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Title	: Effect of Crop Geometry and Fertigation on Quality and Yield of Parthenocarpic Cucumber Cultivars Under Protected Conditions
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ABSTRACT

The present investigation was conducted at Centre of Excellence for Vegetables, Kartarpur, Jalandhar during September-December in 2014 and 2015 to study the probable effect of plant spacing and fertigation on cucumber under Naturally Ventilated Polyhouse. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications, consisting of thirty treatment combinations i.e. five cultivars (Multistar, Hilton, Isatis, Kian and KUK-9), three plant spacing (40 cm x 30 cm, 40 cm x 40 cm and 40 cm x 50 cm) and two fertigation levels of NPK (F1-70:40:90 and F2-100:50:125Kg Per Acre). All the cucumber cultivars under evaluation showed significant variations for almost all the characters investigated. The study revealed that Multistar cultivar was found to be superior to other cultivars with regard to more number of branches (9.29 and 9.54), maximum fruit length (15.51 cm and 16.27 cm), more number of fruits per vine (43.0 and 44.50), better fruit diameter (4.63 cm and 4.81 cm), maximum average fruit weight (117.08 g and 118.65 g) and better total fruit yield per vine (4.41 Kg and 5.30 Kg) during both years of investigation. Maximum vine length (4.11 m) was recorded in cultivar KUK-9 followed by cultivar Multistar (3.69 m) in year 2015. Among different spacings treatments, spacing of 40 cm x 50 cm showed significantly lesser number of days to first fruiting as compared to other spacing

treatments whereas node number at which first female flower appears was observed at 40 cm x 30 cm. The minimum days taken for appearance of first female flower was recorded at 40 cm x 40 cm plant spacing. The study also revealed the better values for all the parameters under study with application of 100:50:125 Kg of NPK per acre except node number at which first female flower appears and days taken to appearance of first female appears.

It was concluded from the investigation that cucumber cultivar Multistar should be grown at the spacing of 40 cm x 50 cm alongwith the fertigation treatment @ 100:50:125 Kg of NPK per acre for getting higher fruit yield and quality of cucumber under Naturally Ventilated Polyhouse in Punjab.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a member of the family Cucurbitaceae, which comprises 117 genera and 825 species. It is grown in summer season (Gopalakrishnan, 2007). It is thought to be one of the oldest vegetable crops and has been under cultivation for over 3000 years in India (de Candolle 1882), where Chakravarthy (1982) estimated 36 genera and 100 species. Cucumber plant is one of major crops cultivated under greenhouses, it represents about 75% of the total area of the greenhouses that is about 960 hectare (FAO- Regional working Group Greenhouse Crop Production in the Mediterranean Region-1997). Cucumber is the fourth most important vegetable crop after tomato, cabbage and onion in Asia (Tatlioglu, 1997), the second most important vegetable after tomato in Western Europe (Phu, 1997). Cucumber is a thermophillic and frost-susceptible crop, growing best at temperature above 20°C. The crop is grown throughout the world and is the fourth most important vegetable crop after tomato (*Solanum esculentum* L.), cabbage (*Brassica oleracea* L. var. *capitata*), and onion (*Allium cepa* L.) (Tatlioglu 1993) and the second most widely cultivated cucurbit after water melon. It is known to have originated in India (Harlan 1975) because of the fact that *Cucumis sativus* var *hardwickii*, progenitor of cultivated cucumber is found in the Himalayan foothills of India.

Global vegetable production of 956 million tonnes has grown up by 56% in the last decade. Asia cultivates by far the most vegetables in the world and has also shown the strongest growth over the last decade. India is the second largest producer of vegetables in the world next to China with an estimated production of about 136 million tonnes from an area of 8.23 million hectares with an average yield of 16.5 tonnes per hectare. India shares about 15% of the world output of vegetables from about 4% of cropped area in the country. At present an Indian consumes 186 g of vegetable in a day which is lower than the recommended 280 g per capita per day.

