STANDARDISATION OF FERTIGATION SCHEDULE AND SPACING FOR BELL PEPPER (*Capsicum annuum* L.var.grossum sendt.) in POLYHOUSE.

by

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(2015 - 11 - 030)

THESIS

Submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM – 695 522
KERALA, INDIA

2017

DECLARATION

I, hereby declare that this thesis entitled **"STANDARDISATION OF FERTIGATION SCHEDULE AND SPACING FOR BELL PEPPER (*Capsicum annuum* L.var.grossum sendt.) IN POLYHOUSE"** is a bonafide record of research done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani,
Date: 01-08-2017

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CERTIFICATE

Certified that this thesis entitled **"STANDARDISATION OF FERTIGATION SCHEDULE AND SPACING FOR BELL PEPPER (*Capsicum annuum* L.var.grossum sendt.) IN POLYHOUSE"** is a record of research work done independently by Ms. Athira, R. C. (2015-11-030) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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ACKNOWLEDGEMENT

First of all, I bow my head before Lord Almighty for his kindness, countless blessings and unspeakable help rendered through various hands throughout, which made this venture a success.

I would like to put on record of my heartfelt sincere gratitude to ***Dr. T. Sajitha Rani****, Professor (Agronomy), College of Agriculture Vellayani, esteemed chairman of the advisory committee, for her expert and inspiring guidance, timely advice, constant encouragement, motherly affection and understanding throughout the course of this investigation and preparation, critical evaluation of this thesis, without which this work would not have seen the light of the day. I feel proud of myself in confessing that it has been an unique privilege for me to have been one of her students.*

I express my gratitude to the members of the advisory committee, ***Dr. Sheela K. R****, Professor and Head, Department of Agronomy, Associate Professor* ***V. Jayakrishnakumar****, (Agronomy) and Professor* ***Dr. Roy Stephen*** *(Plant Physiology) for their valuable suggestions, moral support, timely correction of thesis and encouragement.*

I gratefully acknowledge ***Cicil chandran*** *(farmer) and labourers of his farm for their co-operation and help during the conduction of the experiment.*

I wish to place on record my thanks to ***Shibu, Vimala, Rajitha, Reshmi, Soumya*** *and* ***Akhil*** *(non teaching staff of Agronomy Department) for their sincere and wholehearted co-operation throughout the research work.*

I am thankful to Kerala Agricultural University for providing the Kerala Agricultural University Junior Fellowship.

I avail this opportunity to express my sincere regards to my batchmates, especially ***Anjana, S., Reshma, M. R., Akhila, C. Thampi., Limisha, N. P., Sethulakhmi, V. S., Bashma, E. K., Harishma, S. J., Gauntamukkala Babu***

Rao., and Madankumar, M. *and my senior and junior friends for their unreserved help during the course of my study.*

At this moment, I recall with love and gratitude, the constant encouragement, prayers, inspiration, blessings and moral support given to me by my parents ***Chandrika, S****. and* ***Ravikumar, K****., sister* ***Anju, R. C****, brother in law* ***Sandeep, H. B. Nair*** *and cousins* ***Athul, H. B, Athulya, H. B****. and* ***Adithya Bhaskar*** *and all other family members.*

Finally, I thank all those people who have supported me during my post graduation programme and helped for the successful completion of this thesis.

Athira

ATHIRA, R.C.

CONTENTS

LIST OF ABBREVIATIONS

@	at the rate of
°C	Degree Celsius
%	Per cent
₹	Rupees
CD	Critical difference
cm	Centimetre
DAT	Days after transplanting
DMP	Dry matter production
et al.	And others
Fig.	Figure
FYM	Farmyard manure
ha^{-1}	Per hectare
g	Gram
g^{-1}	Per gram
K	Potassium
K_2O	Potash
kg ha^{-1}	Kilogram per hectare
K. lux	Kilolux

LIST OF ABBREVIATIONS CONTINUED

LAI	Leaf area index
L^{-1}	Per litre
m^{-2}	Per square metre
Max.	Maximum
mg	Milligram
Min.	Minimum
ml	Millilitre
MOP	Muriate of potash
N	Nitrogen
No.	Number
NS	Non significant
P	Phosphorus
P_2O_5	Phosphate
$Plant^{-1}$	Per plant
q ha^{-1}	Quintal per hectare
RH	Relative humidity

LIST OF ABBREVIATIONS CONTINUED

SE	Standard error
Sl.	Serial
t	Tonnes
$t\ ha^{-1}$	Tonnes per hectare
viz.	Namely

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INTRODUCTION

1. INTRODUCTION

Bell pepper (*Capsicum annuum* L.var.grossum sendt.) also known as capsicum, sweet pepper or shimla mirch is one among the most popular vegetables grown in polyhouses worldwide. It is a native of Mexico and was introduced in India by the British in the 19th century in Shimla hills. The bell pepper fruits are available in different attractive colours and they have great demand in Indian markets. Bell pepper is non-pungent and sweet with thick flesh. Bell pepper has attained status of a high value vegetable and occupies a pride place among vegetables because of more consumer preference and uses in various culinary purposes coupled with delicacy and pleasant flavor.

Bell pepper is rich in proteins, vitamin A, ascorbic acid, riboflavin, thiamin, niacin and minerals like potassium, magnesium and calcium (Joshi and Singh, 1975). The vitamin A and viatamin C content of red bell pepper are more compared to green. Bell pepper protects against rheumatoid arthritis and free radicals, promotes lung and heart health, lowers cholesterol and functions as an antioxidant (Ensminger and Esminger, 1986). Bell pepper is low in calories, high in complex carbohydrates and contains no fat. It is also a good source of dietary fibre and folate (Kumar *et al*. 2015).

Bell pepper is used for the preparation of various delicious food items either as raw or cooked. It can be eaten as salads, soup or cooked in stir-fries. It is one of the popular ingredients of fast food items such as pizza, burger, stuffings and pasta.

Being a cool season crop, year round production of quality bell pepper fruits is not possible in open field condition. Crops are more vulnerable to weather fluctuations in open field (Ochigbu and Harris, 1989) with more pests and diseases incidence leading to low productivity as well as quality. Besides this, the shrinking land area for cultivation also hampers vegetable production. Protected cultivation techniques can be effectively utilized for the production of good quality produce with high productivity. In protected condition microclimate surrounding the plant is controlled fully or partially, as per the requirement of crop species grown (Mishra *et al.*, 2010). Compared to open field cultivation, polyhouse cultivation resulted in 2-3 times yield enhancement in bell pepper (IIHR, 2011).

The most important factors of crop production *viz.,* water and nutrients are becoming costlier over the years. Efficient use of these inputs are necessary for survival of agriculture due to shrinking land area, energy crisis, increasing cost of cultivation, wide spread pollution and fast degradation of natural resources. Loss of nutrients and water can be minimized by application of fertilizers and water to the crop root zone based on crop requirement. In modern agriculture fertigation (application of fertilizers along with irrigation water) is gaining importance as the practice helps to enhance the productivity. It also helps to reduce labour, increase fertilizer use efficiency and increase flexibility of fertilizer application (Haynes, 1985).

Efficient and optimum application of fertilizer under protected condition ensures improved growth, yield and quality of bell pepper along with minimized loss of inputs and increased economic benefits. Among the essential elements NPK has great influence on crop productivity and quality. Nitrogen is essential for synthesis of chlorophyll, amino acid, vitamins, nucleic acid and protein synthesis. Phosphorous has significant influence on energy storage and transfer, root formation, flower setting, fruit and seed formation while potassium plays a key role in various biological activities.

In recent years foliar application of water soluble fertilizers has gained importance. Application of nutrients in foliar form is very effective when soil nutrient availability is limited and root activities of plants are low. It helps to reduce the nutrient loss and improve the efficacy of applied nutrients. More over nutrients penetrate through the stomata or leaf cuticle and rapidly diffuse into the cell thus help to ameliorate nutrient deficiencies rapidly. Thus, foliar application of nutrients in plants helps to enhance the yield and quality of produce.

Green house production technology of vegetables emphasizes the need for having appropriate plant densities in order to boost up the production per unit area by utilizing the available space and nutrients. Growth and yield of bell pepper is highly affected by plant spacing (Islam *et al.*, 2011). Adoption of appropriate plant spacing is one of the important aspects of successful crop production. Optimum plant spacing ensures proper growth and development of plants resulting in maximum yield of crop and economic use of land. Yield of bell pepper is positively influenced by plant density.

There is not much information available on fertigation scheduling and response of bell pepper to varying plant population in polyhouse situation. Hence the present study has been planned with the following objectives:

1. To standardize suitable fertigation schedule for bell pepper under polyhouse condition.
2. To standardize suitable spacing for bell pepper under polyhouse condition.
3. To work out the economics of growing bell pepper under polyhouse condition.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Bell Pepper (*Capsicum annuum* L. var. grossum sendt) is one among those vegetables widely cultivated in polyhouses. The coloured fruits of bell pepper are of great demand in Indian markets. Adoption of ideal fertigation schedule and spacing under polyhouse condition help farmer to increase marketable yield and reduce cost of production thereby fetching high net returns.

The literature pertaining to fertigation dose, spacing and foliar application have been reviewed and presented in this chapter.

2.1 Effect of Nutrients on Growth Attributes of Bell Pepper

Shrivastava (1996) in an experiment to study the influence of fertilizer doses on bell pepper reported that taller plants were produced at higher dose of NPK (250:200:200 kg ha^{-1}).

Raut (2001) in an investigation to study the influence of levels of fertigation on bell pepper grown under polyhouse condition at Rahuri, Maharashtra reported that vegetative parameters of plant like plant height (249.40 cm) and number of leaves (872.80) were higher for 80 per cent recommended dose of fertilizers (280: 32: 416 kg ha^{-1}) through water soluble fertilizers.

Ghoneim (2005) in a study on the performance of bell pepper under different levels of N fertigation (60, 90 and 120 kg ha^{-1}) observed that plant height, number of leaves, leaf area and dry matter production were significantly increased with higher N fertigation.

Alabi (2006) studied the influence of different levels (0, 25, 50, 75, 100 and 125 kg ha^{-1}) of P fertilizer on growth and yield of pepper and noted that plant height, number of leaves, branches and leaf area increased when P dose was increased from 0 to 125 kg ha^{-1}.

Chaudhary *et al.* (2007) in a trial to study the effect of N (100, 150, 200 and 250 kg N ha^{-1}) and P (100, 150 and 200 kg P_2O_5 ha^{-1}) in bell pepper reported that plant height and number of branches $plant^{-1}$ were positively influenced by higher N dose.

El-Bassiony *et al.* (2010) in an experiment to study the effect of levels of K (50, 100 and 200 kg ha^{-1}) on growth and yield of bell pepper reported that the tallest plants, highest number of leaves $plant^{-1}$, branches $plants^{-1}$ as well as highest fresh and dry weights of leaves were obtained at 200 kg ha^{-1} of K.

IIHR (2011) suggested the fertilizer recommendation for bell pepper under protected cultivation as 50:62.5:50 kg N, P_2O_5 and K_2O ha^{-1} as basal dose followed by fertigation with 12 kg (19:19:19), 4.5 kg (potassium nitrate) and 4.5 kg (calcium nitrate) ha^{-1}.

Aminifard *et al.* (2012) in trials on effect of four levels of N (0, 50, 100, and150 kg ha^{-1}) in bell pepper observed that application of 100 kg ha^{-1} produced the highest number of lateral stem (9.08).

Ayodele *et al.* (2015) in an experiment in hot pepper to study the effect of four levels of N (0, 25, 50 and 75 kg ha^{-1}) reported that 75 kg ha^{-1} of N increased plant height, number of leaves, number of branches and leaf area $plant^{-1}$.

2.2 Effect of Nutrients on Yield and Yield Attributes of Bell Pepper

According to Moshe, Sne. (1988) the optimum NPK recommendation for bell pepper under protected condition is 350:40:520 kg NPK ha^{-1}

The influence of nitrogen fertigation (0, 84, 168, 252 and 356 kg ha^{-1}) on bell pepper was studied by Hartz *et al.* (1993) and it was confirmed that the maximum yield and fruit size increased upto 252 kg ha^{-1} beyond that N has a suppressive effect.

The effect of N fertigation on fruit yield of bell pepper was examined by Olsen *et al.* (1993) and it was observed that fruit yield was maximum with N fertigation @ 210 to 280 kg ha^{-1} as 10 equal doses through fertigation.

Neary *et al.* (1995) in a study conducted in sandy loam soil reported that the weight of bell pepper fruits increased when the N fertigation was increased upto 230 kg ha^{-1}

Shrivastava (1996) in an investigation to study the influence of fertilizer dose on bell pepper reported that the highest fruit weight (128 g), yield $plant^{-1}$ (628 g) and yield ha^{-1}(92.95 q) was obtained from NPK dose of 250:200:200 kg ha^{-1}.

Aliyu (2002) examined the influence of different levels of N (0, 80, 160, 240 and 360 kg ha^{-1}) and P application (0, 22 and 44 kg ha^{-1}) and plant population on bell pepper and it was reported that the yield increased upto 240 kg ha^{-1} of N.

Ghoneim (2005) in a study to evaluate the performance of bell pepper under different levels of N fertigation (60, 90 and 120 kg) noted that yield $plant^{-1}$, number of fruits $plant^{-1}$ and average fruit weight were obtained under 90 kg of N.

Chaudhary *et al.* (2007) in a trial to study the effect of different levels of N (100, 150, 200 and 250 kg N ha^{-1}) and P (100, 150 and 200 kg P_2O_5 ha^{-1}) in bell pepper reported that 250 Kg N ha^{-1} resulted in the highest yield ha^{-1} which was on par with 200 kg N ha^{-1} and application of P up to 150 kg ha^{-1} has significant influence on the yield and yield attributes of bell pepper.

An investigation to study the influence of different levels of P (0, 10, 15 and 20 kg potassium sulphate $polyhouse^{-1}$) on bell pepper grown under polyhouse (504 m^{-2}) was done by Idan (2016) and it was reported that 20 kg of K_2SO_4 registered maximum number of fruits (22.10), yield $plant^{-1}$ (4.07 kg) and total yield (3.25 tones) under poly house (504 m^{-2}).

Mishra *et al.* (2016) in an experiment to evaluate the influence of different levels of N (125, 150, 175 and 200 Kg ha^{-1}) and P (125 and 150 Kg ha^{-1}) on bell pepper reported that most of the yield and yield attributing characters were increased with higher dose of N and K. However, the optimum dose of N and K were reported as 175 kg ha^{-1} N and 150 kg ha^{-1} K along with 75 kg ha^{-1} P.

Sharma (2016) in a study on bell pepper grown under polyhouse reported that the increased dose of NPK gave higher fruit yield ha^{-1}. It was also noted that when 50 % more of the recommended dose (150:112.5:112.5) of NPK was applied, there was a yield enhancement of 96.10 % over 50 % less than recommended dose of NPK.

2.3 Effect of Nutrients on Quality Attributes of Bell Pepper

Ghoneim (2005) evaluated the performance of bell pepper under different levels of N fertigation (60, 90 and 120 kg ha_{-1}) and noted that total soluble salts, K content and ascorbic acid content were high under 90 kg of N fertigation.

Candido *et al.* (2009) investigated the influence of different N levels (0, 100, 200, 300 kg ha^{-1}) on yield and quality with and without water stress on bell peppers grown under plastic green house and it was noted that 200 kg ha^{-1} N produced the highest yield and good quality fruits.

El-Bassiony *et al.* (2010) in an experiment to study the effect of levels of K (50, 100 and 200 kg ha^{-1}) on growth and yield of bell pepper reported that average fruit weight, fruit length and vitamin C content were significantly increased with higher dose of K.

Aminifard *et al.* (2012) in a trial to evaluate the effect of four levels of N (0, 50, 100, and150 kg ha^{-1}) on bell pepper reported that increasing N level from 50 to 150 kg ha^{-1} decreased the vitamin C content.

The effect of nitrogen fertilizer on hot pepper was studied by Ayodele *et al.* (2015) and it was reported that application of N increased the carbohydrate, fat, protein, ash, crude fibre, vitamin C and mineral content.

Rekha *et al*. (2017) reported that 100 per cent recommended dose of NPK along with irrigation at 0.75 IW/CPE registered higher yield and good quality fruits in bell pepper.

2.5 Effect of Nutrients on Nutrient Uptake of Bell Pepper

Qawasmi *et al*. (1999) evaluated the response of bell peppwer grown in plastic house to nitrogen fertigation and it was reported that higher levels of N increased the nitrogen uptake by plants and at the same time enhanced the uptake of P and K.

2.5 Effect of Nutrients on Economics of Bell Pepper Cultivation

Raut (2001) in an investigation to study the influence of fertigation on bell pepper grown under polyhouse condition observed that the maximum net returns (Rs.1,18,650/-) was obtained from 80 per cent recommended dose (280:32:416 kg ha^{-1}) through water soluble fertilizers.

Brahma *et al*. (2010) in an experiment to study the effect of N and P fertigation on growth, yield, quality and economics of bell pepper cultivation under naturally ventillated polyhouse reported that 100 per cent recommended dose of N and K (120: 60 kg ha^{-1}) increased growth, yield, quality of fruits and B: C ratio (1: 1.72).

Singh *et al*. (2016) in a study to examine the influence of different source of manures on bell pepper production and it was confirmed that 50 % FYM (10 t ha^{-1}) + 50 % NPK (50:30:30 kg ha^{-1}) + Biofertilizers (*Azospirillum and phosphotica*) produced the highest profit under polyhouse.

2.5 Effect of Spacing on Growth Characters of Bell Pepper

The effect of plant density on growth and yield of paprika pepper was studied by Aminifard *et al*. (2012) and it was reported that plant height, leaf chlorophyll content and lateral stem length decreased when plant density was increased.

Islam *et al.* (2011) studied the effect of three levels of spacings (50 cm x 50 cm, 50 cm x 40 cm, 50 cm x 30 cm) on bell pepper and it was reported that closer spacing (50 cm x 30 cm) produced the tallest bell pepper plants, while number of leaves and branches plant^{-1} significantly increased with wider plant spacing.

