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## EFFECT OF VARIOUS CONCENTRATIONS OF NITROBENZENE ON BELL PEPPER (*Capsicum annuum* L.) YIELD UNDER GREEN HOUSE CONDITIONS

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### Abstract

Bell pepper (*Capsicum annuum* L.) is grown extensively throughout the world especially in temperate countries. Poor fruit-set as well as loss of reproductive structures due to moisture stress is one of the major barriers to tropical adaptation of bell pepper. Hence the objective of the present study was to examine the effect of various concentrations of nitrobenzene (flowering stimulant and yield booster) on bell pepper yield. The study was conducted at a farmer poly tunnel located in Pilimathalawa (WU1), Sri Lanka. The experiment was laid out in a Completely Randomize Design (CRD) with four treatments randomized in three replicates. The treatments were T<sub>1</sub> – Control (without Nitrobenzene), T<sub>2</sub> – Nitrobenzene 15%, T<sub>3</sub> – Nitrobenzene 20%, T<sub>4</sub> – Nitrobenzene 25%. Plants were established in drip-fertigated bags in the Poly tunnel and standard crop management practices were applied throughout the study. Nitrobenzene was sprayed to the seedlings 40, 55, 80 and 105 days after planting. Albert solution, 6: 30: 30 fertilizer mixture 20: 20 fertilizer mixture and Ca(NO<sub>3</sub>)<sub>2</sub> were used as recommended fertilizers. Measurements were taken on flowering, fruit setting, yield as well as the quality of the fruits. The data obtained were tabulated and analysed subjected to the Analysis of Variance (ANOVA) procedure of Statistical Analysis System (SAS). Duncan's New Multiple Range Test (DNMRT) was performed to compare the differences among treatment means at  $p=0.05$ . The highest number of fruits and flowers plant<sup>-1</sup> was observed in T<sub>3</sub> and T<sub>4</sub>, i.e. 20% and 25% Nitrobenzene applied treatments. On the other hand, the lowest number of flowers as well as fruits were recorded from T<sub>2</sub> (15% nitrobenzene) and T<sub>1</sub> (control of the experiment). Among different treatments tested, 25% nitrobenzene applied plants showed superior results in contrast to other nitrobenzene levels with enhancing flowering, fruit setting, yield quality as well as post-harvest performance under greenhouse conditions.

**Key words:** Bell pepper, Fruit setting, Nitrobenzene, Poly tunnel, Quality, Yield

### INTRODUCTION

Bell pepper (*Capsicum annuum* L.) is one of the most important vegetable crops grown extensively throughout the world especially in temperate countries. The crop is very sensitive to environmental factors (Bhatt *et al.*, 1992). The optimum temperature requirement for bell pepper growth ranged from 16-25°C (Boswell, 1964). Higher night temperature is more detrimental to fruit set than the day temperature (Rylski and Spigelman, 1982). When large fruited bell peppers are exposed to environmental stresses during the flowering and fruiting period, abscission of flowers and flower buds occurs (Cochran, 1936). This loss of reproductive structures can result in

serious yield decrease, and constitutes a major risk factor in pepper production. Nitrobenzene is a combination of nitrogen and plant growth regulators, extracted from sea weeds that act as plant energizer, flowering stimulant and yield booster (Aziz and Miah, 2009). Nitrobenzene produces best results in combination with plant growth regulators, which have capacity to increase flowering in plant and also prevent flower shedding. It is specially recommended for vegetable crops and flowering plants (Khalil and Mandurah, 1989). Nitrobenzene 20% w/w is a new generation plant energizer and yield booster of low cost PGRs compared to others. Nitrobenzene is quickly absorbed into the plants. It influences the bio chemical pathway of the plants to uptake more

nutrients from the soil. It also increases the nutrient use efficiency thus improves the vegetative growth. Induces profuse flowering and helps in the retention of the flowers and fruits (Mithila *et al.*, 2012). On the other hand, 'Flora' improves the organoleptic factors and keeping quality of the produce, which increases the harvestable yield of any crops (Karim and Fattah, 2004). As a further improvement step for greenhouse fruit set of bell pepper, nitrobenzene can be adopted. Four sprays of nitrobenzene during 40, 55, 80 and 105 days after sowing (DAS) improve the yield up to 40 %. Unfortunately, very limited research has been carried out regarding the use of growth regulators on bell pepper varieties in Sri Lanka. Therefore, this research was designed to study the effect of various concentrations of nitrobenzene on bell pepper yield and the quality. Furthermore, it was expected to assess the most effective nitrobenzene concentration to reduce cost of production in order to improve the profit.