Vegetable Production : Global Status				
Country	Area (mha)	Production (000'MT)	Productivity (t/ha)	Share
China	23.94	448.98	19	47
India	8.23	136	16.5	13
USA	1.33	38.08	29	4

However, keeping in view the awareness about the importance of vegetables there is need to increase the area under vegetables. Besides vegetable cultivation and production holds important component of Indian economy and its fresh food bowl. Vegetables production in our country is significantly influenced by the seasonality and agro-climatic conditions. The extent of abundance and deficiency in production and availability cause considerable fluctuations in the prices and quality of vegetables. The major challenge for the modern technology is to make vegetable cultivation economically viable. Beside production of vegetables there is a need to improve the quality of vegetables. For this we need to have precision farming. The main objective of precision farming of vegetable production is to create a conducive micro-climate for the sustained growth of plants so as to realize its maximum potential even in adverse climatic conditions. Vegetable growers can substantially increase their income by protected cultivation of vegetables in off-season as the vegetables produced during their normal season generally do not fetch good returns due to large availability of these vegetable in the markets. Among the peak period protected cultivation practices can be defined as a cropping technique wherein the micro environment surrounding the plant body is controlled partially/ fully as per plant need during their period of growth to maximize the yield and resource saving. It is also known as controlled environment agriculture (CEA). It is highly productive, conservative of land and water beside protection against hazards of environment (Jensen 2002). It is the most contemporary approach to produce horticultural crops qualitatively and quantitatively and has spread extensively over the world in the last few decades. Off-season cultivation of cucurbits under protected structures is one of the most profitable technologies. The cucumber responds like a semitropical plant. It grows best under conditions of high temperature and light intensity and with an uninterrupted supply of water and essential elements. Protected cultivation not only ensures good quality and high productivity of produce but it also provides opportunity to capture the market in off-season during early summer.

For vegetables, because of their short duration cycle, the frequency of nutrients and water application play an important role in getting higher yield and quality. The short duration crops like cucumber are much more receptive to right combination of fertilizer and irrigation. Fertigation through drip irrigation has the potential to ensure right proportion of fertilizers and water at crop root zone and meet the water and

nutrient requirements. Knowledge on crop physiology and crop demand for various nutrients at different growth stages is very vital for a successful cucumber production. It has been proved that the fertigation saves about 25 to 30% of fertilizers coupled with higher productivity and quality (Raman *et al.* 2000)

India's first exposure to truly hi-tech protected farming of vegetables and other high-value horticultural produce came through the Indo-Israel project on greenhouse cultivation, initiated at New Delhi-based Indian Agricultural Research Institute (IARI) in 1998. It has, in the past 10 years, managed to refine and upscale the system to reduce costs, besides designing greenhouse structures to suit local conditions. The area under greenhouse cultivation, reported by the end of 20th century was about 110 ha in India and world over 275,000 hectare (Mishra *et al.* 2010). During last decade this area must have increased by 10 per cent if not more. The states that have consistently expanded the area under protected cultivation for the period of 2007-2012 are Andhra Pradesh, Gujarat, Maharashtra, Haryana, Punjab, Himachal Pardesh Tamil Nadu and West Bengal. Maharashtra and Gujarat had a cumulative area of 5,730.23 hectares and 4,720.72 hectares respectively under the protected cultivation till 2012.

The success of protected cultivation of vegetables is largely dependent on level and quality of applied technology and the factors such as local climate, purchasing power of consumers, transport organization, market intelligence and access to local and international market. An important aspect for successful vegetable production venture is the time of the year for which the fresh vegetable and flowers can be made available in domestic markets at a time when production is not sufficient or absent altogether.