Ganjare *et al.* (2013) studied four levels of plant spacings (50 cm x 45 cm, 50 cm x 55 cm, 50 cm x 65 cm and 50 cm x 75 cm) in bell pepper and it was observed that plant height, number of branches plant^{-1}, leaf area and stem diameter increased with wider spacing.

The influence of four levels of plant spacings (60 cm x 40 cm, 60 cm x 50 cm, 60 cm x 60 cm, and 60 cm x 75 cm) on growth of bell pepper was studied by Alabi *et al.* (2014) and it was reported that plant height, number of leaves, number of branches, leaf area plant^{-1}, leaf area ratio, leaf, stem and root dry matter yield, relative growth rate, net assimilation rate increased with increased spacing and the highest values were obtained from the spacing 60 cm x 75 cm.

Kumar and Chandra (2014) studied the effect of three levels of spacing (45 cm x 30 cm, 45 cm x 45 cm, 45 cm x 60 cm) on bell pepper under polyhouse and it was reported that the maximum number of leaves plant^{-1} (105.67) obtained when plants were spaced wider while the tallest plants (147.21 cm) were obtained from closer spacing.

The effect of three levels of plant spacing (60 cm x 45 cm, 45 cm x 45 cm and 45 cm x 30 cm) on growth and yield of bell pepper was studied by Kamboj and Sharma (2015) and it was confirmed that plant height, number of branches plant^{-1} and plant spread/ canopy width were highest for the spacing 60 cm x 45 cm.

2.6 Effect of Spacing on Yield and Yield Attributes of Bell Pepper

Metwally *et al.* (1982) studied different spacings (20 cm, 30 cm and 40 cm within row) and (60 cm, 70 cm and 90 cm inter rows) and reported that the highest fruit yield in bell pepper was obtained at 30 cm x 60 cm.

Manchanda *et al.* (1988) in a study on the effect of different spacings (45 cm x 20 cm, 45 cm x 30 cm or 45 cm x 40 cm) and N application (40, 80, 120 or 160 kg ha^{-1}) of bell pepper reported higher plant density with higher levels of N produced the highest yield (115.4 q ha^{-1}).

Sanchez *et al.* (1993) reported that lower the plant density, larger will be the fruit size in bell pepper

Clough and Bratsch (1994) in a trial on spacing of bell pepper reported that increased plant density decreased leaf area and dry matter content.

A study was done by Locascio and Stall (1994) to find out the effect of spacing on bell pepper and it was reported that yield $plant^{-1}$ decreased with increased plant population m^{-2}.

According to Cebula (1995) higher plant density (8 plants ha^{-1}) and plants pruned to one shoot increased yield in green house bell pepper.

Aliyu (2002) examined the influence of different levels of N and P application and plant population (20000, 40000 and 60000 plants ha^{-1}) on bell pepper and reported that the yield $plant^{-1}$ decreased with increased plant population while yield ha^{-1} was highest when plant population was highest (60000 plants ha^{-1}).

Jovicich *et al.* (2004) in a study on green house bell pepper to examine the influence of plant densities (2, 3 and 4 plants m^{-2}) and pruning reported that increasing plants m^{-2} to 4 increased the marketable yield.

Choudhary and Singh (2006) reported that the maximum fruit yield ha^{-1} was recorded at 60 cm x 50 cm spacing which was significantly superior to 75 cm x 50 cm spacing but on par with spacing 45 cm x 50 cm.

Chaudhary *et al.* (2007) reported that yield ha^{-1} in bell pepper can be increased by decreasing the plant spacing.

Zende (2008) in a trial to find out production technique of bell pepper under protected condition with three levels of spacing (45 cm x 30 cm, 45 cm x 45 cm, 45 cm x 60 cm) observed the highest fruit yield $plant^{-1}$ (2.15 kg) in 45 cm x 60 cm while spacing of 45 cm x 30 cm produced the maximum fruit yield ha^{-1} (73.26 t).

Narayan *et al.* (2009) studied the effect of three levels of spacing (60 cm x 30 cm, 60 cm x 45 cm and 60 cm x 60 cm) on seed production of paprika and it was observed that 60 cm x 30 cm spacing produced the highest seed yield (3.63q ha^{-1})

Maniutiu *et al.* (2010) in a trial to compare the influence of two plant density (30000 and 40000 plants ha^{-1}) and pruning (2 shoots and 3 shoots) on yield of bell pepper grown under plastic tunnel confirmed the superiority of higher plant density of 40000 plants ha^{-1} and 3 shoots pruning.

Alam *et al.* (2011) in a trial to study the effect of three levels of spacing (50 cm x 50 cm, 50 cm x 40 cm, 50 cm x 30 cm) on the yield and yield attributing characters of bell pepper reported that number of fruits $plant^{-1}$, fruit length and individual fruit weight were highest for wider spacing while highest yield ha^{-1} (19.36 t) was obtained from closer spacing (50 cm x 30 cm).

Islam *et al.* (2011) studied the effect of three spacing in bell pepper (50 cm x 50 cm, 50 cm x 40 cm, 50 cm x 30 cm) and it was observed that the highest yield ha^{-1}, days to 50 % flowering and fruit breadth significantly increased with decreasing the plant spacing while fruits $plant^{-1}$, individual fruit weight and fruit length significantly increased with wider spacing.

Aminifard *et al.* (2012) in a study to evaluate the effect of plant density on bell pepper reported that increasing plant density decreased the reproductive factors like fruit weight, fruit volume and plant yield while total yield ha^{-1} increased. The highest and lowest yield was observed at 20 cm x 50 cm and 30 cm x 100 cm respectively.

A study was conducted to assess the effect of planting date and spacing on the growth and yield of bell pepper and reported that bell pepper should be grown as early as possible at a spacing of at least 60 cm to provide enough time and space for growth and development of crops in order to increase yield (Hamma *et al.*, 2012).

Maboko *et al.* (2012) in an experiment to examine the influence of plant densities (2, 2.5 and 3 plant m^{-2}), stem and flower pruning on hydroponically grown bell pepper under shade net reported that plant density of 3 plants m^{-2} along with four stem and zero flower pruning recorded the highest yield.

Kishor (2012) in a trial to study the influence of spacing reported that spacing of 45 cm x 30 cm can be recommended for bell pepper for better fruits and seed yield under commercial cultivation.

Shivakumar *et al.* (2012) conducted an experiment in shade net to find out the effect of plant spacings (45 cm x 45 cm, 45 cm x 30 cm and 30 cm x 30 cm) on the yield of bell pepper and it was reported that wider spacing of 45 cm x 45 cm (49382 plants ha^{-1}) produced the highest fruit weight, fruits $plant^{-1}$, fruit yield $plant^{-1}$, fruit length and girth of fruits however closer spacing of 30 cm x 30 cm (1,11,111 plant ha^{-1}) produced the maximum fruit yield ha^{-1}.

Biradar *et al.* (2014) in an experiment to study the effect of three plant spacings (45 cm x 30 cm, 45 cm x 45 cm, 45 cm x 60 cm) in bell pepper reported that the maximum average fruit weight (251.98 g) and the maximum yield $plant^{-1}$ (3.62 kg) from wider spacing (45 cm x 60cm) while yield m^{-2} (10.14 kg) was highest for closer spacing (45 cm x 30 cm).

Dilipakumar and Malabasari (2014) conducted an experiment to study the influence of three levels of plant spacing (45 cm x 45 cm, 60 cm x 45 cm, 75 cm x 45 cm) on the seed yield of bell pepper and it was observed that seed fruit^{-1} and seed plant^{-1} was highest for the spacing 60 cm x 45 cm while seed yield ha^{-1} was highest for the spacing 45 cm x 45 cm.

Lone (2014) conducted an experiment to study the effect of three levels of spacing (30 cm x 45 cm, 45 cm x 45 cm, 60 cm x 45 cm) on productivity of bell pepper under naturally ventilated polyhouse and it was reported that plants at wider spacing took comparatively lesser time for flower initiation (35.6 days), 50 % flowering (41.4 days), fruit setting (50.3 days) and first picking (68.6 days). The closest spacing produced highest yield ha^{-1} while the highest yield plant^{-1} was obtained from wider spacing.

The effect of three levels of plant spacing (60 cm x 45cm, 45 cm x 45 cm and 45 cm x 30 cm) on growth and yield of bell pepper was studied by Kamboj and Sharma (2015) and it was observed that 60 cm x 45 cm spacing recorded the highest number of fruits plant^{-1} (15.13), green fruit weight (51.33 g), fruit length (6.38 cm), fruit breadth (5.91 cm), while 45 cm x 30 cm produced the highest fruit yield ha^{-1} (320.76 q).

2.7 Effect of Spacing on Quality Attributes of Bell Pepper

Among different plant spacings (60 cm x 40 cm, 40 cm x 40 cm and 40 cm x 20 cm) studied by Kossowski and Hortynska (1984) best quality fruits in Bell pepper was obtained from 40 cm x 40 cm spaced plants.

Dobromilska (2000) conducted a field trial to study the effect of different plant spacings (50 cm x 40 cm, 50 cm x 50 cm and 50 cm x 60 cm) on the yield and quality of bell pepper and it was observed that the closest spacing (50 cm x 40 cm) produced the highest yield while quality of fruits was low when planting density was high.

Zende (2008) conducted a trial to find out production technique of bell pepper under protected condition, among three levels of spacing (45 cm x 30 cm, 45 cm x 45 cm, 45 cm x 60 cm) studied 45 cm x 60 cm recorded significantly higher shelf life (9.09 days).

Aminifard *et al.* (2012) reported that vitamin C content in bell pepper is affected by plant density. Highest and lowest vitamin C content was observed in plants spaced at 30 cm x 100 cm and 30 cm x 50 cm respectively.

2.8 Effect of Spacing on Economics of Bell Pepper Cultivation

Grangs and Leger (1989) reported that increase in the plant density of bell pepper from normal level of 3 plants m^{-2} to 6 plants m^{-2} gave 80 per cent more yield and 50 per cent more gross returns under greenhouse conditions.

According to Islam *et al.* (2011) spacing of 50 cm x 30 cm is ideal while considering the net returns and cost of cultivation.

According to Lone (2014) plants trained to two shoots and planting at the closest spacing of 30 cm x 45 cm resulted in the highest B: C ratio (1.39).

Spehia *et al.* (2014) in an experiment to study the influence of three levels of plant spacing (40 cm x 40 cm, 60 cm x 40 cm, 60 cm x 60 cm) in coloured bell pepper observed that for more income per rupee invested closer spacing of 40 cm x 40 cm is ideal.

Ahirwar and Hedau (2015) in a study on winter bell pepper under protected condition observed that plant density and stem pruning influenced the yield and quality while fruit pruning didn't show any significant effect. The results suggested closer spacing (45 cm x 30 cm) and four leader system of stem pruning is ideal for winter bell pepper under polyhouse condition in Uttrakhand Hills.

2.9 Effect of Foliar Application on Growth Characters of Crops

Narayan *et al*. (2012) in a trial to study the influence foliar fertilizers on tomato reported that the tallest plants with more number of primary and secondary branches were produced when plants were supplied with 87.5 % recommended dose of fertilizers + foliar application of water soluble fertilizers.

According to Krishnan *et al*. (2014) application of Starter (NPK 11:36:24) at 2 % + Booster (NPK 8:16:39) at 2 % + recommended dose of fertilizers significantly increased plant height (100.40 cm), number of branches (23.4), number of leaves (60.2), leaf area index (4.16), total chlorophyll content (1.25 mg g^{-1}), and dry weight $plant^{-1}$ (178.37 g) in tomato.

Mudalagiriyappa *et al*. (2016) in a trial to study the influence of feeding on chickpea reported that application 19:19:19 at 1.5 % had a positive influence on the growth attributes like plant height, number of branches, leaf area and LAI. Further increase in spray dose has no significant effect on growth and yield attributes.

2.10 Effect of Foliar application on Yield and Yield Attributes of Crops

Kolota and Osinska (2001) conducted a study to find out the influence of foliar nutrition on vegetable crops and it was observed that a yield enhancement of 10.8 % in onion, 20.3 % in cabbage and 7.3 % in cucumber was obtained under foliar fertilization.

Baloch *et al*. (2008) reported that foliar application of micro nutrients mixture increased yield in chillies.

Patil *et al*. (2008) observed that in tomato, application of boric acid @ 100 ppm resulted in the maximum number of primary branches (18.30), yield $plant^{-1}$ (2.07 kg) and fruit yield (30.50 t ha^{-1}). This was followed by micronutrient mixture (Bo, Zn, Mn and Fe @ 100 ppm and Mo @ 50 ppm) which produced a yield of 27.98 t ha^{-1}.

Khan *et al.* (2009) in an experiment to find out the influence of foliar spray of urea on wheat observed that 4 % of urea as foliar spray increased the grain yield in wheat by 32 %. However, when concentration was further increased the yield was declined by 25 %.

Premsekhar and Rajashree (2009) in an investigation to study the effect of foliar feeding of water soluble fertilizers on tomato hybrids confirmed that foliar feeding of 5 sprays of 19:19:19 increased plant height, fruit weight, number of fruits plant^{-1}, fruit yield, fruit quality and B: C ratio.

An experiment was done by Ejaz *et al.* (2011) to evaluate the performance of tomato plants when they were subjected to foliar application of micro and macro nutrients mixture. The treatment consists of individual spray of N (2 %), B (5 %) and Zn (6 %), their mixture and control. The results revealed that plants subjected to foliar application of individual nutrients performed better as compared to control while combined application of nutrient mixture produced significantly superior plants. Thus, it was confirmed that foliar application of micro and macro nutrients mixture improves the growth and yield of tomato.

Narayan *et al.* (2012) in an experiment to study the influence of foliar fertilizers on tomato reported that more fruits plant^{-1}, fruit weight, fruit diameter, fruit pericarp thickness, and fruit-yield ha^{-1}, the highest B: C ratio (2.73) and net returns (Rs.1,25,890.05) were obtained when plants are supplied with 87.5 % recommended dose of fertilizers + foliar application of water soluble fertilizers.

Raj *et al.* (2012) carried out an experiment in tomato to study the influence of foliar application of micro and secondary nutrients on tomato productivity. The results from the study confirmed that foliar nutrition has a positive influence on yield parameters. Foliar application of micro and secondary nutrients and split application of N and P improved productivity of tomatoes.

According to the study done by Dilipakumar and Malabasari (2014) to find out the influence of foliar spray of micronutrients on bell pepper application of borax (0.5 %) resulted in the highest number of fruits (8.39), fruits weight plant^{-1} (377.18 g), number of seeds fruit^{-1} (221.20), seed weight fruit^{-1} (1.06 g), seed weight plant^{-1} (8.63 g) and seed yield ha^{-1} (349.45 kg.

According to Krishnan *et al.* (2014) application of Starter (NPK 11:36:24) at 2 % + Booster (NPK 8:16:39) at 2 % + recommended dose of fertilizers significantly increased fruit setting percentage (81.07), number of fruits plant^{-1} (38.60), fruit volume (63.0 ml), average fruit weight (55.60 g), fruit size (10.98 cm2), yield plant^{-1} (2.03 kg) and yield ha^{-1} (39.87 Mg ha^{-1}).

Azam *et al.* (2016) conducted a field analysis to find out the influence of foliar application of micronutrients in bell pepper and it was observed that the foliar application of potassium chloride and calcium chloride helped to improve the yield and chemical parameters.

Mendes *et al.* (2016) carried out an experiment on bell pepper to study the influence of foliar application of amino acid and urea, from the results it was reported that foliar application of amino acid increased fruit diameter and length while increased dose of urea registered some morphological changes in pepper fruits but the amino acid utilization was low.

2.11 Effect of Foliar Application on Quality Attributes of Crops

Narayan *et al.* (2012) conducted an experiment to study the influence of foliar fertilizers on tomato and it was reported that total soluble salt and acidity were high when plants are supplied with 87.5 % recommended dose of fertilizers + foliar application of water soluble fertilizers

Michaaoj and Dzida (2012) conducted a study to understand the influence of foliar application of calcium in bell pepper and it was reported that foliar application of calcium increased the vitamin C content

Raj *et al.* (2012) carried out an experiment in tomato to study the influence of foliar application of micro and secondary nutrients on tomato productivity. The results from the study confirmed that foliar nutrition enhanced the fruit quality parameters like acidity, ascorbic acid, TSS and shelf-life content

Yadav and Choudhary (2012) studied the influence of foliar nutrition on cowpea and it was observed that application of 2 % urea, 2 % DAP and 2 % KCl increased the NPK and protein content in cowpea seeds.

Buczkowsk *et al.* (2015) conducted a study to observe the influence of foliar application of calcium in bell pepper and it was reported that foliar application of calcium nitrate increased the vitamin C content.

2.12 Effect of Foliar Application on Nutrient Uptake of Crops

Based on study conduted by Wojcik (2004) to investigate the influence of foliar nutrition on nutrient uptake, application of nutrients in foliar form is very effective when soil nutrient availability is limited and root activity of plants is low. Also, foliar nutrition will increase the fruit Ca^{2+} and cereal grain protein content. So integration of foliar nutrition in palnt production system helps to enhance the yield and quality of produce.

Effect of foliar nutrition on nutrient uptake of broccoli was studied by Yildirim *et al.* (2007) and noted that foliar application of urea along with soil application of N increased almost all nutrient content in leaves and heads of broccoli.

Yadav and Choudhary (2012) studied the influence of foliar nutrition on cowpea and it was reported that application of 2 % urea, 2 % DAP and 2 % KCl increased the uptake of NPK.

Devi (2016) reported that during foliar application, nutrients penetrate through the stomata or leaf cuticle and rapidly diffuse into the cell thus helps to ameliorate deficiencies of nutrients rapidly.

2.13 Effect of Foliar Application on Pest and Disease Incidence in Crops

Kolota and Osinska (2001) in a trial to a study to find out the influence of foliar nutrition on vegetable crops reported that there was a significant reduction in cucumber downy mildew (*Pseudoperonospora cubensis*) infestation under foliar fertilization.

Haytova (2013) observed that foliar application of nutrients helps to increase resistance to insect pests and diseases along with drought tolerance and improved crop quality.

2.14 Effect of Foliar Application on Economics of Crop Cultivation

Chaurasia *et al*. (2005) in an experiment to study the influence of foliar feeding on tomato reported that foliar feeding of water soluble fertilizers has significant influence on growth, yield and quality attributes of tomato. Foliar application of 5 sprays of 19:09:19 produced the tallest plants, more number of branches, yield, net returns and B: C ratio followed by 19:19:19.

