^{ns}	**Wet**	**Dry**	**Mean** ^{ns}
GS $_{1-}$ Inside Plastic Tunnel	19.76	14.60	17.18	27.64	25.85	26.74
GS $_{2-}$ Outside Plastic Tunnel	23.51	10.97	17.24	29.50	13.71	21.60
Mean	21.64	12.78		28.57	19.78	

ns – not significant

2. Number of Days to Flowering

Table 2.0 Showed that bell pepper planted in wet season reached 71 days to flower, while peppers planted during wet season reached 54 days to bear flower. The amount of water or soil moisture contributed to the number of days to flowering. The need of sufficient amount of water for early flower production was also seen in the analysis of the study.

Sweet bell pepper grown inside the plastic tunnel flowered earlier and got the mean of 57 days than grown outside plastic tunnel which furthermore implied that the time of flowering in the growing structure varies according to variety and environmental conditions. (Feleafel and Mirdad, 2013)

Table 2.0 Average number of days to flowering of sweet bell pepper as affected by growing structure and season.

	SEASON		
GROWING STRUCTURE	**Wet**	**Dry**	**Mean** ^{ns}
GS $_{1-}$ Inside Plastic Tunnel	53.00	72.00	62.50
GS $_{2-}$ Outside Plastic Tunnel	54.00	70.00	62.00
Mean *	54.00 ^{b}	71.00 ^{a}	

*Mean of growing structure having similar letter are not significantly different at 5% level of significance, DMRT.

3. Number of Days to First Harvest

Number of days to first harvest is presented in Table 3.0. Analysis conferred that growing structure and growing season used in the study did not affect the number of days to first harvest. Apparently, 86.87 days during dry season was more number of days to first harvest than 81.72 days during wet season. There were no difference between the two treatments of growing structure as noted in the mean of 84.09 which contradicted to the findings of (Bergonio, 2001) that plants grown outside plastic tunnel took more days to harvest than plants grown outside plastic tunnel.

Table 3.0 Average number of days to first harvest of sweet bell pepper as affected by growing structure and season.

	SEASON		
GROWING STRUCTURE	**Wet**	**Dry**	**Mean ^{ns}**
GS $_{1}$- Inside Plastic Tunnel	80.38	87.80	84.09
GS $_{2}$- Outside Plastic Tunnel	83.07	85.98	84.53
Mean ^{ns}	81.73	86.89	

ns – not significant

4. Number of Days to Senescene

Table 4.0 showed that the earliest senescene period was 164 days after transplanting as demonstrated by plants grown outside plastic tunnel, while the longest was shown by bell pepper grown inside the plastic tunnel. On the growing seasons, bell pepper planted in wet season had shorter days to senescence with a mean of 132 days while those planted in dry season had longer days to senescence. It was also observed that there were significant effects of the growing structure and growing season to days of senescence. It was observed that the number of days to senescence of bell pepper grown inside plastic tunnel and planted in dry season was 268 and the ones grown outside plastic tunnel planted in dry season was 122 days.

The observed effects of extended senescene period of bell pepper was a positive influence of tunnel effect as suggested in the findings of Hancock (1988) that the more effective utilization of heat and light energy from the sun and the heat energy radiated from the soil through tunneling helped increase and extend the growing period of plants. An improved yield and extended cropping period was similarly reported by Robinson and Brae (1991).

Table 4.0 Average number of days to senescene of sweet bell pepper as affected by growing structure and season.

	SEASON		
GROWING STRUCTURE	**Wet**	**Dry**	**Mean ^{ns}**
GS $_{1}$- Inside Plastic Tunnel	143 ^{c}	268 ^{a}	206 ^{a}
GS $_{2}$- Outside Plastic Tunnel	122 ^{d}	205 ^{b}	164 ^{b}
Mean *	132 ^{b}	236 ^{a}	

*Mean of growing structure having similar letter are not significantly different at 5% level of significance, DMRT.