Protected cultivation offers several advantages to produce vegetables of high quality and yields-particularly during the off-season when prices are higher, thus using the land and other resource more efficiently. However, growing vegetables under protected conditions requires high input cost and good management practices and proper planning to achieve maximum benefits which have direct bearing on the economic viability of production system. Since cucumber is the one of the important vegetable crop which has high demand for throughout the year. Fruit quality is very important and to have best quality fruits polyhouse production is the best choice.

Advantages of polyhouse cultivation are like protection from excess rainfall, wind current, scorching sun light and extreme cold conditions, under minimum space we can have maximum production of crop, humidity is maintained, efficient use of CO₂, Efficient utilisation of irrigation water and fertilizers, labour efficient, diseases and insect-pests can be controlled easily, production of crop throughout the year, labour cost is reduced, quality of product is better.

The present annual requirement of vegetables is estimated to be 150 million tonnes and is expected to be over 165 million tonnes by 2015 in the country. This leap can be best achieved through use of improved varieties and hybrid technology in combination with superior crop management skills.

Cucumber cultivation in protected structures is performed in two growing seasons basically, autumn season, which starts from early September and terminates by end of December, and second season ranges from first week of February to end of May.

It is a low energy and high water content vegetable crop used for salad purpose. It contains 0.6 g protein, 2.6 g carbohydrate, 12 cal energy, 18 mg Ca, 0.2 mg Fe, 0.02 mg thiamine, 0.02 mg riboflavin, 0.01 mg niacin and 10 mg vitamin C per 100 g of edible portion (Rashid 1999). The high water content makes cucumber a diuretic and it promotes cleaning action within the body by removing accumulated pockets of old waste material and chemical toxins. The high level of potassium and magnesium helps to regulate blood pressure and relaxes nerves and muscles. Ascorbic acid (vitamin C) and caffeic acid present in cucumber reduces skin irritation and swelling. It is said to have cooling effect and prevents constipation.

Cucumber is grown throughout the world at large commercial farms, green houses and small gardens. Unlike other cucurbits, cucumber is commonly harvested in immature stage and is consumed as salad or pickle. Three distinct types of salad cucumbers are grown in polyhouses i.e. American standard Slicer, Japanese Slicer and European Slicer.

There are several cultivars available for greenhouse cucumber production. Selection of cultivars adapted to local growing conditions and seed quality are significant production factors that deserve careful planning and consideration. The

main criteria in selecting the best cultivars are overall productivity, plant growth habit and vigour, fruit quality i.e. length, diameter, shape, colour and smoothness, fruit shelf life, disease resistance and energy requirement.

Out of the three types of varieties for protected cultivation European slicer, are the most preferred one as these are gynocious and set fruits parthenocarpically. These varieties generally produce higher yield and the fruits are 12-20 inches long, slightly wrinkle surface, uniformly green, thin skinned and possesses short neck at the stem end.

Cucumber requires a constant water supply to produce high quality yield. During the period of growth, flowering and fruit enlargement the plant is most susceptible to irrigation deficit. The frequency of irrigation is largely depended on soil type and weather conditions. In general, greenhouse cucumbers are irrigated through drip system and fertilizers are also applied with irrigation water. The amount of fertilizers varies with crop growth and season of cultivations. Being shallow rooted it is heavy feeder crop and plants easily suffer root damage from fertilizer overdose or extreme fluctuations in fertilizer supply. Unbalanced nutrition regime may cause excessive vegetativeness or overbearing of the plant resulting in sub optimal performance of the crop. Insufficient potassium will result in misshapen fruit or "bottlenecks" known as crooked fruits. Likewise, application of less nitrogen restricts growth, modifies the length-to-diameter ratio of fruit, reduces fruit set and colour development. Plant density and spacing also contribute to marketable yield in various ways such as ability of plants to obtain the sunlight needed for growth and adequate air circulation around the plants to minimize the threat of fungal and insects attacks. The suitable plant spacing with pruning gave higher yield of cucumber (Dykun *et al.* 1990).