Patil *et al*. (2008) in a trail to investigate the effect of foliar nutrition on tomato observed that foliar application of boron registered higher B: C ratio (1.80) and net returns (Rs 97,850 ha^{-1}) followed by micronutrient mixture spray.

Narayan *et al*. (2012) in an experiment to investigate the influence foliar fertilizers on tomato reported that the highest net returns were obtained when tomato plants are subjected to 87.5 % recommended dose of fertilizers + foliar application of water soluble fertilizers.

Yadav and choudhary (2012) studied the influence of foliar nutrition on cowpea and it was reported that application of 2 % urea, 2 % DAP and 2 % KCl increased the net returns.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The experiment entitled "Standardisation of fertigation schedule and spacing for bell pepper (*Capsicum annuum* L.var.grossum sendt.) in polyhouse" was taken up at farmer's field in Parassala block, Thiruvananthapuram, Kerala. The objectives of the field experiment were to standardise the fertigation schedule and spacing of bell pepper under poyhouse condition and to work out the economics of cultivation. The details of materials used and methods adopted are presented in this chapter.

3.1 EXPERIMENTAL SITE

The experiment was conducted in the polyhouse attached to farmer's field in Parassala block, Thiruvananthapuram. The field is situated at 8.3^0 North latitude and 77.1^0 East longitude, at an altitude of 51 m above mean sea level.

3.1.1 Soil

The mechanical composition and chemical properties of the soil of the experimental site are presented in Table 1.

The soil of the experimental site was sandy clay loam, belonging to the taxonomical order Oxisol. It was acidic in reaction, high in organic carbon content, low in available nitrogen and potassium and high in available phosphorus.

3.1.2 Cropping History of the Field

The area was under a bulk crop of cowpea before the experiment.

3.1.3 Climate

The experimental site enjoys a warm humid tropical climate. The field experiment was conducted during *Kharif* season (June to November, 2016). The data on various weather parameters recorded inside the polyhouse during the cropping period are given in the Fig. 1. and Appendix 1.

Table 1. Mechanical composition and chemical properties of soil prior to the experiment.

Sl. No	Parameters	Content (%)	Methods used
A. Mechanical composition			
1	Coarse sand	46.26	Bouyoucos hydrometer method (Bouyoucos, 1962)
2	Silt	26.42	
3	Clay	25.90	
B. Chemical properties			
1	Available N	225.79 kg ha^{-1} (low)	Alkaline permanganate method (Subbiah and Asija, 1956)
2	Available P_2O_5	336.78 kg ha^{-1} (high)	Bray colorimeter method (Jackson, 1973)
3	Available K_2O	94.68 kg ha^{-1} (low)	Ammonium acetate method (Jackson, 1973)
4	Organic carbon	1.4 per cent (high)	Walkley and Blacks's rapid titration method (Jackson, 1973)
5	Soil pH	5.5 (acidic)	1:2.5 Soil solution ratio using pH meter with glass electrode (Jackson,1973)

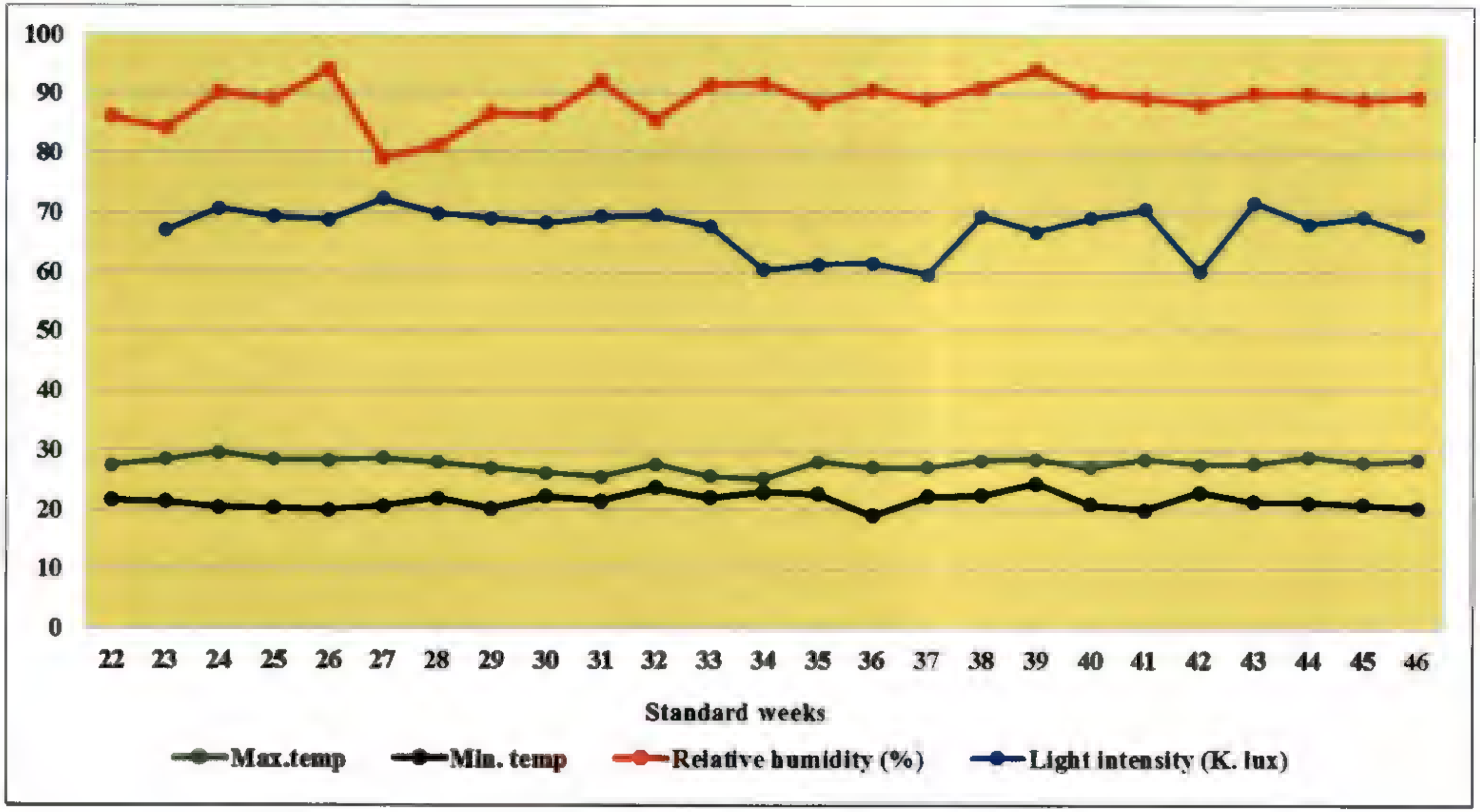

Fig. 1. Weather data in poly house during the cropping period June to November, 2016

3.2 MATERIALS

3.2.1 Seedling

The bell pepper variety, selected for the experiment was 'Inspiration'. It is a red variety with medium to large sized blocky fruits. The plants are short and exhibit vigorous growth under polyhouse condition. The fruits are of good quality with longer shelf life. The seedlings were purchased from D.J.M Admatha, Hitech Nursery Garden, Amaravila.

3.2.2 Manures and Fertilizers

Farm yard manure (0.35 per cent N, 0.2 per cent P_2O_5 and 0.50 per cent K_2O) was used as the organic source of nutrient. Urea (46 per cent N), Rajphos (20 per cent P_2O_5), Potassium chloride (60 per cent K_2O), 19:19:19, Diammonium phosphate (18 per cent N and 46 per cent P_2O_5) and Potassium nitrate (13 per cent N and 46 per cent K_2O) were used as the inorganic sources for fertigation.

3.3 METHODS

3.3.1 Design and Layout

The investigation was laid out in split plot design with three replications. The main plot treatments were four levels of fertigation and the sub plot treatments were three spacings. The details are given below. The lay out of experiment is given in Fig. 2.

Design	:	Split plot
Treatments	:	Four levels of fertigation and three spacing
Replication	:	3
Variety	:	Inspiration
Plot size	:	2.7 m x 1.8 m

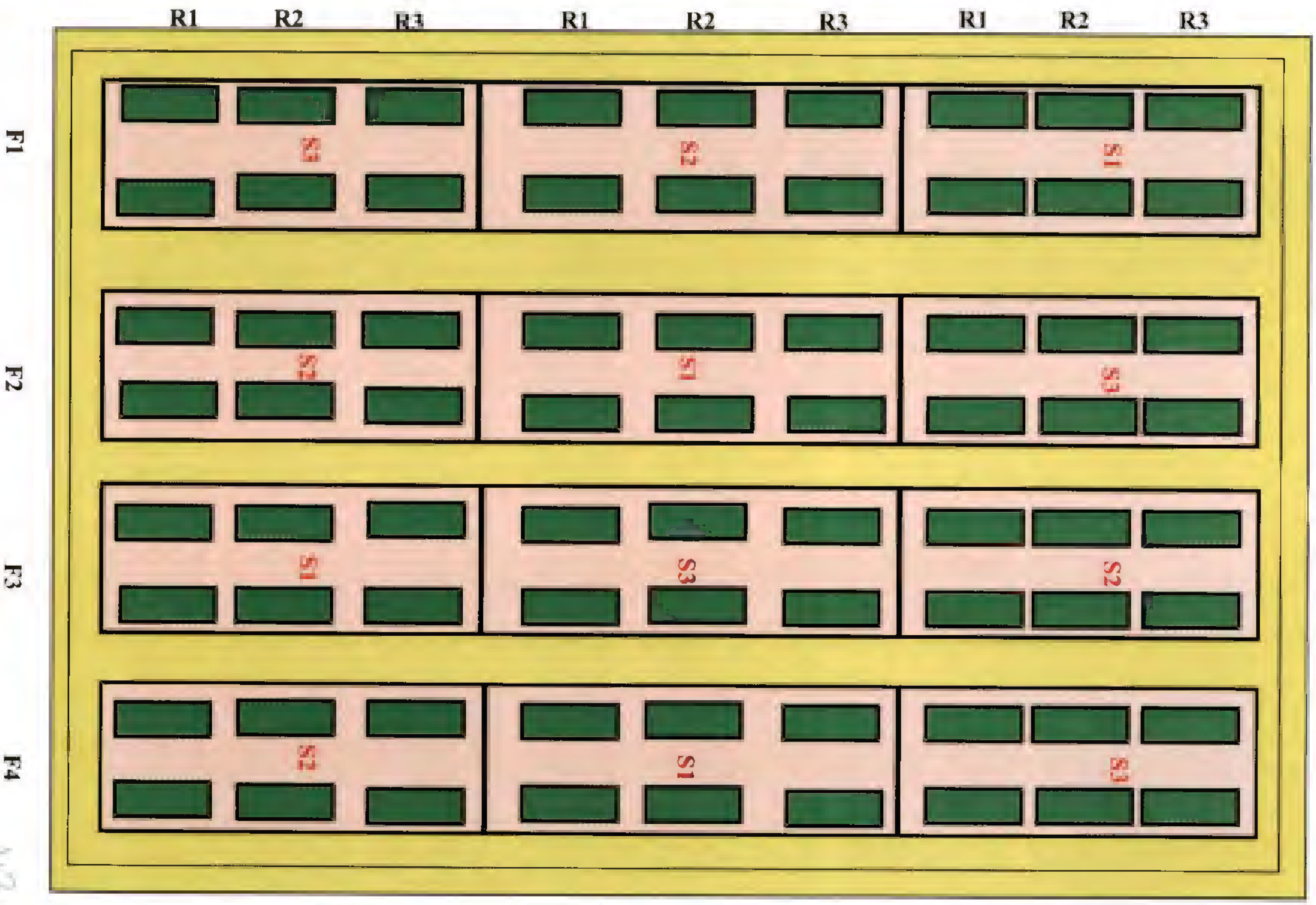

Fig. 2. Layout of the experiment plot

Plate 1. General view of the experiment

3.3.1.1 Treatments

A. Main plot treatments- Fertigation (F)

F_1 : 100 % *adhoc* recommendation of KAU for precision farming.

F_2 : 50 % *adhoc* recommendation of KAU for precision farming.

F_3 : 50 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT.

F_4 : 25 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT.

B. Sub plot treatments – Spacing (S)

S_1 : 45 cm x 30 cm

S_2 : 45 cm × 45 cm

S_3 : 45 cm × 60 cm

Treatment combinations

f_1s_1	f_2s_1	f_3s_1	f_4s_1
f_1s_2	f_2s_2	f_3s_2	f_4s_2
f_1s_3	f_2s_3	f_3s_3	f_4s_3

3.3.2 CULTURAL OPERATIONS

The details of cultural operations carried out during the course of investigation are as follows.

3.3.2.1 Land Preparation

The land was ploughed twice to bring the soil to fine tilth. Weeds and stubbles were removed. Raised beds of 90-100 cm wide and 15-22 cm height were taken and drip system was installed. Healthy seedlings of 30 days old were transplanted.

3.3.2.2 Manure and Fertilizer Application

Farmyard manure @ 25 t ha^{-1} was given as basal to all the treatments. The KAU *adhoc* recommendation of bell pepper for precision farming is 230:25:250 N, P_2O_5 and K_2O kg ha^{-1}as fertigation along with 24 kg ha^{-1} rajphos as basal. The details of nutrients used for fertigation as per KAU *adhoc* recommendation of bell pepper for precision farming are given in Table 2. For treatments requiring foliar nutrition combined solution of urea and potassium chloride each at 1.25 % was given.

Table 2. Fertigation schedule as per KAU *adhoc* recommendation of bell pepper for precision farming

Source	Quantity (kg ha^{-1})	Splits	Interval
19:19:19	72.64	40	3 days
Potassium nitrate	522		
Urea	314		
DAP	16.66	34	

3.3.2.3 Drip Irrigation

Water and fertilizers were applied through drip irrigation using fertilizer injector pump. The fertigation was given at three days interval.

3.3.2.4 Gap Filling

Gap filling was done eight days after transplanting to ensure optimum plant population.

3.3.2.5 Other Management Practices

Two hand weedings were done at 25 and 45 days after transplanting (DAT). Pruning was done at 30 DAT and it was followed at a regular interval of 8- 10 days. Plants were tied at base with plastic twines hung from the top for providing support. Prophylactic measures to control pest and diseases were also taken (Copper oxy chloride @ 4 g L^{-1} and Spiromesifen @ 1 ml L^{-1}).

3.3.2.6 Harvest

The crop was ready for first harvest at 70 DAT. Fruits was harvested using sharp knife when 50 - 80 per cent of colour has developed. The weight of individual fruits and total number of fruits from each observational plant were recorded.

3.4 OBSERVATIONS

For recording the observations, five plants were selected randomly from the net plot area in each treatment. The parameters and procedures followed are given below.

3.4.1 Growth and Growth Attributes

3.4.1.1 Plant Height

Height was taken from the base to the growing tip of plants at six growth stages *viz.*, 30, 60, 90, 120, 150 DAT and at final harvest. The mean plant heights were worked out and expressed in cm.

3.4.1.2 Number of Branches Plant^{-1}

Numbers of branches plant^{-1} at 50 per cent flowering and at final harvest were taken and the mean was worked out.

3.4.1.3 Leaf Area Index (LAI)

The leaf area during 50 per cent flowering and at final harvest were calculated using a general relationship, A= bx l x w where b is a coefficient. The LAI during 50 per cent flowering and at final harvest were calculated using the formula developed by Watson (1947)

$$LAI = \frac{\text{Leaf area plant}^{-1}\ (cm^2)}{\text{Land area occupied by the plant}\ (cm^2)}$$

3.4.2 Yield and Yield Attributes

3.4.2.1 Number of Fruits Plant^{-1}

Numbers of fruits of five observational plants from each harvest were recorded and the mean was worked out.

3.4.2.2 Girth of the Fruit

The girth of fruits obtained from observational plants was recorded from each harvest and the mean girth was calculated and expressed in cm.

3.4.2.2 Total Fruit Yield Plant^{-1}

The mean fruit weight obtained from observational plants from each harvest was recorded and the total fruit yield plant^{-1} were calculated and expressed in kg.

3.4.2.3 Total Fruit Yield m^{-2}

The mean fruit yield m^{-2} was recorded from each harvest and total yield was calculated and expressed in kg.

3.4.3 QUALITY ASPECTS

3.4.3.1 Shelf Life

Five fruits per treatment were selected and kept in ambient condition until they remain fresh and at acceptable quality. The number of days taken by fruits to become shrunken and to lose firmness was recorded as shelf life in days.

3.4.3.2 Ascorbic Acid Content

Ascorbic acid content of fruits was estimated by 2, 6-dichlorophenol indophenols dye method (Sadasivam and Manickam, 1992). Ascorbic acid content of the sample was calculated using the formula.

$$\text{Ascorbic acid content (mg 100 g}^{-1}\text{ fresh fruit)} = \frac{\text{Titre value x dye factor x volume made upto x 100}}{\text{Aliquot of extract taken x weight of sample taken}}$$

3.4.3.3 Capsaicin Content

Capsaicin content was determined by Folin-Dennis method. The pungent principle reacts with Folin-Dennis reagent to give a bluish complex, which was estimated colorimetrically (Mathew *et al.*, 1971). The capsaicin values were represented in per cent.

3.5 CHEMICAL ANALYSIS

3.5.1 Plant Analysis

The plant samples were subjected to chemical analysis for determining the total N, P, and K content. For this purpose, plant samples from each plot were dried in an electric hot air oven to constant weights at a temperature of 70 ^{o}C ± 5 ^{o}c, ground and passed through a 0.5 mm sieve. The required quantity of sample was weighed out accurately in an electronic balance and was subjected to acid extraction before carrying out the chemical analysis.

3.5.1.1 Uptake of Nitrogen

The nitrogen content in plant sample was estimated by the modified micro kjeldhal method (Jackson, 1973) and the uptake of nitrogen was calculated by multiplying the nitrogen content of plant sample with the total dry weight of plants and expressed in kg ha^{-1}.