B. Yield and Yield Components

5. Number of Flowers

The interactions of the growing structure outside plastic tunnel and the growing season specifically wet season obtained the higher number of flowers with a mean of eleven (11) and fourteen (14) respectively. The lower ones were obtained from the interactions of growing structure inside plastic tunnel and the dry season with a means of eight (8) and five (5) respectively. The aforesaid results contradict the findings of the study of Bergonio which stated that

there is a significant influence of plastic tunnel to the number of flowers. The decrease of flower production was seen as caused by the warm effects inside the plastic tunnel and the rapid evaporation of soil moisture caused by dry season.

Table 5.0 Average number of flowers of sweet bell pepper as affected by growing structure and season.

	SEASON		
GROWING STRUCTURE	**Wet**	**Dry**	**Mean** ^{ns}
GS $_{1}$- Inside Plastic Tunnel	9	6	8 ^{b}
GS $_{2}$- Outside Plastic Tunnel	18	4	11^{a}
Mean *	14 ^{a}	5 ^{b}	

*Mean of growing structure having similar letter are not significantly different at 5% level of significance, DMRT.

6. Numbers of Fruits

As recorded, the outside plastic tunnel plants had more fruits of eight (8) as a mean compared to the inside tunnel plants which had only seven (7). Between the two growing seasons, wet obtained the higher number of fruits than the dry season with mean of ten (10) and six (6) respectively. These data preceded the idea of pollination that took place more outside the plastic tunnel than inside because more flowers were fertilized in outdoor rather than in tunneled.

These results explained that the temperature inside the plastic tunnel was higher in the absence of mulching materials that should have prevented too much evaporation, which then caused the lack or insufficient supply of water for fruit development. The observation that pointed out the mulching and tunneling applications to have increased the soil temperature and the unheated greenhouse conditions that in turn increased vegetative development band fruit yield of tomatoes.(Abdrabbo et. al, 1992)

Table 6.0 Average number of fruits of sweet bell pepper as affected by growing structure and season.

	SEASON		
GROWING STRUCTURE	**Wet**	**Dry**	**Mean** ^{ns}
GS $_{1}$- Inside Plastic Tunnel	8 ^{b}	5 ^{b}	6 ^{b}
GS $_{2}$- Outside Plastic Tunnel	11^{a}	6 ^{b}	8 ^{a}
Mean *	10 ^{a}	6 ^{b}	7 ^{b}

*Mean of growing structure having similar letter are not significantly different at 1% level of significance, DMRT.

7. Fruit Size

The biggest fruits in terms of growing structure were those from peppers grown inside plastic tunnel with a mean of 16.12 sq. cm and those ones grown during wet season in terms of growing season got the mean of 17.82 sq. cm. The smallest fruit noted were those from peppers outside plastic tunnel reached only the mean of 14.78 sq. cm and those ones planted during dry season in terms of growing season got a mean of 13.08 sq. cm. These observations were conformed

with an established findings that pepper crop development increases by the increase of soil temperature by the tunnel effect. (Gerber et. al., 1988) The raise of soil and air temperature inside plastic tunnel can increase the size and quality of pepper. (Brae and Robinson, 1991)

Table 7.0 Average fruit size (sq.cm) of sweet bell pepper as affected by growing structure and season.

	SEASON		
GROWING STRUCTURE	**Wet**	**Dry**	**Mean** ^{ns}
GS $_{1}$- Inside Plastic Tunnel	17.50 ^{a}	14.75 ^{b}	16.12 ^{a}
GS $_{2}$- Outside Plastic Tunnel	18.13 ^{a}	11.42 ^{c}	14.78 ^{b}
Mean *	17.82 ^{a}	13.03 ^{b}	

*Mean of growing structure having similar letter are not significantly different at 5% level of significance, DMRT.

8. Fruit Weight

Fruit weight of peppers varied significantly high both in the growing structure and in the growing season. The highest mean of fruit weight of 55.83 grams were from the peppers grown inside the plastic tunnel that was significantly different to the mean of 39.98 grams from peppers grown outside the plastic tunnel. Peppers planted on the wet growing season produced the highest weight of 90.41 grams than the peppers planted on the dry growing season which only had 5.59 grams.