## MATERIALS AND METHODS

**Experimental design and treatments:** The experiment was laid out in a Completely Randomize Design (CRD) with four treatments randomized in three replicates. The treatments were four different concentrations of nitrobenzene (%) applied to the seedlings to cover whole aerial parts of the plant as an aqueous spray by using a hand sprayer as given below.

Treatments	Nitrobenzene levels (%)
T1	Control (without nitrobenzene)
T2	Nitrobenzene 15%
T3	Nitrobenzene 20%
T4	Nitrobenzene 20%

**Planting materials and handling:** The study was conducted at a farmer Poly tunnel located in Pilimathalawa (WU1- Wet Zone area in Up country), Sri Lanka. Plants were established in drip-fertigated bags in the Poly tunnel and standard crop management practices were done

through out the study. Nitrobenzene was sprayed at the 40, 55, 80 and 105 days after transplanting of seedlings in pots. Albert solution, 6: 30: 30 fertilizer mixture and  $\text{Ca}(\text{NO}_3)_2$  were used as recommended fertilizers.

**Measurements:** Data were collected at 50, 65, 90 and 115 days after transplanting. Measurements were taken on growth, yield and yield determining parameters with post-harvest quality. Bell peppers are harvested at an immature stage when they are in full size and green. The total yield was measured directly in the field by using a digital balance with four digits. Ten fruits were selected randomly from each treatment and kept in normal environmental conditions and at the same time remaining five fruit samples were kept in refrigerator to determine the shelf life (days). At the same time weight loss was recorded at five days intervals by using a digital balance.

**Statistical Analysis:** The data obtained were tabulated and analysed subjected to the Analysis of Variance (ANOVA) procedure of Statistical Analysis System (SAS). Duncan's New Multiple Range Test (DNMRT) was performed to compare the differences among treatment means at  $p=0.05$ . Correlation analysis was used to determine the strength of the relationships between measured parameters of bell pepper.

## RESULTS AND DISCUSSION

**Evaluation of plant growth parameters:** Among different treatments tested, the plant growth parameters did not show any significant differences ( $p>0.05$ ) between T3 and T4, i.e. 20% and 25% nitrobenzene applied treatments. But, control treatment showed the lowest values when compared to other growth parameters in the experiment. On the other hand, the highest number of flowers  $\text{plant}^{-1}$  was observed from the treatment T4, i.e. 25% nitrobenzene applied treatment whilst the lowest number of flowers was observed from the control (Table-1).

**Table-1. Effect of different concentrations of nitrobenzene on growth parameters of bell pepper**

Treatments	Plant height (cm)	Plant girth (cm)	Number of leaves $\text{plant}^{-1}$	Leaf Area Index	Number of flowers $\text{plant}^{-1}$	Number of fruits $\text{plant}^{-1}$
(T1)	63.92 <sup>b</sup>	3.55 <sup>b</sup>	38.44 <sup>b</sup>	0.26 <sup>a</sup>	7.22 <sup>b</sup>	4.67 <sup>b</sup>
(T2)	66.00 <sup>ab</sup>	3.61 <sup>b</sup>	41.21 <sup>a</sup>	0.27 <sup>a</sup>	7.66 <sup>b</sup>	6.17 <sup>a</sup>
(T3)	66.56 <sup>a</sup>	3.93 <sup>a</sup>	41.39 <sup>a</sup>	0.28 <sup>a</sup>	10.64 <sup>a</sup>	6.25 <sup>a</sup>
(T4)	67.65 <sup>a</sup>	3.97 <sup>a</sup>	41.27 <sup>a</sup>	0.31 <sup>a</sup>	10.89 <sup>a</sup>	6.92 <sup>a</sup>