Cucumber cultivation under protected structure is becoming popular in Punjab and its demand is increasing. At present there are number of varieties/hybrids of cucumber released by both public and private sectors, yet the information on the performance of cucumber varieties/hybrids and its production technology under protected cultivation is meagre. Keeping in view the importance of protected cultivation and demand the present investigation entitled "Effect of Crop Geometry

and Fertigation on Quality and Yield of Parthenocarpic Cucumber Cultivars Under Protected Conditions” was therefore carried out with following objectives:

- i. To find out suitable cultivar for protected cultivation under Punjab conditions.
- ii. To assess the response of cucumber cultivars to variable crop geometry under polyhouse conditions.
- iii. To assess the response of cucumber cultivars to fertigation under polyhouse.
- iv. To identify the best spacing and fertigation schedule for obtaining high yield in cucumber under protected conditions.

REVIEW OF LITERATURE

Cucumber (*Cucumis sativus* L.) is one of the most important vegetable crop grown in Punjab. It is a short duration annual crop and is used as salad. Therefore, it is essential to know effects and causes of scientific research made in developing agro-techniques under protected structures in past for boosting the productivity and production. Although, seeds of many cultivars of cucumber are available in the market for cultivation, but lesser yield is the main constraint. Besides the cultivars, to exploit the potential of gynodioecious hybrids of cucumber in polyhouse along with fertigation and spacing is also equally important. Therefore efforts have been made in this chapter to collect the scientific information on agro-techniques to identify the causes of the problems related to quality and low productivity of cucumber. The literature available on this aspect has been reviewed in this chapter under the following sub-heads.

2.1 PERFORMANCE OF CUCUMBER CULTIVARS UNDER PROTECTED CULTIVATION

In modern agriculture, seeds of hybrid varieties are considered as the basic input in any commercial crop production programme. However, the yield traits of a particular variety is genetically controlled. New cultivars play a vital role in increasing vegetable production due to high yield potential, early maturing, vigorous, superior quality, pest and disease resistance attributes and more efficient in the use of water and fertilizers. Characteristics of a hybrid/variety as well as combination of traits significantly differ with climatic conditions of the locality. At present there is urgent need to identify suitable for growing under protected structures. Therefore, an experiment for evaluation and characterization of presently available germplasm is carried out to identify the elite cultivars for different characters.

Crespo (1982) evaluated five cultivars of cucumber for yield attributes. Higher fruit yield was exhibited by cultivar Sumter (40.753 Qt/ha) followed by cultivar Premier (35.0 Qt/ha).

Hussain *et al.* (1990) evaluated four hybrids of cucumber in NARC Islamabad to evaluate their performance. The most yielding hybrids were Serano (9.15 kg/m²) and Maram (7.74 kg/m²). Maximum fruit weight/plant was also recorded in this

hybrid followed by (1393 g). Serano also exhibit maximum number of fruits/plant (11.50).

Vijayakumari *et al.* (1991) studied different varieties of cucumber under protected environment. Their study revealed that varieties Kian, Malini and Alamgir CT-180 during rabi season and the variety Malini and Hilton during summer season were superior than the check variety PPC-3.

Walters and Wehner (1994) evaluated 866 cultigens (718 accessions, 38 breeding lines and 110 new cultivars) for early flowering and concluded that days from planting to first staminate flower ranged from 26 to 45 and the earliest cultigens was P1-249561 (26 days to flower) and late bearing cultigen was P1-470254 (45 days to flower).

Suchkova (1995) evaluated Russian F₁ hybrid varieties (Villina, Yuventa, Reddo, Korelek and Izumrud) under greenhouse conditions and found that hybrids Villina and Yuventa produced smooth fruits with a mean length of 22-27 cm whereas, fruits of other hybrids had warty skin and variation in length ranged from 14-16 cm (Izamrud), 16-18 cm (Korelek) and 18-20 cm (Reddo).