Results further revealed a highly significant interaction effects among the growing structures and the growing seasons. Observations recorded the heaviest fruit with a mean of 106.01 grams from the peppers raised inside the plastic tunnel and planted in wet season and the lightest fruit of 5.39 grams mean from the ones outside the plastic tunnel and planted in dry season which means that the sweet peppers grown inside plastic tunnel increased their weight as claimed also by Singh, K et. al. (2007)

Table 8.0 Mean fruit weight (g) of sweet bell pepper as affected by growing structure and season.

	SEASON		
GROWING STRUCTURE	**Wet**	**Dry**	**Mean** ^{ns}
GS $_{1}$- Inside Plastic Tunnel	106.008 ^{a}	5.645 ^{c}	55.83 ^{a}
GS $_{2}$- Outside Plastic Tunnel	74.821 ^{b}	5.135 ^{c}	39.98 ^{b}
Mean *	90.410 ^{a}	5.390 ^{b}	

*Mean of growing structure having similar letter are not significantly different at 1% level of significance, DMRT.

9. Fruit Yield

The sweet bell pepper varieties grown inside plastic tunnel in two growing seasons yielded 901.57kg/ha, followed by those plants grown outside the plastic tunnel during wet and dry season with 765.54 kg/ha. In Table 8.0 explained highly significant difference on the growing structure,

season and interaction effects between the two growing structures, the inside and the outside plastic tunnel with the two growing seasons, the wet and dry season. Sweet bell pepper grown inside the plastic tunnel and planted during wet season produced the highest fruit yield of 1,366.39 kg/ha. The 436.7 kg/ha lowest yield of bell peppers grown inside the plastic tunnel and planted during dry season did not differ much from the 599.37 kg/ha attained by bell peppers outside the plastic tunnel and planted also during dry season. These observations agreed to the statement about the polyethylene films serving as sun selector that absorbed or reflected infrared radiation in the range of 7 to 15 microns of Ginegar (2003). The absorption or reflection in the said range reduced loss of energy that had been accumulated throughout the day in the greenhouse and prevented heat loss at night which resulted in 30% yield increase, he said further.

Table 9.0 Mean yield (kg/ha) of sweet bell pepper as affected by growing structure and season.

	SEASON		
GROWING STRUCTURE	**Wet**	**Dry**	**Mean** ^{ns}
GS $_{1}$- Inside Plastic Tunnel	1366.39 ^{a}	436.75 ^{c}	901.57^{a}
GS $_{2}$- Outside Plastic Tunnel	931.92 ^{b}	599.37^{c}	765.64^{b}
Mean *	1149.16 ^{a}	518.06^{b}	

*Means of growing structure having similar letter are not significantly different at 1% level of significance, DMRT.

Incidence of Pests

The presence of pests inside the plastic tunnel occurred only during dry season during flowering stage of sweet bell pepper. Warm temperature inside the plastic tunnel and direct protection by tunnel could have driven away the white flies, leaf miners and other insects. Yet five or less were seen and observed to damage two plants. Occurrence of pests to sweet bell peppers outside the plastic tunnel was observed both during rainy and dry season although population did not increase due to the early application of chemical control Deltrametrin (Decis). Leaf miners were seen infesting the leaves and puncturing the fruit with their tunnel while red ants stayed on the stem of the peppers. The insect pest infestation both inside and outside the growing structures was very negligible.

Incidence of diseases, both inside and outside the plastic tunnel on the other hand, was not observed in two growing seasons of the study.

Cost and Return of Sweet Bell Pepper

Table 10.0 reveals the returns on a hectare basis of sweet pepper grown inside plastic tunnel during wet season were able to pay back the cost of production and a return of Php 59,433.50. However, this income is not sufficient enough of raising sweet bell pepper for six months only, while sweet bell pepper grown both inside and outside plastic tunnel in two growing seasons (wet and dry) were all negative.