Means followed by the same letter/s along the column are not significantly different at  $P=0.05$

The highest concentration of Auxin and Gibberellins is present in 25% of nitrobenzene which influences the elongation of cells so that the plant height is increased dramatically. According to the study findings of Nickell (1982) and Richard (1985), the cell growth and elongation are influenced by Auxins and Gibberellins. Cytokinin and Auxin with higher ratios of nitrobenzene influence the lateral growth of parenchyma cells in stem so that the plant girth is increased with higher concentrations of nitrobenzene (Hutchinson *et al.*, 2002). The best concentration of nitrobenzene is present in 20% and 25% nitrobenzene which influence to increase the flowering in plant, prevent flower shedding, enhance early flowering and plants take less time to flower so that the number of flowers is increased for the highest concentration of nitrobenzene (Kumar, 2011). This would have helped in the early transformation from the vegetative phase to reproductive phase. The induction of early flower bud initiation might

be influenced by triggering of such metabolic processes and narrowing of the carbon: nitrogen ratio by the significant accumulation of carbohydrates. The result on earliness in flowering in this experiment goes with the study findings of Singh and Mukherjee (2000).

**Evaluation of yield determining parameters:**

The highest fruit weight was observed from 25% nitrobenzene applied treatment and the lowest was recorded from control treatment. Nuruzzaman *et al.* (2015) also found that the maximum fruit weight was provided by the foliar application of nitrobenzene on strawberry. On the other hand, the fruit length did not show any significant difference ( $p>0.05$ ) among treatments tested. These results were supported by Sharma *et al.* (1999) in bell pepper. The increase in fruit length may be attributed to increase in the number and elongation of cells which are the characteristic actions of any auxinic group of chemicals.

Table-2. Effects of different concentrations of Nitrobenzene on yield parameters

Treatment	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Pericarp thickness (mm)
(T1)	240 <sup>c</sup>	14.6 <sup>b</sup>	28.2 <sup>b</sup>	10.0 <sup>b</sup>
(T2)	246 <sup>bc</sup>	15.5 <sup>a</sup>	28.7 <sup>a</sup>	11.6 <sup>ab</sup>
(T3)	252 <sup>ab</sup>	15.6 <sup>a</sup>	28.8 <sup>a</sup>	12.4 <sup>ab</sup>
(T4)	256 <sup>a</sup>	16.1 <sup>a</sup>	28.8 <sup>a</sup>	13.6 <sup>a</sup>

Means followed by the same letter/s along the column are not significantly different at  $P=0.05$

The highest pericarp thickness was recorded in 25% nitrobenzene applied treatment and lowest thickness was recorded in the control treatment. On the other hand, T2 and T3, i.e. 15% and 20% nitrobenzene did not show any significant effect ( $p>0.05$ ) (Table-2). The enhanced concentration of Auxin in Nitrobenzene on the pericarp due to external application of Nitrobenzene would have diverted the photo-assimilates to develop the cell wall of the pericarp instead of the ovules. The

similar results were reported by Lyngdon and Sanyal (1992) in capsicum.

**Total yield per plant (kg):** The highest yield was recorded for 25% of nitrobenzene applied treatment and lowest yield was recorded in control treatment. Total yield for the rest of the concentrations was in between these limits (Figure 1).