Hochmuth *et al.* (1996) evaluated twelve greenhouse cucumber cultivars in two seasons under protected environment in Florida and observed that there is no significant variation for early yield, average fruit diameter in both seasons, but found significant variation in fruit length that ranges from 12.1 inches to 14.0 inches. They also found that total marketable yield varies from 11.5 lb/plant to 15.2 lb/plant and 16.1 lb/plant to 19.7 lb/plant during fall and spring season respectively.

Dhillon and Ishiki (1998) conducted an experiment to determine the level of hybrid (G) x year (Y) interaction for fruit number per plant and yield per plant and found that G x Y interaction were significant for both characters but these were of a lower magnitude for yield per plant.

Muhammad *et al.* (1998) evaluated eleven parthenocarpic cucumber hybrids (Dala, Belcanto, Bellando, Safa, Mubis, Taha, Luna, Pigal, Maram, Dina and Nibal) under ordinary plastic tunnels at Islamabad, Pakistan and revealed that hybrids Taha, Luna and Dala were most promising for yield 5.58, 4.48 and 4.17 kg/m², respectively,

during spring summer season while average yield of 2.48, 2.30 and 2.24 kg/m², respectively was recorded during autumn season.

Sharma *et al.* (2000) studied the performance of cucumber cultivars Poinsett, K-75, K-90 and Green Long under field and greenhouse conditions at Palampur, Himachal Pradesh during rainy seasons of 1996, 1997 and 1998. The yield was higher by 11.28, 27.08 and 31.69% in 1996, 1997 and 1998 respectively. Poinsett and K-75 had higher yields than the other cultivars due to greater fruit length, fruit weight and yield/plant.

Saikia *et al.* (2001) studied the off season production of cucumber inside low cost polyhouse at Assam. The variety AAUC-2 recorded the highest mean values for characters such as number of fruits per plant, fruit length, average fruit weight and yield per plant. The highest benefit: cost ratio was observed in AAUC-2 (3.48:1) followed by AAUC-1 (3.18:1).

Lopez and Staub (2002) carried out combining ability study in four cultivars for yield attributing traits in USA and reported that general combining ability was significantly influenced for most of the traits under study whereas specific combining ability was significant only for fruit number and days to flowering.

Hamid *et al.* (2002) reviewed the performance of six genotypes of cucumber namely Baby long, PARC-1, Ashly, Albeit, Peshawer local and Swat local and reported that maximum number of fruits and highest fresh fruit yielding (10.66 t/ha) obtained from PARC-1 genotype while minimum yield of 8.33 tonnes per hectare was recorded in Peshawar local, Albeit and Ashly.

Zamin *et al.* (2002) conducted an experiment to evaluate the best cultivar among five cultivars viz., CRO-100, CRO-200, CRO-600, CRO-700 and CRO-1000 and found that CRO-1000 performs best with regard to highest fruit/plant (12.45), maximum number of branches (4.33), bigger fruit size (391.2 cm), better average weight (243.3 g) and average yield/hectare (22.14 tonnes).

Cardoso and Silva (2003) evaluated fifteen cucumber hybrids in summer and fourteen in autumn winter season under protected conditions at Sao Manuel, Sao Paulo State, Brazil. They found that among these hybrids, Tsuyataro (25.4 fruits/plant) and Rensei (25.3 fruits/plant) were the highest yielding hybrids during

summer whereas Nikkey (26.8 fruits/plant) and Top Green (23.4 fruits/plant) were the highest yielding during autumn.

Chaudhary *et al.* (2003) evaluated the performance of ten cucumber hybrids/lines (Beijing 101, 201, 301 and 401, straight eight, Merry swallow, Japanese hybrid, Chinese hybrid, Thai short and Shabi genchu under plastic tunnel. They observed maximum yield in Beijing 101 (4.48 kg/m²) while lowest yield was recorded in Merry swallow (1.72 kg/m²).