3.5.1.2 Uptake of Phosphorus

The plant sample was undergone nitric-perchloric (9:4) digestion and phosphorus content in plants samples was determined colorimetrically using Vanadomolybdo phosphoric yellow colour method (Jackson, 1973). The uptake of phosphorus was calculated by multiplying the phosphorus content of plant sample with the total dry weight of plants and expressed in kg ha^{-1}.

3.5.1.3 Uptake of Potassium

The plant sample was undergone nitric-perchloric (9:4) digestion and potassium content in plants samples was determined by flame photometry method (Jackson, 1973). The uptake of potassium was calculated by multiplying the potassium content of plant sample with the total dry weight of plants and expressed in kg ha^{-1}.

3.5.2 SOIL ANALYSIS

Soil samples were taken from the experimental area before and after the experiment. The air dried samples passed through 2 mm sieve were used for the analysis of physico-chemical properties.

3.5.2.1 Organic Carbon Content

The soil organic carbon content before and after the experiment was expressed in per cent. It was estimated using Walkley and Black's rapid titration method (Jackson, 1973) and expressed in per cent.

3.5.2.2 Available Nitrogen Content

The available N content in soil was estimated using alkaline permanganate method (Subbiah and Asija, 1956) and expressed in kg ha^{-1}.

3.5.2.3 Available Phosphorus Content

The available P content in soil was estimated using Dickman and Bray's molybdenum blue method using Bray No.1 reagent for extraction and estimated using spectrophotometer (Jackson, 1973) and expressed in kg ha^{-1}.

3.5.2.4 Available Potassium Content

The available K content in soil was determined using neutral ammonium acetate extract and was read in Flame photometer (Jackson, 1973) and expressed in kg ha^{-1}.

3.6 INCIDENCE OF PEST AND DISEASES

No incidence of pests and diseases were found to infect the crop beyond the economic threshold level demanding control measures and hence no scoring was done

3.7 ECONOMIC ANALYSIS

Economics of cultivation was worked out for the field experiment after taking into account the cost of cultivation and prevailing market price of bell pepper. The net returns and B: C ratio were calculated as follows.

3.7.1 Net Returns

Net returns (₹ 10 $cents^{-1}$) was calculated using the formula

$$\text{Net returns} = \underset{(\text{₹ 10 cents}^{-1})}{\text{Gross income}} - \underset{(\text{₹ 10 cents}^{-1})}{\text{Total expenditure}}$$

3.7.2 Benefit Cost ratio

Benefit cost ratio worked out using the formula

$$\text{B: C} = \frac{\text{Gross income (₹ 10 cents}^{-1}\text{)}}{\text{Cost of cultivation (₹ 10 cents}^{-1}\text{)}}$$

3.8 STATISTICAL ANALYSIS

The data generated from the characters studied uder different treatments were subjected to statistical analysis applying ANOVA technique and significance tested by ‘F’ test (Snedecor and Cochran, 1975). In the cases where the effects were found to be significant, critical difference was calculated at five or one per cent probability level and non significant is denoted as NS.

RESULTS

4. RESULTS

The experiment entitled "Standardisation of fertigation schedule and spacing for bell pepper (*Capsicum annuum* L.var.grossum sendt.) was under taken in the farmer's field, parassala block, Thiruvananthapuram, during June to November, 2016. The main objectives of the study were to standardize the fertigation schedule and spacing of bell pepper under polyhouse condition and to work out the economics. The results of the experiment are presented in this chapter.

4.1 GROWTH CHARACTERS

4.1.1 Height of the Plant

Average height of the plants recorded at 30, 60, 90, 120, 150 DAT and at final harvest are presented in Table 3, 4 and 5.

The perusal of the data revealed that fertigation schedules influenced the plant height. The treatment F_1 (100 % *adhoc* recommendation of KAU for precision farming) recorded the tallest plants of 73.57 cm, 127.9 cm and 148.17 cm at 60, 120 DAT and at final harvest respectively. At 90 DAT, the tallest plants were recorded from F_1 (105.96 cm) which was more or less similar to F_2 (50 % adhoc recommendation of KAU for precision farming). Also the same treatment F_1 registered taller plants (139.04 cm) at 150 DAT and it was on par with F_3 (50 % adhoc recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT). At all growth stages the lowest plant height was registered by 25 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT (F_4).

Different plant spacings had significant influence on plant height at all growth stages except at 30 and 90 DAT. Closer spacing of 45 cm x 30 cm (S_1) recorded the maximum plant height of 70.40 cm at 60 DAT while at 120 DAT, it was 122.90 cm and was on par with S_2 (45 cm x 45 cm) (122.86 cm). At 150 DAT

Table 3. Effect of fertigation levels and different spacings on plant height at 30 and 60 DAT (cm)

Treatments	30 DAT				60 DAT			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	47.21	35.06	39.00	40.42	82.00	70.94	67.78	73.57
F_2	37.33	37.33	36.56	37.07	70.06	69.06	65.22	68.11
F_3	35.11	38.11	38.00	37.07	68.50	67.22	65.67	67.13
F_4	37.00	35.67	34.67	35.78	61.06	64.39	63.83	63.09
Mean	39.16	36.54	37.06		70.40	67.90	65.63	

	F	S	F x S			F	S	F x S
SE m ±	2.027	1.299	2.597		SE m ±	1.922	1.031	2.062
CD (0.05)	NS	NS	NS		CD (0.05)	4.703	2.186	4.371

Table 4. Effect of fertigation levels and different spacings on plant height at 90 and 120 DAT (cm)

Treatments	90 DAT				120 DAT			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	108.39	107.17	102.33	105.96	133.06	130.67	120.00	127.9
F_2	104.00	101.78	97.89	101.22	126.83	119.78	118.56	121.72
F_3	101.33	101.78	96.78	99.96	121.06	120.22	119.67	120.31
F_4	93.56	95.67	98.67	95.96	110.67	120.78	115.74	115.67
Mean	101.82	101.60	98.92		122.90	122.86	118.49	

	F	S	F x S			F	S	F x S
SE m ±	1.964	2.022	4.044		SE m ±	1.782	1.840	3.680
CD (0.05)	4.805	NS	NS		CD (0.0)	4.360	3.901	7.802

Table 5. Effect of fertigation levels and spacing on plant height at 150 DAT and at final harvest (cm)

Treatments	150 DAT				Final harvest			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	141.44	137.78	137.89	139.04	151.67	148.89	143.97	148.17
F_2	135.33	133.44	132.78	133.85	146.83	139.78	138.56	141.72
F_3	144.56	137.56	134.33	138.81	147.67	140.22	139.67	142.52
F_4	125.33	131.44	129.67	128.81	130.67	140.78	139.19	136.88
Mean	136.67	135.06	133.67		144.21	142.42	140.34	

	F	S	F x S
SE m ±	1.952	0.952	1.904
CD (0.05)	4.779	2.019	4.038

	F	S	F x S
SE m ±	2.280	1.453	2.907
CD (0.05)	5.579	3.081	6.162

and at harvest the taller plants were registered from S_1 and it was comparable to S_2.

The interaction of fertigation levels and spacing (F x S) caused significant variation in plant height at 60, 120, 150 DAT and at harvest. The treatment F_1 (100 % *adhoc* recommendation of KAU for precision farming) with closer spacing of 45 cm x 30 cm (f_1s_1) recorded taller plants at 60 and 120 DAT, while at 150 DAT F_1 recorded taller plants with all levels of spacing.

4.1.2 Number of Branches Plant^{-1}

Average number of branches plant^{-1} recorded at 50 % flowering and at final harvest is presented in Table 6.

Number of branches plant^{-1} was significantly influenced by the levels of fertigation at 50 % flowering and at final harvest. At 50 % flowering plants grown with higher dose of fertigation (F_1) registered most number of branches plant^{-1} (4.60). At final harvest number of branches produced by F_1 (7.81) was comparable with F_3 (7.52). Both at 50 % flowering and at final harvest the lowest number of branches plant^{-1} was reported from F_4.

Plant spacing has significant influence on number of branches at 50 % flowering and final harvest. Wider spacing of 45 cm x 60 cm (S_3) reported more number of branches (4.44) at 50 % flowering and at final harvest (7.25), while at both stages the lowest number of branches plant^{-1} was registered from closer spacing of 45 cm x 30 cm (S_1).

The interaction of fertigation levels and spacings (F x S) was absent at both stages.

4.1.3 Leaf Area Index (LAI)

LAI recorded at 50 % flowering and at final harvest is presented in the Table 7.

Table 6. Effect of fertigation levels and different spacings on number of branches plant^{-1} at 50 % flowering and at final harvest

Treatments	50 % Flowering				Final harvest			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	4.75	4.68	4.37	4.60	7.44	8.22	7.78	7.81
F_2	3.67	3.70	4.37	3.91	5.44	6.00	7.67	6.37
F_3	3.33	3.68	4.49	3.83	7.22	7.78	7.57	7.52
F_4	3..00	3.47	4.52	3.66	5.44	5.44	6.00	5.63
Mean	3.69	3.88	4.44		6.39	6.86	7.25	

	F	S	F x S
SE m ±	0.217	0.196	0.392
CD (0.05)	0.532	0.416	NS

	F	S	F x S
SE m ±	0.462	0.218	0.435
CD (0.05)	1.131	0.461	NS

The study revealed that different levels of fertigation caused significant variation in LAI during 50 % flowering and final harvest. Higher LAI of 4.42 and 6.63 was recorded from plants with 100 % *adhoc* recommendation of KAU for precision farming (F_1) at 50 % flowering and final harvest respectively, while at both stages the lowest LAI was produced by F_4.

From the data, it was noted that spacing significantly influenced LAI during 50 % flowering and final harvest. Wider spacing of 45 cm x 60 cm (S_3) produced higher LAI of 3.57 and 5.36 at 50 % flowering and final harvest respectively. At both stages closer spacing (S_1) registered the lowest LAI.

Interaction of fertigation levels and spacing (F x S) had no significant influence on LAI.

4.2 YIELD ATTRIBUTES AND YIELD

4.2.1 Number of Fruits Plant^{-1}

The data on number of fruits plant^{-1} is presented in Table 8.

The results revealed that number of fruits plant^{-1} showed significant variation due to different levels of fertigation. The plants with F_1 (15.15) recorded the maximum number of fruits plant^{-1} followed by F_3 (13.49) and F_2 (12.37). The lowest number of fruits plant^{-1} was recorded from F_4 (11).

Spacing had shown significant influence on number of fruits plant^{-1}. The plants spaced at wider spacing of 45 cm x 60 cm (S_3) produced the highest number of fruits plant^{-1}(13.75). The number of fruits plant^{-1} at 45 cm x 30 cm (S_1) and 45 cm x 45 cm (S_2) were 12.58, 12.67 respectively which were on par.

No significant variation was observed from the interaction of fertigation level and different (F x S) spacing.

Table 7. Effect of fertigation levels and different spacings on LAI at 50 % flowering and final harvest

Treatments	50 % Flowering				Final harvest			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	4.27	4.31	4.67	4.42	6.41	6.47	7.01	6.63
F_2	3.46	3.47	3.52	3.49	5.20	5.21	5.28	5.23
F_3	3.51	3.58	3.74	3.61	5.26	5.37	5.62	5.41
F_4	2.14	2.22	2.35	2.24	3.21	3.33	3.53	3.36
Mean	3.35	3.40	3.57		5.02	5.09	5.36	

	F	S	F x S
SE m ±	0.040	0.050	0.101
CD (0.05)	0.098	0.107	NS

	F	S	F x S
SE m ±	0.060	0.076	0.151
CD (0.05)	0.147	0.160	NS

Table 8. Effect of fertigation levels and different spacings on number of fruits plant^{-1} and fruit girth

Treatments	Number of fruits plant^{-1}				Fruit girth (cm)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	15.11	14.78	15.56	15.15	24.23	27.57	26.93	26.24
F_2	11.44	12.00	13.67	12.37	23.13	23.82	24.70	23.89
F_3	12.67	13.00	14.79	13.49	23.87	25.59	26.27	25.24
F_4	11.11	10.89	11.00	11.00	22.10	21.66	23.00	22.25
Mean	12.58	12.67	13.75		23.33	24.66	25.23	

	F	S	F x S
SE m ±	0.372	0.376	0.752
CD (0.05)	0.909	0.797	NS

	F	S	F x S
SE m ±	0.521	0.462	0.924
CD (0.05)	1.274	0.979	NS

4.2.2 Girth of the Fruit

The effect of fertigation levels and different spacings on fruit girth is presented in Table 8.

Girth of fruit showed significant variation due to different levels of fertigation. The treatment F_1 recorded the maximum fruit girth (26.24 cm) and it was on par with F_3 (25.24 cm) which were significantly superior to F_2 (23.89 cm) The lowest fruit girth was reported by F_4 (22.25 cm).

The results revealed that different spacings influenced the fruit girth. The maximum fruit girth was recorded by S_3 (25.23 cm) while the lowest fruit girth was reported by S_1 (23.33 cm) and it was on par with S_2 (24.66 cm).

The interaction between fertigation levels and different spacings (F x S) failed to show significant influence on fruit girth.

4.2.3 Total Fruit Yield Plant^{-1}

The effect of fertigation levels and different spacings on total fruit yield plant^{-1} is presented in Table 9.

The data revealed that different levels of fertigation had significant influence on fruit yield plant^{-1}. The maximum fruit yield plant^{-1} (1.72 kg) was recorded by F_1 followed by F_3 (1.40 kg). Both the treatments were significantly superior over F_2 (1.32 kg). The lowest fruit yield plant^{-1} was reported for F_4 (1.15 kg).

Fruit yield plant^{-1} was influenced by different spacings. Maximum fruit yield plant^{-1} (1.53 kg) was recorded from S_3 (45 cm x 60 cm). The lowest fruit yield plant^{-1}(1.30 kg) was obtained from S_1 (45 cm x 30 cm) and it was on par with S_2 (45 cm x 60 cm) (1.36 kg).

The interaction effect of fertigation and spacing (F x S) had no significant influence on fruit yield plant^{-1}.

Table 9. Effect of fertigation levels and different spacings on total fruit yield plant^{-1} (kg) and total fruit yield m^{-2} (kg)

Treatments	Total Fruit Yield Plant^{-1}				Total Fruit Yield m^{-2}			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	1.64	1.70	1.83	1.72	9.68	8.40	6.81	8.30
F_2	1.15	1.27	1.54	1.32	8.51	6.28	5.72	6.84
F_3	1.31	1.43	1.45	1.40	9.10	7.09	5.38	7.19
F_4	1.13	1.04	1.28	1.15	8.37	5.17	4.76	6.10
Mean	1.30	1.36	1.53		8.92	6.74	5.67	

	F	S	F x S
SE m ±	49.153	44.155	88.310
CD (0.05)	120.277	93.609	NS

	F	S	F x S
SE m ±	0.268	0.237	0.474
CD (0.05)	0.656	0.502	NS

4.2.4 Total Fruit Yield m^{-2}

The effects of fertigation levels and different spacings on fruit yield m^{-2} are presented in Table 9.

The data revealed that total fruit yield m^{-2} was significantly influenced by different levels of fertigation. The treatment F_1 recorded higher fruit yield m^{-2} (8.30 kg) followed by F_3 (7.19 kg) which was more or less similar to F_2 (6.84 kg). The lowest fruit yield m^{-2} was noted from F_4 (6.10 kg).

From the results it was observed that different levels of spacing had significant influence on total fruit yield m^{-2}. The highest total fruit yield m^{-2} was recorded from S_1 (8.92 kg) followed by S_2 (6.74 kg) and both the treatments were significantly superior over S_3 (5.67)

The perusal of the data showed that the interaction of fertigation and spacing (F x S) had no significant variation on total fruit yield m^{-2}.

4.3 QUALITY ASPECTS

4.3.1 Ascorbic Acid Content

The results of ascorbic acid content analysis are presented in Table 10.

The data revealed that different levels of fertigation had significant influence on ascorbic acid content of bell pepper. The maximum ascorbic acid content (122.15 mg 100 g^{-1}) was registered by plants treated with F_1 (100 % *adhoc* recommendation of KAU for precision farming) and it was significantly superior to all other treatments.

The ascorbic acid content was observed to differ significantly among the spacings. The treatment S_3 (45 cm x 60 cm) recorded the maximum ascorbic acid content (111.75 mg 100 g^{-1}).

Interaction effect of F x S had no significant effect on ascorbic acid content of bell pepper.

Table 10. Effect of fertigation levels and different spacings on ascorbic acid content and shelf life (days)

Treatments	Ascorbic acid content (mg 100 g^{1})				Shelf life (days)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	123.96	114.40	128.08	122.15	8.00	7.83	8.58	8.14
F_2	97.60	95.55	97.35	96.83	8.17	8.60	9.08	8.62
F_3	86.75	104.11	110.94	100.60	8.00	8.67	8.83	8.50
F_4	95.86	81.33	110.61	95.93	7.83	8.50	8.67	8.33
Mean	101.04	98.84	111.75		8.00	8.40	8.79	

	F	S	F x S		F	S	F x S
SE m ±	8.465	4.967	9.934	SE m ±	0.252	0.235	0.470
CD (0.05)	20.714	10.530	NS	CD (0.05)	NS	0.498	NS

4.3.2 Shelf Life

The details of shelf life recorded are presented in Table 10.

Shelf life of bell pepper fruits was not significantly influenced by fertigation levels.

From the results it was confirmed that different spacings significantly influenced the shelf life of fruits. Fruits obtained from plants spaced at 45 cm x 60 cm (S_3) recorded more shelf life (8.79 days).

Interaction effect of fertigation and spacing (F x S) had no significant influence on fruit shelf life.

4.3.3 Capsaicin Content

The result of capsaicin analysis is presented in Table 11.

Treatments like fertigation (F), spacing (S) and their interaction (F x S) didn't cause significant influence on capsaicin content of bell pepper.

4.4 PLANT ANALYSIS

4.4.1 Nitrogen Uptake

Nitrogen uptake is presented in Table 12.

Levels of fertigation had significant influence on nitrogen uptake. The maximum nitrogen uptake (245.21 kg ha^{-1}) was recorded by plants grown with 100 % *adhoc* recommendation of KAU for precision farming (F_1) and it was on par with 50 % adhoc recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT (F_3) (228.25 kg ha^{-1}).

Nitrogen uptake was not significantly influenced by spacing (S) and interaction of fertigation and spacing (F x S).