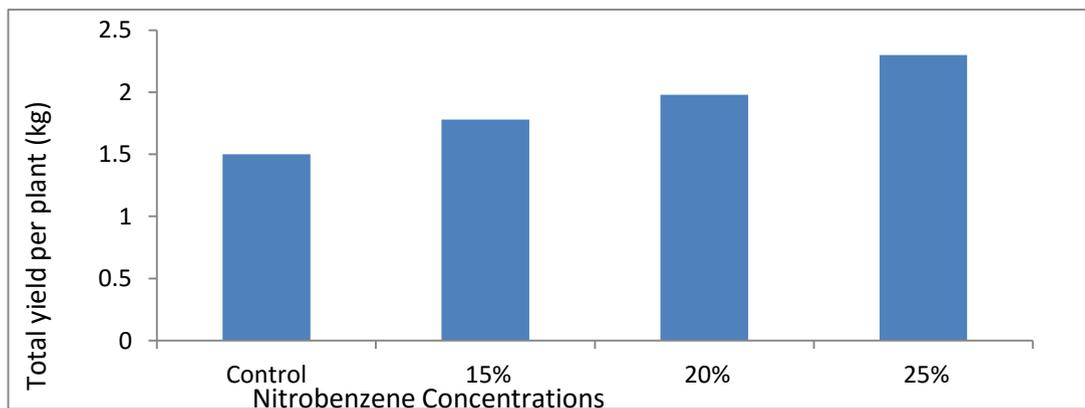


Figure 1 Effect of different concentrations of nitrobenzene on total yield (kg) of Bell pepper

nitrobenzene is quickly absorbed into the plants, which has capacity to increase the flowering in plants and maximum number of fruits plant<sup>-1</sup> (Mithila *et al.*, 2012). The highest yield plant<sup>-1</sup> was recorded in the 25% nitrobenzene applied treatments and lowest yield plant<sup>-1</sup> was recorded in control treatment. Nitrobenzene increased the fruit weight as well as the fruits size, thus the total yield increased due to its application as compared to the control treatment (Singh *et al.*, 2007). Nitrobenzene can be used as spray or in granular form, which increases flower forming substances by altering auxin, cytokinin, gibberellic acid and Ethylene ratio favourably tilting to a higher level of flower forming substances, thereby increasing flowers by more than 40 to 45% and yield

(Theenachandran, 2005).

**Correlation Analysis:** When linear correlation analysis was performed for the overall data set, there was a highly significant ( $p < 0.0001$ ) positive correlation between plant height and number of fruits per plant. On the other hand, there was a significant ( $p = 0.05$ ) positive correlation among shelf life of bell pepper fruits, total yield per plant, number of flowers per plant as well as number of fruits per plant. Leaf area index showed a non-significant ( $p > 0.05$ ) correlation amongst yield parameters. Furthermore, there was a highly significant positive correlation apparent amongst number of flowers plant<sup>-1</sup>, number of fruits plant<sup>-1</sup> as well as the total yield of bell pepper (Table-3).

Table-3. Linear correlation coefficients between Plant Height (PH), Plant Girth (PG), Leaf Area Index (LAI), Number of Flowers Plant<sup>-1</sup> (NFLO), Number of Fruits Plant<sup>-1</sup> (NFUPP), Total yield Plant<sup>-1</sup> (TYLD) and Shelf Life (SL) of bell pepper

	PH	PG	LAI	NFLO	NFUPP	TYLD	SL
PH	-						
PG	0.71624**	-					
LAI	-0.08192 <sup>ns</sup>	0.21027 <sup>ns</sup>	-				
NFLO	0.61762*	0.87982**	0.35235 <sup>ns</sup>	-			
NFUPP	0.91320***	0.65674*	0.02409 <sup>ns</sup>	0.70117*	-		
YYLD	0.75055**	0.87640**	0.28498 <sup>ns</sup>	0.86007**	0.81251**	-	
SL	0.59750*	0.57419*	0.29882 <sup>ns</sup>	0.60661*	0.68439*	0.61555*	-

NS (non-significant at  $p = 0.05$ ); \* (significant at  $p < 0.05$ ); \*\* (significant at  $p < 0.01$ ); \*\*\* (significant at  $p < 0.0001$ )

## CONCLUSION

Results enumerated that the application of nitrobenzene had a significant ( $p < 0.05$ ) effect on growth, yield and quality parameters of bell pepper. Among different treatments tested, 25% nitrobenzene showed optimum results to ensure the yield as well as the post-harvest performance of bell pepper. However, 20% (T3) and 25% (T4) nitrobenzene applied treatments did not show much difference in growth and yield parameters tested. A long shelf life was observed in T4 i.e. 25% nitrobenzene applied treatment. Furthermore, high nitrobenzene levels showed a significant positive impact on post-harvest quality of bell pepper with extending the shelf life. In the light of this situation, the application of 25% nitrobenzene can be considered the most effective treatment to

get better yield from bell pepper under greenhouse conditions.

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