Kanwar *et al.* (2003) conducted an trial at Solan with 26 indigenous and exotic cucumber genotypes. Cucumber genotypes vary widely among themselves in different traits except for harvesting duration. The genotypes Fazlika Coll.-94 and Market Long produces high yield with good quality. Genotype LC-7 was poor performer in terms of yield and its contributing characters but was found to be good for rind thickness, flesh and TSS content. They also reported negative correlation between yield and quality traits. Likewise, Khokhar *et al.* (2003) evaluated ten cucumber hybrids namely Beijing 101, 201, 301 and 401, straight eight, merry swallow, Japanese hybrid, Chinese hybrid, thai short and shabi genchu under plastic tunnel and concluded that Beijing 101, 201 and 301 yielded 4.48, 4.04 and 3.52 kg/m² and are best suitable for good returns under plastic tunnel.

Ahmed *et al.* (2004) evaluated six exotic and indigenous cultivars of cucumber namely Market More, Poinsett-76, Electron, Konkurent, Yadenctva and Punjab Local for growth and yield traits at Rawalakot (AJK). They showed that cucumber cultivars differed significantly in yield attributing traits. Cultivar Punjab Local produces maximum vine length and leaf number. The cultivar Konkurent is late maturing whereas cultivar electron resulted in early maturity. They, further reported that cultivar Market More produces maximum female flower, maximum number of fruits/plant with more fruit length as well as maximum fruit yield/plant.

Badgujar and More (2004) evaluated fourteen cucumber hybrids in off-season to see their performance for earliness and yield attributing traits in Rahauri area (Maharashtra). The most yielding hybrids and high potential for earliness were H-27, H-210, H-312, H-42, H-26, H-211, H-36 and H-11.

Cardoso (2006) revealed that cucumber varieties differ significantly in their production potential. Significant variability was observed for vegetative characters as obvious from the wide range obtained for the different characters. He suggested that variety selection should be based on disease resistance, light intensity, fertility requirements and market demands for size, colour, shape, flavour and productivity.

Sharma and Bhattarai (2006) evaluated four exotic hybrids of cucumber namely Malini, Korean White, Japanese Green and Green Long along with one commercial cultivar namely Bhaktapur Local. They found that hybrid Malini has more vigor and early in maturity with higher number of fruits (252 thousands/ha) and significantly higher yield (69.6 t/ha). So, performance of malini is superior than other cultivars and is suitable for cultivating at low hills during summer rainy season.

Sharma and Sharma (2006) studied the genetic divergence for yield and yield contributing traits among thirty one cucumber genotypes. They found that the genotypes Jorji Local, Bengal 60, JIL and Derabassi Local were superior in terms of yield per plant and fruit length whereas Gyn-2, Gyn-3 and Gyn-4 had good number of fruits per plant. Average fruit weight and fruit breadth was promising in Chakkimore Local, Farukabad Local, Chamoli Local and Chamba Local genotypes.

Afangideh and Uyoh (2007) evaluated eleven exotic and six indigenous cucumber cultivars for yield and quality traits and reported that fruit yield was significantly higher in the indigenous cultivars. In an experiment conducted by Cardoso (2007) on the performance of 18 experimental hybrids, 12 lines and two commercial hybrids under protected environment reported significant differences for yield. Total yield was very less in lines as compared with hybrids.

Soleimani *et al.* (2009) tested the performance of different cultivars of cucumber in southern Iran. Ample variability was observed among morphological and yield attributing traits. They observed a variation of 77.5 per cent. They further observed that out of this variation, 45 percent variation is associated with yield, 18 per cent variation is associated with diameter of stem and length of stem whereas 15 per cent of total variation is associated with length and diameter of fruit. Highest correlation was recorded between number of fruit and yield.

Bisht *et al.* (2010) conducted experiments for 3 years and reported that hybrids are more productive than the corresponding parental varieties and have more rapid development, but they were at par for chemical composition and taste qualities.