Table 11. Effect of fertigation levels and different spacings on capsaicin content

Treatments	Capsaicin content (%)			
	S_1	S_2	S_3	Mean
F_1	0.092	0.091	0.098	0.093
F_2	0.077	0.088	0.096	0.087
F_3	0.093	0.096	0.109	0.099
F_4	0.082	0.080	0.073	0.078
Mean	0.086	0.089	0.094	

	F	S	F x S
SE m ±	0.0051	0.0035	0.0070
CD (0.05)	NS	NS	NS

Table 12. Effect of fertigation levels and different spacings on nutrient uptake (kg ha^{-1})

Treatments	N uptake				P uptake			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	245.45	244.47	245.71	245.21	26.50	27.57	24.27	26.11
F_2	204.67	214.99	211.10	210.25	23.42	25.49	25.30	24.74
F_3	239.08	230.67	214.99	228.25	23.11	24.99	24.50	24.20
F_4	208.89	206.00	206.00	206.96	23.10	22.66	24.96	23.57
Mean	224.52	224.03	219.45		24.03	25.18	24.76	

	F	S	F x S
SE m ±	9.602	6.543	13.086
CD (0.05)	23.496	NS	NS

	F	S	F x S
SE m ±	0.328	0.738	1.476
CD (0.05)	0.803	NS	NS

Table 13. Effect of fertigation levels and different spacings on nutrient uptake (kg ha^{-1})

Treatments	K uptake			
	S_1	S_2	S_3	Mean
F_1	105.54	105.12	105.66	105.44
F_2	88.01	92.45	90.77	90.41
F_3	102.80	99.19	92.45	98.15
F_4	89.82	88.58	88.58	88.99
Mean	96.54	96.33	94.36	

	F	S	F x S
SE m ±	4.129	2.813	5.627
CD (0.05)	10.103	NS	NS

4.4.2 Phosphorus Uptake

Phosphorus uptake is presented in Table 12.

Different fertigation levels showed significant variation in phosphorus uptake. Plants grown with 100 % *adhoc* recommendation of KAU for precision farming (F_1) registered the maximum phosphorus uptake (26.11 kg ha^{-1}).

Spacing (S) and interaction of fertigation and spacing (F x S) didn't cause significant influence on phosphorus uptake.

4.4.3 Potassium Uptake

Potassium uptake is presented in Table 13.

The results revealed that different levels of fertigation showed significant variation in potassium uptake. The higher potassium uptake (105.44 kg ha^{-1}) was recorded for F_1 (100 % *adhoc* recommendation of KAU for precision farming) and it was on par with 50 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT (F_2).

The data confirmed that spacing (S) and interactions of fertigation and spacing (F x S) had no significant influence on potassium uptake.

4.5 SOIL ANALYSIS

4.5.1 Organic Carbon Content

Organic carbon content is presented in Table 14.

Neither the treatments nor their interaction effect have significant influence on organic carbon content in soil.

4.5.2 Available N Status in Soil

Available N status is presented in Table 14.

Table 14. Effect of fertigation levels and spacing on organic carbon and available soil nitrogen

Treatments	Organic carbon (%)				Available N (kg ha^{-1})			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	1.51	1.37	1.41	1.43	265.00	275.67	257.43	266.03
F_2	1.47	1.44	1.36	1.42	241.19	260.22	271.57	257.66
F_3	1.41	1.40	1.37	1.39	231.71	249.89	258.93	246.84
F_4	1.44	1.54	1.47	1.48	231.00	226.56	255.56	237.70
Mean	1.46	1.44	1.40		242.23	253.08	260.87	

	F	S	F x S
SE m ±	0.048	0.024	0.048
CD (0.05)	NS	NS	NS

	F	S	F x S
SE m ±	5.243	7.808	15.616
CD (0.05)	12.830	NS	NS

Fertigation levels significantly influenced the available N status in soil. The treatment F_1 (100 % *adhoc* recommendation of KAU for precision farming) recorded higher (266.03 kg ha^{-1}) available N in the soil and it was comparable with F_2 (257.66 kg ha^{-1}).

There was no significant difference on available N content in soil with different spacings and interaction effects of fertigation and spacing (F x S).

4.5.3 Available P Status in Soil

Available P status is presented in Table 15.

Fertigation levels significantly influenced the available P status in soil. The treatment F_1 (100 % adhoc recommendation of KAU for precision farming) recorded higher (340.75 Kg ha^{-1}) available P in soil and it was on par with 50 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT (F_3) (339.08 kg ha^{-1})

There was no significant difference on available P content in soil with different spacings and interaction effects of fertigation and spacing (F x S).

4.5.4 Available K status in Soil

Available K status is presented in Table 15.

There was no significant difference on available K content in soil with different levels of fertigation, spacing and their interaction effects.

4.6 INCIDENCE OF PEST AND DISEASES

No incidence of pests and diseases were found to infect the crop beyond the economic threshold level demanding control measures and hence no scoring was done

Table 15. Effect of fertigation levels and different spacings on available soil nutrients (kg ha^{-1})

Treatments	Available P				Available K			
	S_1	S_2	S_3	Mean	S_1	S_2	S_1	Mean
F_1	339.76	340.98	341.52	340.75	95.37	93.67	97.73	95.59
F_2	336.82	336.82	335.42	336.35	95.10	95.84	95.16	95.37
F_3	338.00	338.72	340.53	339.08	91.33	95.54	95.59	94.15
F_4	332.19	334.03	336.26	334.16	94.37	93.83	94.14	94.12
Mean	336.69	337.64	338.43		94.04	94.72	95.66	

	F	S	F x S
SE m ±	0.726	0.821	1.643
CD (0.05)	1.777	NS	NS

	F	S	F x S
SE m ±	0.775	0.614	1.229
CD (0.05)	NS	NS	NS

4.7 ECONOMIC ANALYSIS

The results on the effect of fertigation levels, spacing and their interaction on net returns and benefit cost ratio are presented in Table 16.

4.7.1 Net returns

The perusal of the data showed that fertigation levels had significant influence on net returns (Table 16). Significantly higher net returns (₹ 1,59,018 10 cents^{-1} was recorded by the treatment F_1 (100 % *adhoc* recommendation of KAU for precision farming) followed by F_3 (₹ 1,28,869 10 cents^{-1}). The treatment F_4 recorded the lowest net returns (₹ 1,01,973 10 cents^{-1}).

The different spacings exerted a pronounced effect on net returns. The treatment S_1 (45 cm x 30 cm) registered the highest net returns (₹ 1,64,423 10 cents^{-1}) while wider spacing (45 cm x 60 cm) recorded the lowest (₹ 98,668 10 cents^{-1}).

The interaction between fertigation and spacing did not have any significant effect on net returns. Even though from the data we can confirm that 100 % *adhoc* recommendation of KAU for precision farming along with closer spacing of 45 cm x 30 cm (f_1s_1) registered highest net returns (₹ 1,88,956 10 cents^{-1}).

4.7.2 B: C ratio

Benefit cost ratio also showed significant variation among fertigation levels (Table 16). The highest B: C ratio (3.16) was registered by F_1 (100 % *adhoc* recommendation of KAU for precision farming) which was followed by F_3 (50 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAP) (2.91).

The influence of spacing on B: C ratio was significant. From the results it was observed that S_1 (45 cm x 30 cm) reported the highest B: C ratio (3.22).

The data revealed that interaction between two treatments was not significant. Even though the results confirmed that 100 % *adhoc* recommendation of KAU for precision farming along with closer spacing of 45 cm x 30 cm (f_1s_1) registered the highest B: C ratio (3.30).

Table 16. Effect of fertigation levels and different spacings on net returns and benefit-cost ratio

Treatments	Net returns (₹ 10 cents^{-1})				Benefit-cost ratio			
	S_1	S_2	S_3	Mean	S_1	S_2	S_1	Mean
F_1	188956	163604	124494	159018	3.30	3.29	2.88	3.16
F_2	162692	111131	101065	124962	3.15	2.72	2.71	2.86
F_3	161187	133891	91527	128869	3.13	3.07	2.55	2.91
F_4	144857	83475	77585	101973	3.01	2.36	2.39	2.59
Mean	164423	123025	98668		3.22	2.86	2.63	

	F	S	F x S
SE m ±	4054.0	5490.6	10981.3
CD (0.05)	9920.1	11640.2	NS

	F	S	F x S
SE m ±	0.063	0.088	0.176
CD (0.05)	0.154	0.186	NS

DISCUSSION

5. DISCUSSION

The experiment entitled "Standardisation of fertigation schedule and spacing for bell pepper (*Capsicum annuum* L.var.grossum sendt.) was undertaken to assess the optimum fertigation schedule and spacing of bell pepper under polyhouse condition and also to work out the economics of cultivation. The results of the experiment are discussed briefly in this chapter.

5.1 GROWTH CHARACTERS

Plant height was significantly influenced by fertigation levels except at early growth stages. Among the fertigation levels plants grown in 100 % *adhoc* recommendation of KAU for precision farming (F_1) recorded taller plants compared to lower levels of fertigation. At 90 and 150 DAT the height of plants in F_1 was on par with F_2 (50 % *adhoc* recommendation of KAU for precision farming) and F_3 (50 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAP) respectively. Similar findings of taller plants due to higher levels of NPK (280: 32: 416 kg ha^{-1}) in bell pepper under polyhouse was reported by Raut (2001). The increased availability of N might have exerted a positive influence on photosynthesis and meristematic activity of cells thereby increasing the plant height. The present result is in conformity with the findings of Shrivastava (1996).

It could be seen from the results presented in the Table 6. and Fig. 5. that 100 % *adhoc* recommendation of KAU for precision farming (F_1) recorded the highest number of branches $plant^{-1}$ at 50 % flowering (4.0), while the number of branches at final harvest (7.81) was comparable with F_3. The same treatment (F_1) registered higher LAI at 50 % flowering (4.42) and final harvest (6.63). The increased growth attributes by the application of higher dose of fertilizer might be due to the higher availability of NPK. The increased availability of all the major nutrients in treatment F_1 might have enhanced meristematic activity which resulted in more number of buds thereby producing more number of branches.