The cost of production incurred in bell pepper grown inside plastic tunnel was very much higher than the expenses incurred in bell pepper grown in open field due to the construction of

plastic tunnel. Losses were also high in bell pepper raised under plastic tunnel than raising bell pepper in an open field. Table 10.0 revealed the Return on Production Cost (RPC) of a hectare of sweet pepper production both inside and outside the plastic tunnel planted during wet and dry seasons. Sweet Bell Pepper grown inside plastic tunnel planted during wet season that generated a profit of about P 0.19 and P 0.16 respectively per peso invested for first cropping season. Based on the financial analysis, this research study can pay back the production cost for about two years (four cropping's) both inside and outside the growing structure.

The results point out that growing bell pepper under plastic tunnel is not economically feasible in short term for a big scale bell pepper production. A plastic tunnel is ideal for small- scale vegetable production.

Table 10.0 Estimated Return on Production (RPC) of a hectare of sweet bell pepper grown inside and outside plastic tunnel.

	WET SEASON			**DRY SEASON**		
Growing Structure	Net Income	Production Cost	RCP	Net Income	Production Cost	RCP
Inside Plastic Tunnel	(59,233.50)	315,900.00	(0.19)	(301,755.60)	315,900.00	(0.96)

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Responses of sweet bell pepper grown inside and outside plastic tunnel during wet and dry seasons manifested highly significant differences in the number of days to senescence, number of flowers, number of fruits, fruit size, fruit weight and fruit yield. Sweet bell pepper grown inside plastic tunnel performed best in most parameters particularly when planted during wet season.

Growing sweet pepper inside plastic tunnel both in wet and dry season to obtain maximum plant height, longer growing period, more flowers and fruit production, bigger fruit size, higher yield and higher income.

A similar study using drip irrigation and mulching to maintain the soil moisture especially to plants grown inside plastic tunnel and planted during dry season is recommended to obtain more conclusive results.

LITERATURE CITED

Gerber, J.M., Mohd-Khir, and Splittoesser, 1988. Row Tunnel Effects on Growth and Fruit Quality of Bell Pepper. HortScience, 26(3-4):191-197.

Ginegar, 2003 Cover Films for Greenhouse and Tunnel, Israel.

Nelson, P. U. 1978**.** Greenhouse Operation & Management, North Carolina, United State of America.

Abdrabbo, M.A, Farag A.A. and Hassan in, M. K. 1992. Irrigation Requirements for Cucumber under Different Mulch Colors. Retrieved from http://www.academia.edu/81491 17/Irrigation Requirements_for_Cucumberunder_Different_Mulch_Colors.

Bergonio, J.M. 2001. Effective, Absorption and Coefficient. Retrieved from www.science.gov/ Topicspages/e/effective+absorption+coefficients.html.

Feleafel, M.N. and Mirdad, Z. M. 2013. Optimizing the Nitrogen, Phosphorus and Potash Fertigation Rates and Frequency for Eggplant in Arid Regions. Retrieved from http:// www.fspublishers.org/published_papers/87019.

Grant, A. _____. Excessive Rain on Plants: How to Garden in Wet Ground. Retrieved from www.gardeningknowhow.com/plant-problems/environmental/excessive-rain-on-plants.htm.

Hancock, M. 1988. Mineral additives for thermal barrier plastic film. *Proceedings, Conference on `Plastics in the Nineties'*. Retrieved from http://keshilluesibujqesor.al/?p=19351988.

Robinson, D.W. and Brae, B. 1991. Developments in plastic structures and materials for horticultural crops. Retrieved from www.fftc.agnet.org

Robinson, D.W, and Brae, B. 1991. Developments in Plastic Structures and Materials for Horticultural Crops. Retrieved from http://www.agnet.org/library.php?func=view&id= 20110729171201.

Rusell, Joyce. 2011. Polytunnel superpower for your veg. Retrieved from http://www. telegraph. co.uk/gardening/gardeningadvice/8293920/Polytunnel-superpower-for-your-veg.html

Singh, K et. al. 2007. Effect of Low Poly-Tunnel on the Growth, Yield and Harvesting Span of Sweet Pepper. Retrieved from http://www.academia.edu/3621328/22.9

Wikipedia, The Free Encyclopedia. 2013. Plasticulture. Retrieved from https://en.wikipedia.org/ Wiki/Plasticulture.