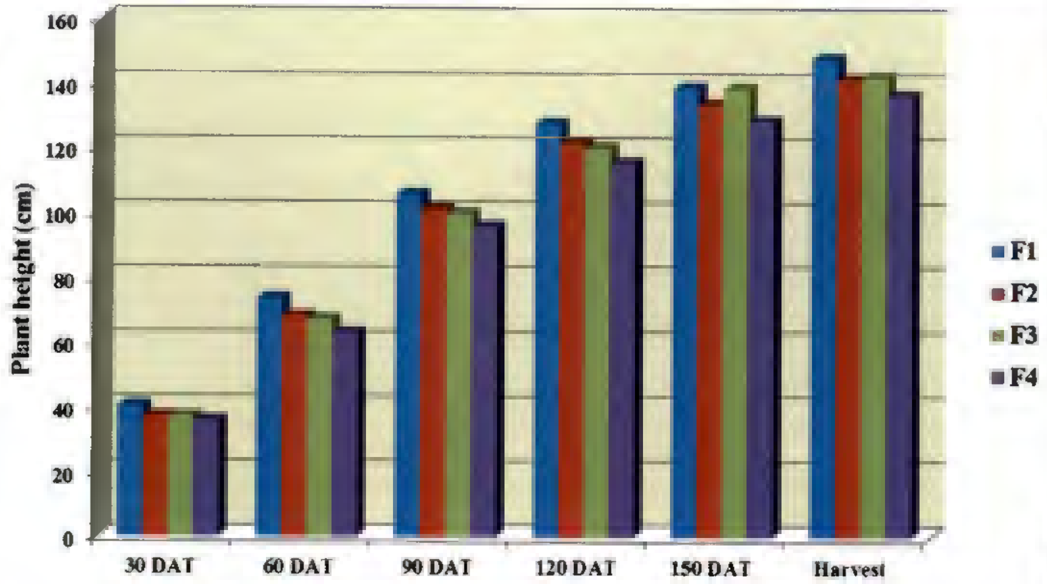

Fig. 3. Effect of fertigation levels on plant height at different growth stages

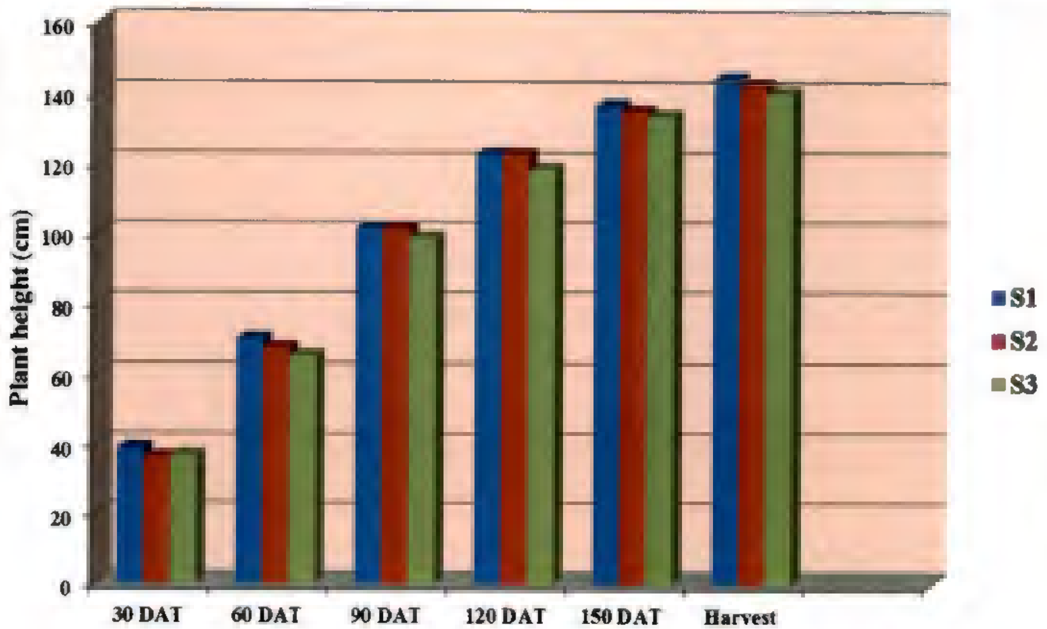

Fig. 4 Effect of different spacings on plant height at different growth stages

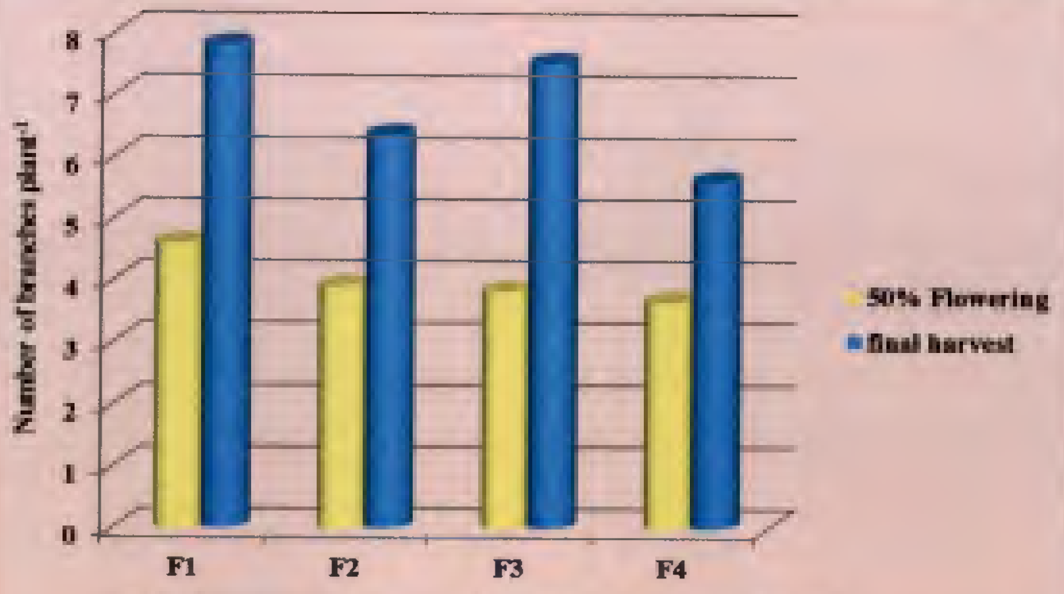

Fig. 5. Effect of fertigation levels on number of branches plant^{-1}

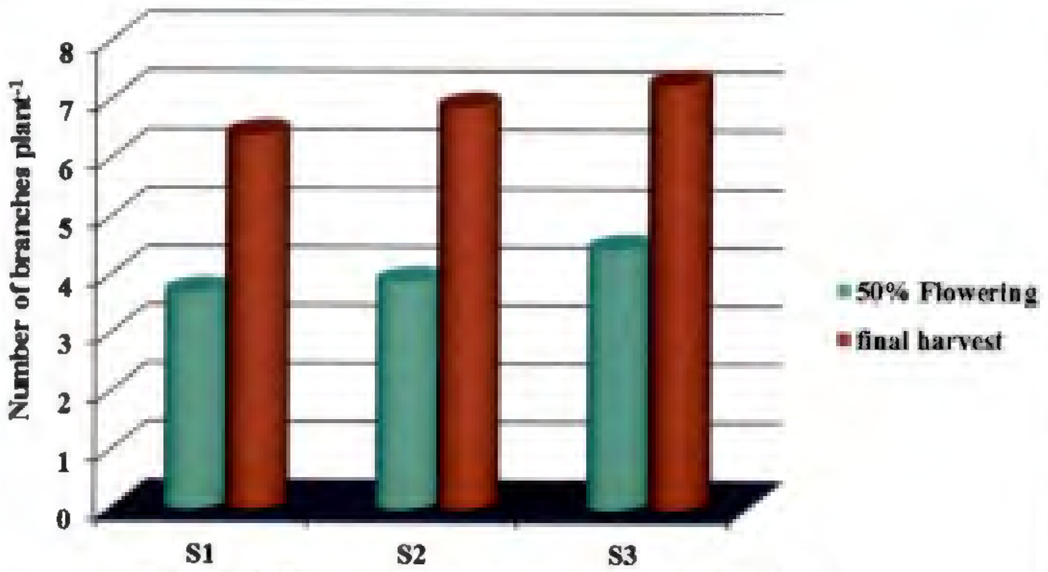

Fig. 6. Effect of different spacings on number of branches plant^{-1}

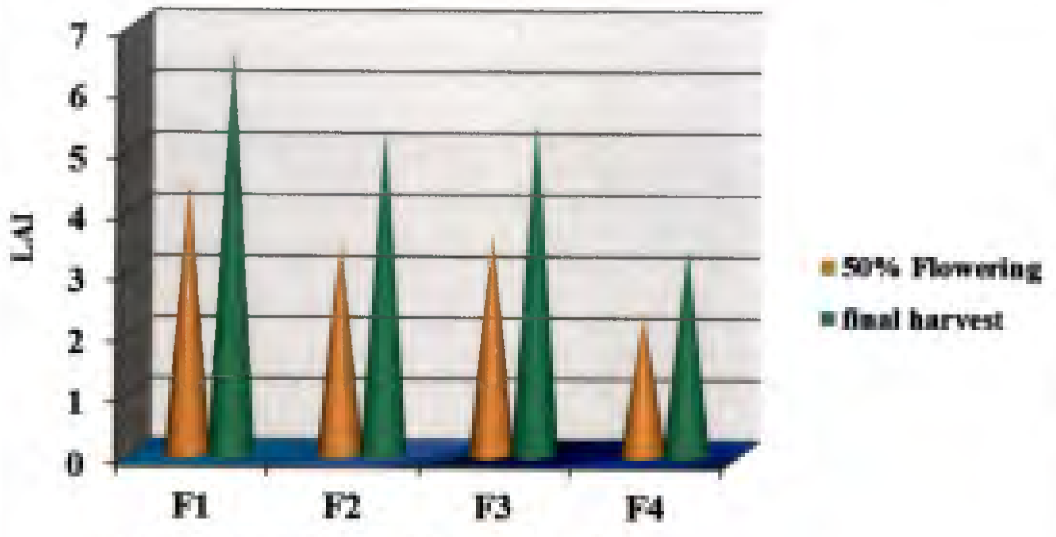

Fig. 7. Effect of fertigation levels on LAI

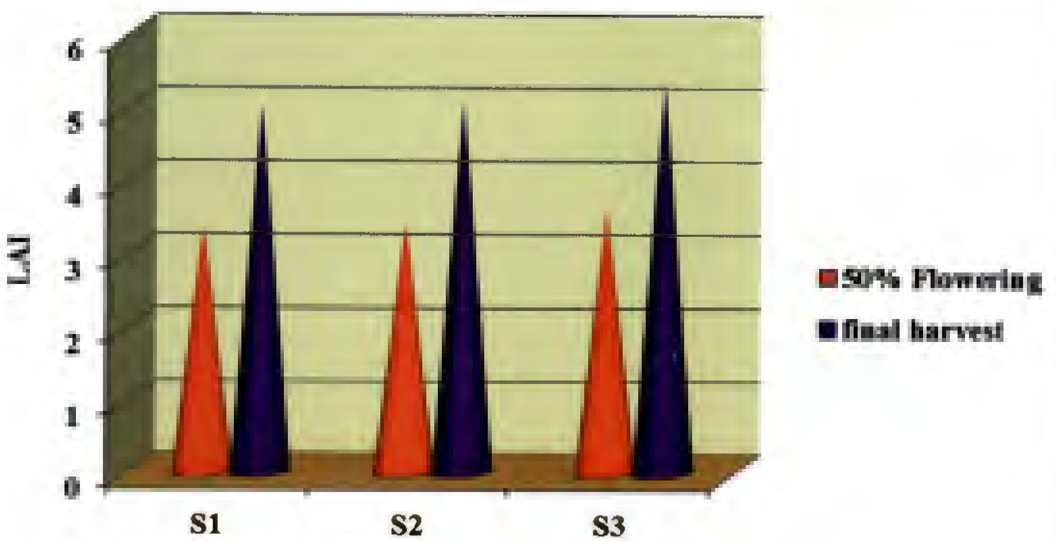

Fig. 8. Effect of different spacings on LAI

Chaudhary *et al.* (2007) also observed increased number of branches at higher level of N.

Increase in plant height and number of branches $plant^{-1}$ in F_1 have attributed to corresponding increase in the number of leaves which in turn might have influenced the LAI. Higher number of leaves and branches plants $^{-1}$ due to K application (200 kg) in bell pepper was reported by El-Bassiony *et al.* (2010).

Different spacingss had significant influence on growth attributes of bell pepper. The closer spacing of 45 cm x 30 cm (S_1) recorded maximum plant height (70.40 cm) at 60 DAT, while at 120 DAT it was 122.90 cm and was on par with S_2 (45 cm x 45 cm). At 150 DAT and at harvest plant height was more in S_1 which was more or less similar to S_2. This might be due to competition for light and space in closer spacing which forced plants to grow taller. Similar results of increase in plant height with closer spacing in bell pepper was reported by Islam *et al.* (2011) and Kumar and Chandra (2014). Wider spacing of 45 cm x 60 cm (S_3) produced more number of branches (4.44) at 50 % flowering and at final harvest (7.25). The widely spaced plants received better solar radiation and enough space for lateral growth resulting in more number of branches $plant^{-1}$. The same treatment (S_3) registered higher LAI at 50 % flowering (3.57) and at final harvest (5.36). Increased vegetatitive growth in S_3 have attributed to corresponding increase in the number of leaves which in turn might have influenced the LAI. Similar findings of higher number of branches $plant^{-1}$ and leaves in bell pepper with wider spacing was reported by Islam *et al.* (2011)

5.2 YIELD AND YIELD ATTRIBUTES

Different fertigation levels had significant influence on number of fruits $plant^{-1}$, girth of the fruit (cm), total fruit yield $plant^{-1}$ and total fruit yield m^{-2}

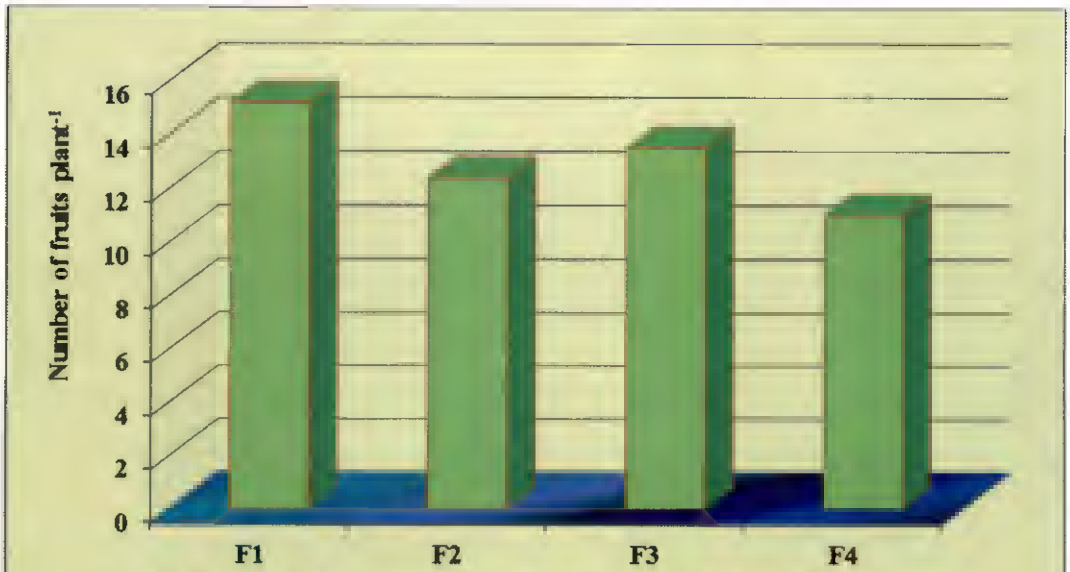

Fig. 9. Effect of fertigation levels on number of fruits plant^{-1}

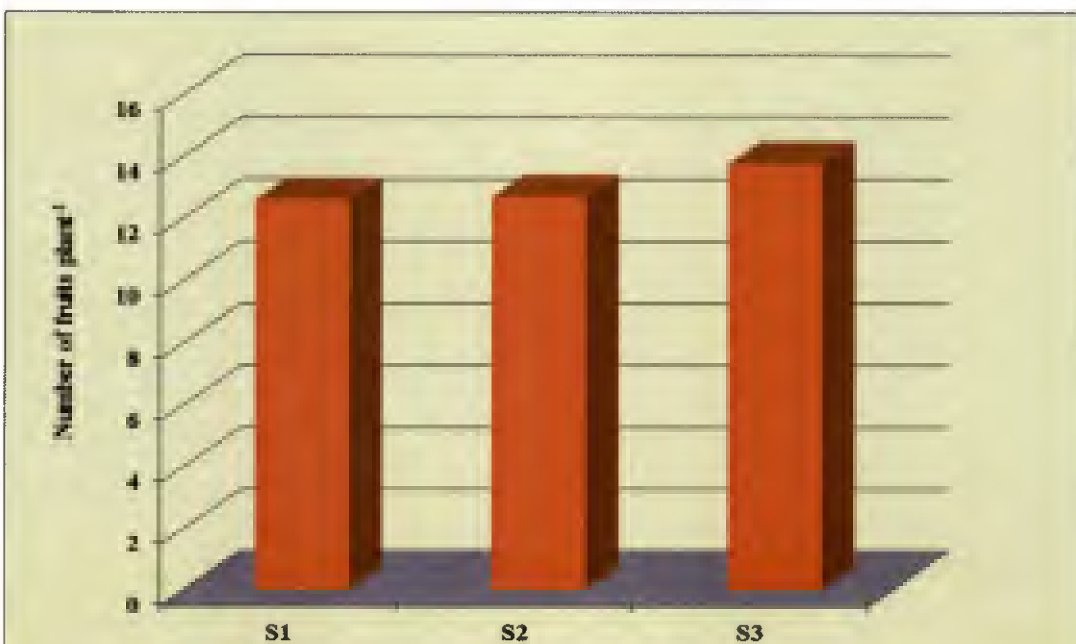

Fig. 10. Effect of different spacings on number of fruits plant^{-1}

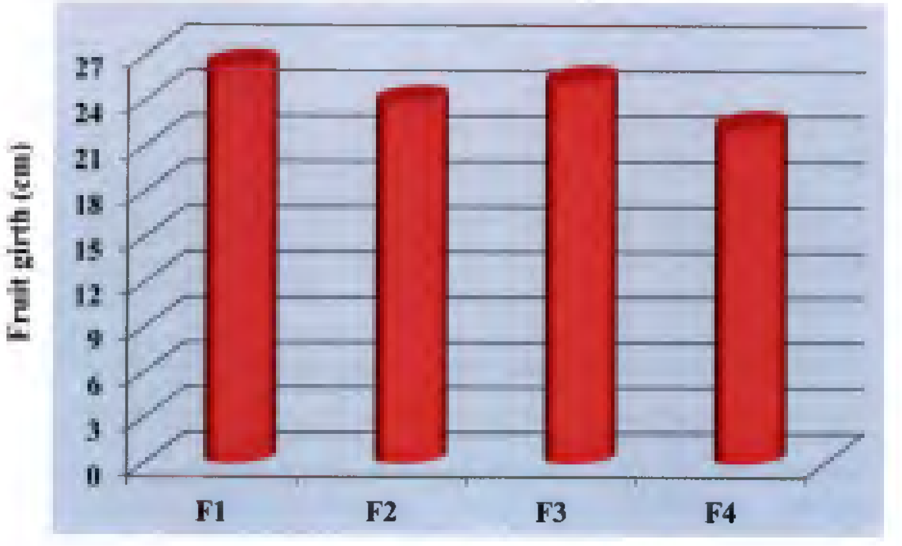

Fig. 11. Effect of fertigation levels on fruit girth

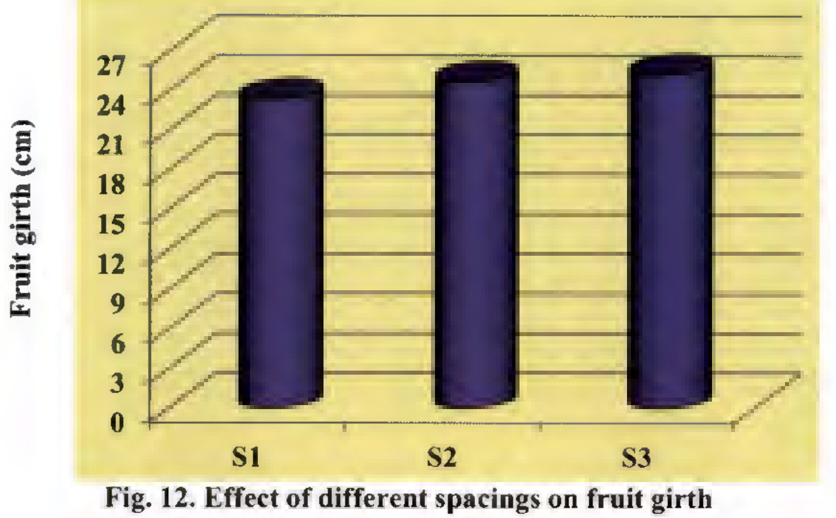

Fig. 12. Effect of different spacings on fruit girth

The treatment F_1 (100 % *adhoc* recommendation of KAU for precision farming) recorded the highest number of fruits plant^{-1} (15.15) followed by F_3 (50 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT) (13.49) and F_2 (50 % *adhoc* recommendation of KAU for precision farming) (12.37). Maximum fruit girth (26.24 cm) was recorded from F_1 and it was on par with F_3 (25.24 cm) and significantly superior to F_2 (23.89 cm) and F_4 (22.25 cm). F_1 also recorded higher fruit yield plant^{-1} (1.72 kg) and fruit yield m^{-2} (8.30 kg). Similar findings of increased yield in bell pepper with 252 kg N and 240 kg N was reported by Hartz *et al*. (1993) and Aliyu (2002) respectively. The increased availability of nutrients for the treatment F_1 might have increased the photosynthate accumulation enhancing the yield attributes and yield. Similar finding of increased fruit weight, yield plant $^{-1}$ and yield ha^{-1} with higher dose of NPK (250:200:200 kg ha^{-1}) was reported by Shrivastava (1996).

Yield and yield attributes were significantly influenced by different plant spacingss. The treatment S_3 (45 cm x 60 cm) recorded the highest number of fruits plant^{-1} (13.75), fruit girth (25.23 cm) and fruit yield plant^{-1} (1.53 kg). This might be due to higher availability of sunshine, more space and less competition for nutrients which in turn promoted more number of flowers and increased photosynthate accumulation. Similar results of of higher yield and yield attributes with wider spacing in bell pepper were reported by Alam *et al*. (2011) and Biradar *et al*. (2014). Closely spaced plants (45 cm x 30 cm) produced the maximum total fruit yield m^{-2} (8.92 kg). The higher plant population in closer spacing resulted in higher fruit yields ha^{-1} compared to wider spacing. Similar findings of increased fruit yield ha^{-1} with closer spacing were reported by Zende (2008) and Shivakumar *et al*. (2012).

5.2 QUALITY ASPECTS

Different levels of fertigation had significant influence on ascorbic acid content of bell pepper. Maximum ascorbic acid content (122.15 mg 100 g^{-1}) was registered in F_1 (100 % *adhoc* recommendation of KAU for precision farming)

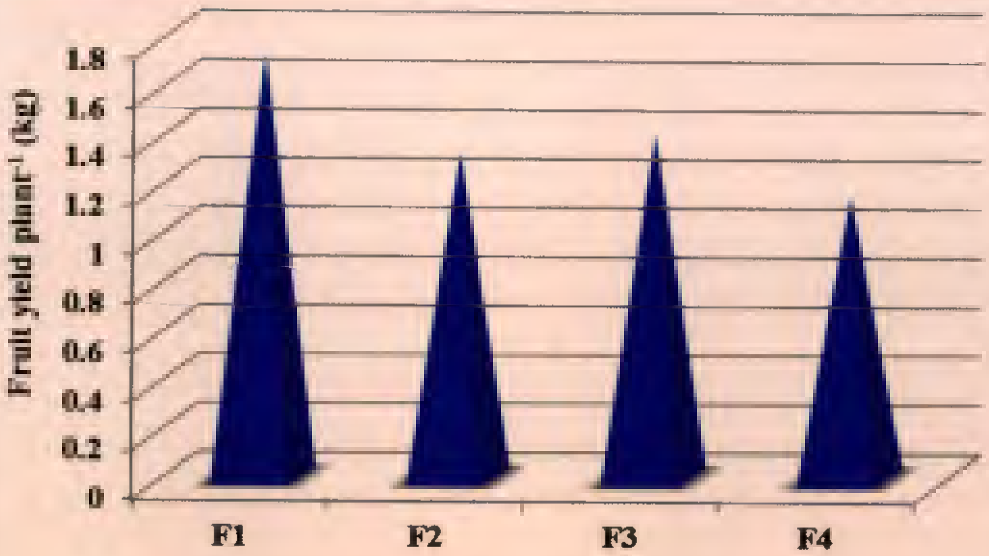

Fig. 13. Effect of fertigation levels on fruit yield plant^{-1}

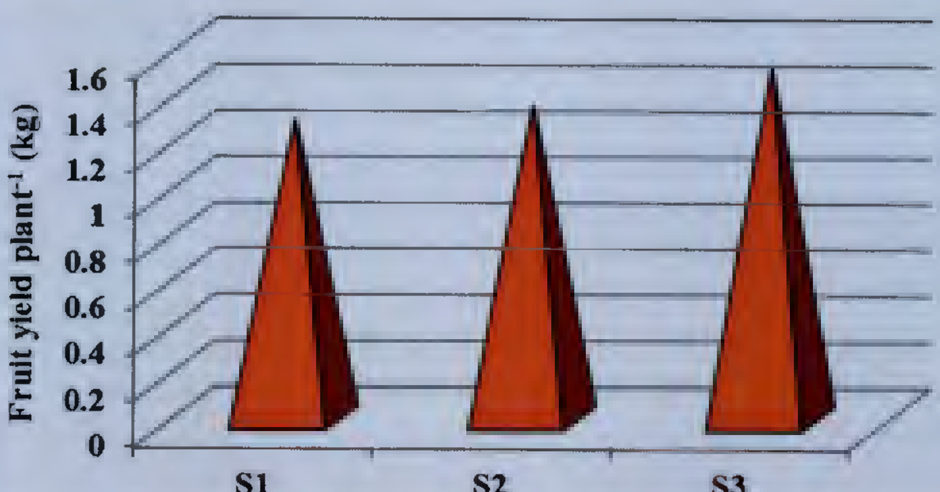

Fig. 14. Effect of different spacings on fruit yield plant^{-1}

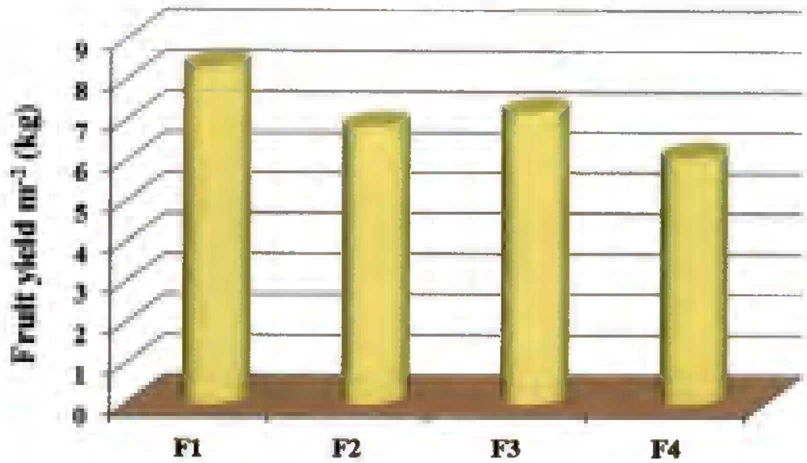

Fig. 15. Effect of fertigation levles on fruit yield m^{-2}

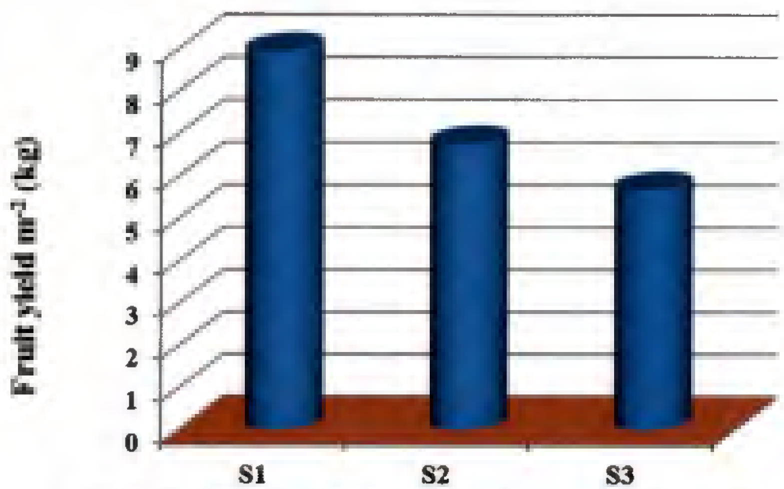

Fig. 16. Effect of different spacings on fruit yield m^{-2}

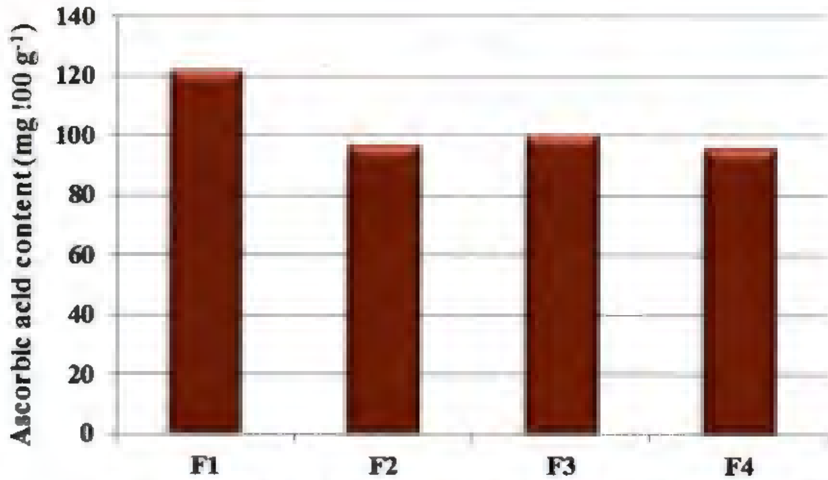

Fig. 17. Effect of fertigation levels on ascorbic acid content

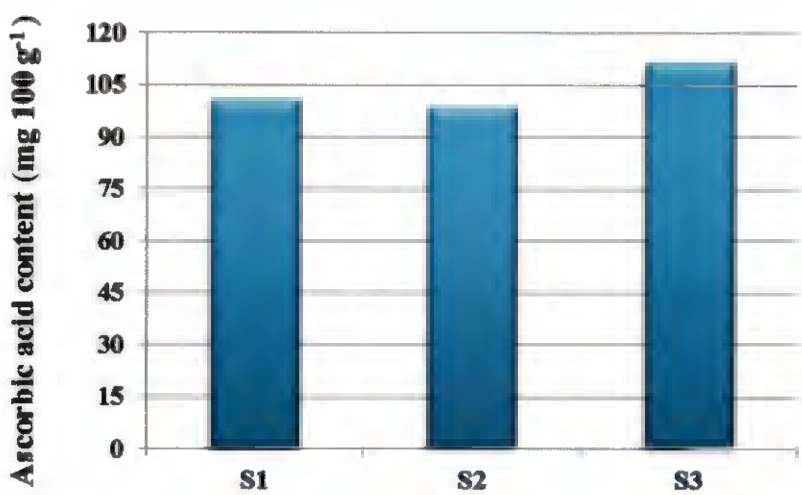

Fig. 18. Effect of different spacings on ascorbic acid content

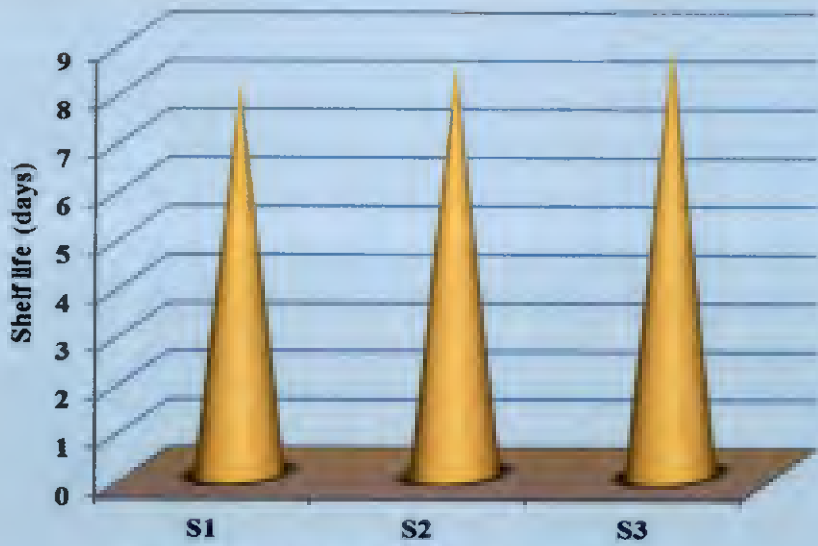

Fig. 19. Effect of different spacings on shelf life

and it was significantly superior to all other treatments. N and P have significant influence on carbohydrate production. Since ascorbic acid is a carbohydrate constituent the higher N and P availability in F_1 might have increased the ascorbic acid content. Similar findings of increased ascorbic acid content with higher dose of N and K in bell pepper were reported by Ayodele *et al.* (2015) and El-Bassiony *et al*. (2010) respectively.

The ascorbic acid content and shelf life were significantly influenced by different plant spacings. Wider spacing of 45 cm x 60 cm (S_3) recorded the highest ascorbic acid content (111.75 mg 100 g^{-1}) and more shelf life (8.79 days). The higher availability of sunlight and more space increased the photosyhthetic activity and carbohydrate accumulation in widely spaced plants which might have resulted in bigger fruits with thick pericarp. This might have contributed to higher shelf life in widely spaced plants. These results are in line with the findings of Zende (2008).

5.3 PLANT ANALYSIS

5.3.1 Uptake of Nutrients

Levels of fertigation significantly influenced nutrient uptake. Maximum nitrogen uptake (245.21 kg ha^{-1}) and K (105.44 kg ha^{-1}) was recorded by plants grown with 100 % *adhoc* recommendation of KAU for precision farming (F_1) which were on par with F_3 (50 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT). The same treatment F_1 also registered higher P uptake (26.11 kg ha^{-1}). The higher nutrient uptake for F_1 might be due to higher DMP and availability of higher levels of nutrients to the crop. Similar result of increased nutrient uptake with higher levels of nutrients in bell pepper and synergistic effect of N on P and K was reported by Qawasmi *et al*. (1999)

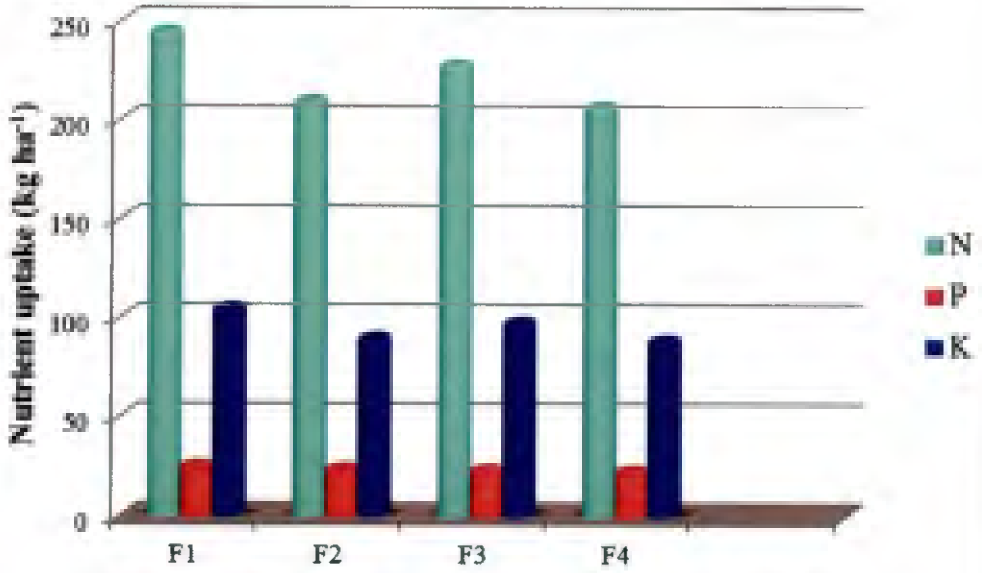

Fig. 20. Effect of fertigation levels of nutrient uptake

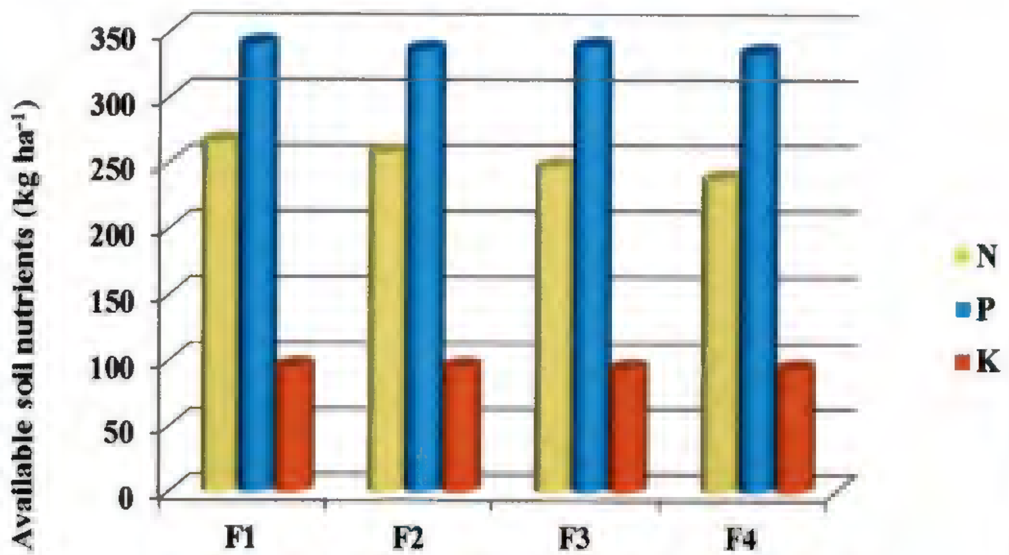

Fig. 21. Effect of fertigation levles on available soil nutrients

5.4 SOIL ANALYSIS

5.4.1 Available Nutrients in Soil

The organic carbon content and available K were not significantly influenced by fertigation levels. The available N and P varied significantly due to different fertigation levels The highest value for available N was registered by F_1 (266.03 kg ha^{-1}) and it was on par with F_2 (257.66 kg ha^{-1}). The available P was highest for F_1 (340.75 kg ha^{-1}) and it was comparable with F_3 (339.08 kg ha^{-1}). The higher available nutrients for F_1 might be due to application of higher amount of nutrients compared to other treatments.

4.7 ECONOMIC ANALYSIS

Significantly higher net returns (₹ 1,59,018 10 $cents^{-1}$) and B: C ratio (3.16) were recorded by 100 % *adhoc* recommendation of KAU for precision farming (F_1). This was due to higher yield registered in this level. Similar result of maximum net returns with higher NPK dose in bell pepper was reported by Raut (2001).

The treatment S_1 (45 cm x 30 cm) registered the highest net returns (₹ 1,64,42310 $cents^{-1}$) and B: C ratio (3.22). The higher plant population in closer spacing resulted in higher fruit yield per unit area resulting in higher net returns and B: C ratio. Similar findings of increased B: C ratio with closer spacing in bell pepper was reported by Lone (2014) and Ahirwar and Hedau (2015)

Even though the interaction between two treatments was not significant, higher net returns (₹1,88,956 10 $cents^{-1}$) and B: C ratio (3.30) were recorded by the application of 100 % *adhoc* recommendation of KAU for precision farming along with closer spacing of 45 cm x 30 cm (f_1s_1).

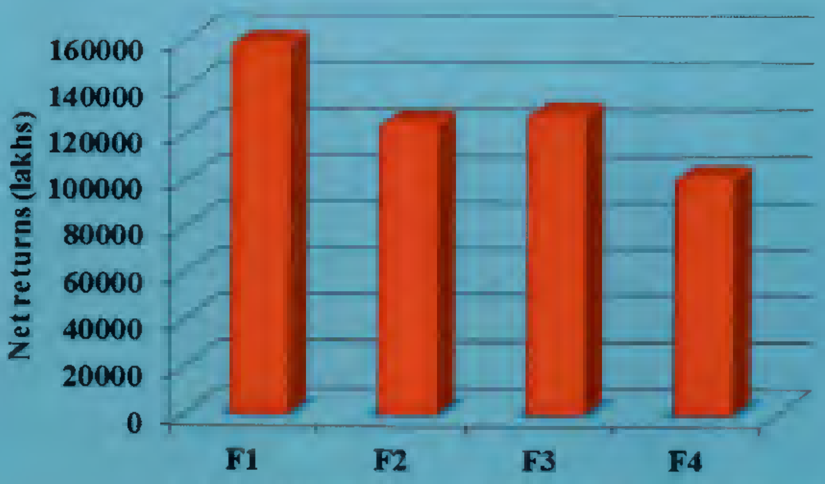

Fig. 22. Effect of fertigation levels on net returns

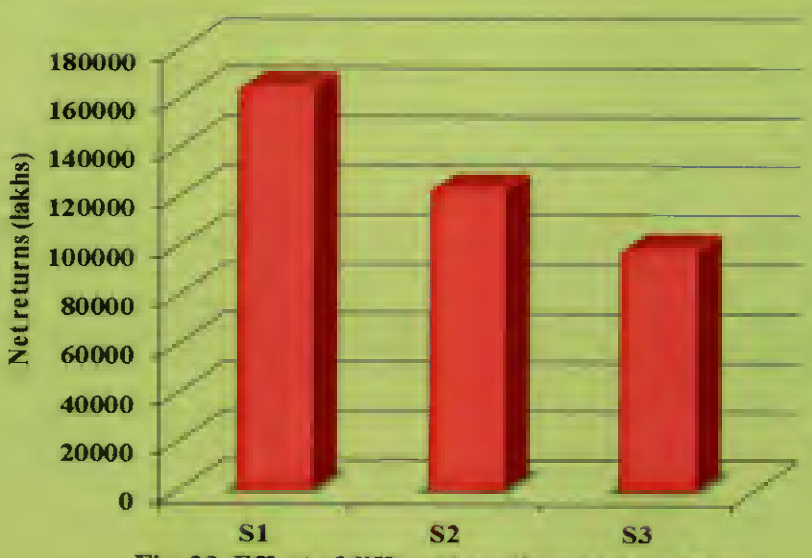

Fig. 23. Effect of different spacings on net returns

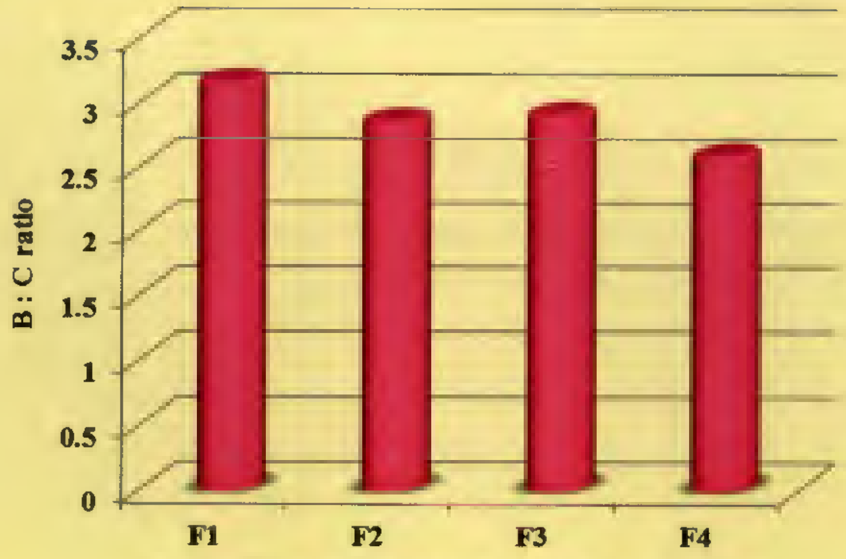

Fig. 24. Effect of fertigation levels on B : C ratio

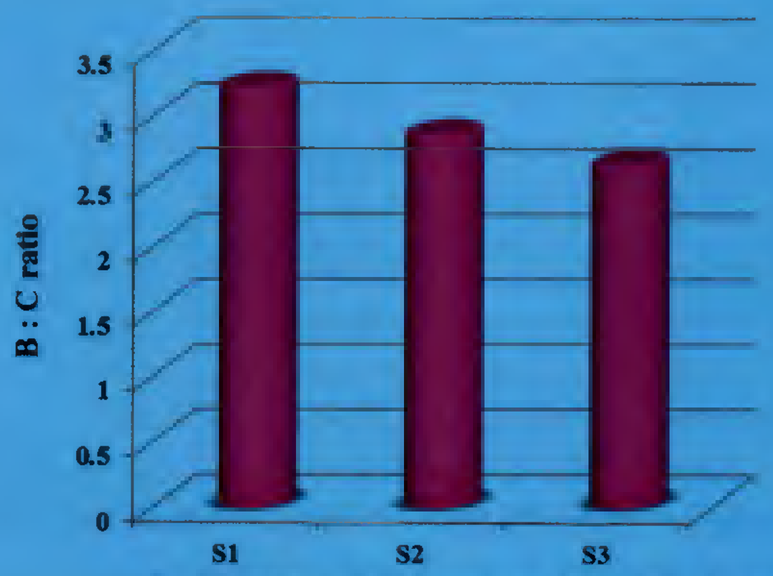

Fig. 25. Effect of different spacings of B : C ratio

SUMMARY

6. SUMMARY

The experiment entitled "Standardisation of fertigation schedule and spacing for bell pepper (*Capsicum annuum* L.var.grossum sendt.) in polyhouse" was conducted in the farmer's field in Parassala block, Thiruvananthapuram, Kerala. The main objectives of the experiment were to standardize fertigation schedule and spacing for bell pepper grown in polyhouse and to work out the economics.

The study was laid out in split plot design with 12 treatment combinations replicated three times. The main plot treatments consisted of four levels of fertigation *viz.*, 100 % *adhoc* recommendation of KAU for precision farming (F_1), 50 % *adhoc* recommendation of KAU for precision farming (F_2), 50 % *adhoc* recommendation of KAU for precision farming + foliar spray of combined solution of urea and potassium chloride each at 1.25 % at 30 and 60 DAT (F_3) and 25 % *adhoc* recommendation of KAU for precision farming + foliar spray of combined solution of urea and potassium chloride each at 1.25 % at 30 and 60 DAT (F_4). The 100 % *adhoc* recommendation of KAU for precision farming is 230:25:250 N, P_2O_5 and K_2O kg ha^{-1}. The subplot treatments consisted of three spacings *viz.*, 45 cm x 30 cm (S_1), 45 cm x 45 cm (S_2) and 45 cm x 60 cm (S_3).

The treatment F_1 (100 % *adhoc* recommendation of KAU for precision farming) recorded the tallest plants of 73.57 cm, 127.9 cm and 148.17 cm at 60, 120 DAT and at harvest respectively and at 150 DAT F_1 was on par with F_3. At 90 DAT F_1 and F_2 recorded taller plants compared to other treatments. At all growth stages the lowest plant height was registered from F_4 (25 % adhoc recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT). At 50 % flowering (4.60) and at final harvest (7.81) maximum number of branches was produced by F_1 and at final harvest the number of branches $plant^{-1}$ was comparable with F_3 (7.52). Treatment F_1 registered plants of maximum LAI at 50 % flowering (4.42) and at final harvest (6.63). The lowest number of branches $plant^{-1}$ and LAI at 50 % flowering and at final harvest was recorded in F_4.

The closer spacing of 45 cm x 30 cm (S_1) recorded the maximum plant height of 70.40 cm at 60 DAT while at 120 DAT it was comparable with S_2 (45 cm x 45 cm). At 150 DAT and at harvest the taller plants were registered from S_1 and it was on par with S_2. At all growth stages the lower plant height was recorded by S_3 (45 cm x 60 cm). Wider spacing of 45 cm x 60 cm (S_3) produced more number of branches at 50 % flowering (4.44) and at final harvest (7.25). LAI was higher at 50 % flowering (3.57) and at final harvest (5.36) for S_3 (45 cm x 60 cm). At both the stages the lowest number of branches plant^{-1} and LAI were registered by S_1 (45 cm x 30 cm).

The treatment 100 % *adhoc* recommendation of KAU for precision farming with closer spacing of 45 cm x 30 cm (f_1s_1) recorded taller plants at 60 and 120 DAT. While at 150 DAT the combination of F_1 with different spacings were found superior.

F_1 recorded the maximum (15.15) number of fruits plant^{-1} followed by F_3 (13.49) and F_2 (12.37). The same treatment (F_1) recorded the maximum fruit girth (26.24 cm) and it was on par with F_3 (25.24 cm) and was significantly superior to F_2 (23.89 cm) and F_4 (22.25 cm). Maximum fruit yield plant^{-1} (1.72 kg) and fruit yield m^{-2} (8.30 kg) were also registered by F_1. The lowest value for all the yield parameters were reported in F_4.

The plants spaced at wider spacing of 45 cm x 60 cm (S_3) produced more number of fruits plant^{-1}(13.75). The number of fruits plant^{-1} at 45 cm x 30 cm (S_1) and 45 cm x 45 cm (S_2) were 12.58, 12.67 respectively and were on par. The same treatment S_3 registered maximum fruit girth (25.23 cm) and fruit yield plant^{-1} (1.53 kg). The lowest fruit girth and fruit yield plant^{-1} were recorded by closer spacing. While fruit yield m^{-2} (8.92 kg) was the highest for S_1 (45 cm x 30 cm) and the lowest for S_3 (5.67).

Maximum ascorbic acid content (122.15 mg 100 g^{-1}) was recorded in F_1 (100 % *adhoc* recommendation of KAU for precision farming) which was significantly superior to all other treatments.

The treatment S_3 (45 cm x 60 cm) recorded maximum ascorbic acid content (111.75 mg 100 g^{-1}) and shelf life (8.79 days). The lowest ascorbic acid content (101.04 mg 100 g^{-1}) and shelf life (8.00 days) was recorded by S_1.

The treatment F_1 (100 % *adhoc* recommendation of KAU for precision farming) recorded significantly higher uptake of N (245.21 kg ha^{-1}) and K (105.44 kg ha^{-1}) which were on par with F_3 (50 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT) while P uptake (26.11 kg ha^{-1}) was higher for F_1. The lowest uptake of NPK was recorded in F_4.

Net returns (₹ 1,59,018 10 $cents^{-1}$) and B: C ratio (3.16) were significantly higher in F_1 (100 % *adhoc* recommendation of KAU for precision farming) followed by F_3 and F_2. The lowest net returns (₹ 1019730 10 $cents^{-1}$) and B: C ratio (2.59) were obtained in F_4.

S_1 (45 cm x 30 cm) reported the highest net returns (₹ 1,64,423 10 $cents^{-1}$) and B: C ratio (3.22) and the lowest net reurns (₹ 98668 10 $cents^{-1}$) and B: C ratio (2.63) were found in S_3.

Even though the interaction between two treatments was not significant, higher net returns (₹ 1,88,956 10 $cents^{-1}$) and B: C ratio (3.30) were recorded from the plants treated with 100 % *adhoc* recommendation of KAU for precision farming along with closer spacing of 45 cm x 30 cm (f_1s_1) .

FUTURE LINE OF WORK

- To study the response of bell pepper to higher levels of nutrients under polyhouse condition.
- To evaluate the response of bell pepper varieties to nutrient levels and fertigation intervals under poly house condition.
- To assess the feasibility of reducing the nutrient dose of bell pepper in poly house by foliar application.

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STANDARDISATION OF FERTIGATION SCHEDULE AND SPACING FOR BELL PEPPER (*Capsicum annuum* L.var.grossum sendt.) in POLYHOUSE.

by

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(2015 - 11 - 030)

ABSTRACT

Submitted in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM – 695 522
KERALA, INDIA

2017

ABSTRACT

The experiment entitled "Standardisation of fertigation schedule and spacing for bell pepper (*Capsicum annuum* L.var.grossum sendt.) in polyhouse" was conducted in the farmer's field in Parassala block, Thiruvananthapuram, Kerala. The main objectives of the experiment were to standardize fertigation schedule and spacing for bell pepper grown in polyhouse and to work out the economics.

The study was laid out in split plot design with 12 treatment combinations replicated three times. The main plot treatments consisted of four levels of fertigation *viz*., 100 % *adhoc* recommendation of KAU for precision farming (F_1), 50 % *adhoc* recommendation of KAU for precision farming (F_2), 50 % *adhoc* recommendation of KAU for precision farming + foliar spray of combined solution of urea and potassium chloride each at 1.25 % at 30 and 60 DAT (F_3) and 25 % *adhoc* recommendation of KAU for precision farming + foliar spray of combined solution of urea and potassium chloride each at 1.25 % at 30 and 60 DAT (F_4). The 100 % *adhoc* recommendation of KAU for precision farming is 230:25:250 N, P_2O_5 and K_2O kg ha^{-1}. The subplot treatments consisted of three spacings *viz*., 45 cm x 30 cm (S_1), 45 cm x 45 cm (S_2) and 45 cm x 60 cm (S_3).

The results revealed that the growth and yield attributes were significantly influenced by levels of fertigation. Among the fertigation levels, 100 % *adhoc* recommendation of KAU for precision farming (F_1) recorded taller plants at all growth stages except at 30 DAT. At 50 % flowering and at final harvest, maximum number of branches $plant^{-1}$ was produced by F_1 and at final harvest the number of branches $plant^{-1}$ was comparable with F_3. Treatment F_1 registered plants of maximum leaf area index at 50 % flowering (4.42) and at final harvest (6.63). Similarly, F_1 recorded the highest number of fruits $plant^{-1}$(15.15), fruit girth (26.24 cm), fruit yield $plant^{-1}$ (1.72 kg), fruit yield m^{-2} (8.30 kg) and higher ascorbic acid content (122.15 mg 100 g^{-1}).

Growth, yield and quality attributes were significantly influenced by spacing. Closer spacing of 45 cm x 30 cm (S_1) produced taller plants. Wider spacing of 45 cm x 60 cm (S_3) produced more number of branches plant^{-1} at 50 % flowering (4.44) and at final harvest (7.25). Leaf area index was higher at 50 % flowering (3.57) and at final harvest (5.36) for S_3 (45 cm x 60 cm). The same treatment S_3 produced the highest number of fruits plant^{-1} (13.75), fruit girth (25.23 cm) and fruit yield plant^{-1} (1.53 kg) while fruit yield m^{-2} (8.92 kg) was the highest for S_1 (45 cm x 30 cm). Wider spacing of 45 cm x 60 cm (S_3) produced fruits with higher ascorbic acid content (111.75 mg 100 g^{-1}) and more shelf life (8.79 days).

The treatment F_1 (100 % *adhoc* recommendation of KAU for precision farming) recorded significantly higher uptake of N (245.21 kg ha^{-1}), and K (105.44 kg ha^{-1}) which were on par with F_3 (50 % *adhoc* recommendation of KAU for precision farming + foliar spray at 30 and 60 DAT) while P uptake (26.11 kg ha^{-1}) was higher for F_1.

The soil analysis before the field experiment revealed that the soil was acidic (5.5) in reaction, high in organic carbon content (1.4 %), low in available nitrogen (225.79 kg ha^{-1}) and potassium (94.68 kg ha^{-1}) and high in available phosphorus (336.78 kg ha^{-1}) After the experiment available N and P were significantly influenced by fertigation levels. The highest value for available N was registered by F_1 (266.03 kg ha^{-1}) which was on par with F_2 (257.66 kg ha^{-1}). The available P was highest for F_1 (340.75 kg ha^{-1}) which was comparable with F_3 (339.08 kg ha^{-1})

Economic analysis revealed that net returns (₹ 1,88,956 10 cents^{-1}) and B: C (3.30) ratio was the highest for f_1s_1 (100 % *adhoc* recommendation of KAU for precision farming with closer spacing of 45cm x 30 cm).

സംഗ്രഹം

ബെൽ പെപ്പറിലെ പോളിഹൗസ് കൃഷിയിൽ അനുവർത്തിക്കേണ്ട ഫെർട്ടിഗേഷനും നടീൽ അകലവും ചിട്ടപ്പെടുത്തുന്നതിനായി തിരുവനന്തപുരം ജില്ലയിലെ പാറശാല ബ്ലോക്കിലെ കർഷകന്റെ കൃഷി ഇടത്തിൽ 2016 ജൂൺ മുതൽ നവംബർ വരെ പരീക്ഷണം നടത്തുകയുണ്ടായി ഈ രീതി മൂലം ബെൽ പെപ്പറിലെ വളർച്ച , വിളവ് ഗുണം, സാമ്പത്തിക ലാഭം എന്നിവയിൽ ഉണ്ടാകുന്ന വ്യതിയാനങ്ങൾ ആണ് പഠനവിധേയമാക്കിയത് .

പ്രസ്തുത പരീക്ഷണത്തിന് സ്പ്ളിറ് പ്ലോട്ട് എന്ന പഠന രീതിയാണ് അവലംബിച്ചത് നാലു അളവിലുള്ള ഫെർട്ടിഗേഷനാണ് പ്രധാനഭൂഭാഗ നിരീക്ഷണത്തിൽ വരുന്നത് അവ ബെൽ പെപ്പറിന്റെ കൃത്യത കൃഷിയ്ക്ക് വേണ്ടി കേരള കാർഷിക സർവകലാശാല അഡ്ഹോക് ശുപാർശയുടെ 100 % 50 % 50 %+ ചെടി നട്ടതിനു 30, 60 ദിവസങ്ങൾക് ശേഷമുള്ള പത്രപോഷണം, 25 % + ചെടി നട്ടതിനു 30, 60 ദിവസങ്ങൾക് ശേഷമുള്ള പത്രപോഷണം എന്നിവയാണ്. മൂന്ന് നടീൽ അകലങ്ങളാണ് (45 cm x 30 cm, 45 cm x 45 cm, 45 cm x 60 cm) ഉപഭൂഭാഗ നിരീക്ഷണത്തിനായി തിരഞ്ഞെടുത്തത്

വിവിധ ഫെർട്ടിഗേഷനുകൾ താരതമ്യം ചെയ്തപ്പോൾ 100 % അഡ്ഹോക് ശുപാർശയിൽ കൃഷി ചെയ്ത ബെൽ പെപ്പർ ചെടികളിൽ നിന്നാണ് കൂടുതൽ വളർച്ചയും, കായ്ഫലവും, അസ്കോർബിക് അമ്ലവും ലഭിച്ചത്

മൂന്നു നടീൽ അകലങ്ങൾ താരതമ്യം ചെയ്തപ്പോൾ 45 cm x 60 cm നിന്നാണ് ഒരു ചെടിയിൽ നിന്നുള്ള കായ്ഫലവും,അസ്കോർബിക് അമ്ലവും കൂടുതൽ കിട്ടിയത്. എന്നാൽ നീളം കൂടി ചെടികളും, സമഗ്രമായ കായ്ഫലവും കൂടുതൽ ലഭിച്ചത് 45 cm x 30 cm നിന്നാണ്

വിവിധ ഫെർട്ടിഗേഷനുകളും നടീൽ അകലങ്ങളും താരതമ്യം ചെയ്തപ്പോൾ 100 % അഡ്ഹോക് ശുപാർശയിൽ 45 cm x 30 cm നടീൽ അകലത്തിൽ വളർത്തിയ ചെടികളിൽ നിന്നാണ് ഏറ്റവും കൂടുതൽ വരുമാനം ലഭിച്ചത്

APPENDIX- I

Weather data in poly house during the cropping period

(June to November, 2016)- Weekly averages

Standard week	Temperature (°C)		Relative humidity (%)	Light intensity (K. lux)
	Max. temp.	Min. temp.		
22	29.40	21.20	86.00	62.30
23	29.60	21.40	90.10	60.70
24	28.00	20.20	89.00	69.34
25	28.30	20.00	94.00	69.80
26	28.10	21.60	79.00	70.20
27	28.60	21.90	84.00	68.80
28	27.00	20.20	85.60	69.45
29	27.20	22.20	86.40	68.20
30	26.60	21.50	92.00	68.30
31	27.70	23.70	85.40	69.49
32	26.70	22.00	91.40	70.70
33	25.20	23.00	91.60	60.30
34	28.40	22.70	87.40	61.30
35	28.20	20.00	91.60	61.50
36	27.40	22.20	89.00	59.80
37	28.20	22.50	91.00	68.40
38	28.50	23.50	90.00	66.80
39	28.20	21.00	94.00	68.20
40	28.20	20.00	89.25	70.60
41	29.70	24.00	87.20	60.06
42	27.80	21.30	91.00	70.70
43	29.20	21.20	90.00	68.10
44	28.00	21.00	88.00	69.20
45	28.40	20.40	89.50	66.30
46	28.50	20.30	90.00	66.10

APPENDIX – II

Average input cost and market price of produce

SL. No	Items	Cost
	Inputs	
A	Seedling	₹ 10 $seedling^{-1}$
B	**Labour**	
1.	Men	₹ 653 day^{-1}
2.	Women	₹ 653 day^{-1}
C	**Cost of manures and fertilizers**	
1.	FYM	₹ 5 kg^{-1}
2.	Lime	₹ 15 kg^{-1}
3.	Urea	₹ 8 kg^{-1}
4.	Raj phos	₹ 15 kg^{-1}
5.	Potassium chloride	₹ 22.5 kg^{-1}
6.	19:19:19	₹ 200 kg^{-1}
7.	Potassium nitrate	₹ 150 kg^{-1}
8	DAP	₹ 35 kg^{-1}
	Output	
A	Market price of bell pepper	₹ 65 kg^{-1}