Hossain *et al.* (2010) studied the variability character association and yield performance of 58 long type cucumber accessions. They observed wide variability for days to seed germination, vine length harvest, petiole length and yield contributing characters such as days to first male and female flowering, number of fruits per plant, average fruit weight, fruit length and fruit diameter. They recorded the highest yield per plant (2.69 kg) in long type cucumber accession CSL51.

Mousavizadeh *et al.* (2010) measured diameter, length, height and weight of three variation of cucumber viz., Green Gold, Dharwad and Super Dominus). The variety Green gold recorded maximum values for diameter, volume, weight and flesh diameter. They also recorded skin thickness (1.48 cm) in variety Super Dominus. They also observed positive correlation between diameter and geometric mean diameter.

Golabadi *et al.* (2012) conducted an experiment for assessment of genetic variation in twenty genotypes of cucumber and found that the genotypes had a great phenotypic variation for different traits under study. Total fruit yield per pickling was highest in Gohar (474.3 g) while lowest fruit yield per pickling was recorded in Tornado (383.3 g).

Hebber *et al.* (2012) evaluated seven hybrids of cucumber during rabi season in a naturally ventilated polyhouse at IIHR, Bangalore for three years during 2005-08. It was found that average yield over the three years was highest in Malini (117.4 t/ha) followed by US 6125 (104.0 t/ha) and Rajdhani (100.4 t/ha). They concluded that a very high productivity of about 100 t/ha in about 4 months duration can be achieved by growing cucumber hybrids like Malini, Rajdhani and US 6125.

Kushwaha *et al.* (2012) conducted a trial on hybrid cucumber under polyhouse at Bharsar, Utrakhand. They reported that hybrid Noori and Malini may be considered as early and high yielding hybrids, respectively for polyhouse cucumber cultivation. Likewise, Kumar and Verma (2012) evaluated eight cultivars of cucumber at Bihar Agricultural University, Sabour, Bhagalpur to explore the possibilities to

grow cucumber under controlled environmental conditions. It was observed that the cultivar Tasty recorded maximum number of fruits/plant (12.6), average fruit weight (195.2 g) and total yield (4.92 t/500m²) and earned maximum returns of Rs 49,200.00 from an area of 500 m² in a short span of three months.

Oniya *et al.* (2012) studied the interrelationship between yield and different yield components in cucumber using organic and inorganic fertilizers. They found that urea gave the longest vine length of 21, 46.4 and 244 cm at 4, 6 and 8 WAP while the control had the least vine length of 17.2, 34 and 108.6 cm at 4, 6 and 8 WAP. They obtained similar results for nodes/plant, number of flowers/plant and fruit yield. They further reported that yield in cucumber was greatly increased with the use of urea than poultry manure and NPK.

Singh *et al.* (2012) conducted an experiment to find out the most appropriate hybrid of cucumber for off-season cultivation at the experimental farm of VCSG College of Horticulture, Bharsar under naturally ventilated polyhouse. They reported that out of five cultivars, Malini and Pant Shankar Khira-1 were found to be most appropriate for growing under naturally ventilated polyhouse in mid-high hill conditions of Uttarakhand.

Tiwari and Mishra (2012) studied morphological traits in five genotypes of cucumber (Bhktapur Local, Mahyco Green Long, malini, Beli and dynasty) during off season. The highest fresh yield of 25.23 t/ha was observed in Bhaktapur Local followed by Mahyco Green Long yielding 24.11 t/ha. Bhaktapur Local and Mahyco Green Long was recommended to be grown in mid hills to get higher yield, whereas cultivar malini is recommended for warm climate.

Yadav *et al.* (2012) revealed that among all the genotypes CC-5, BSC-2, BSC-1, CH-128, CHC-2 and CC-2 gave promising results. Fruit weight at edible stage showed a wide range (97.75-230.43 g) of fruit weight. Days to first fruit harvest and days to first female flower anthesis ranged from 43.24 (CC-7) to 58.27 (CC-9) and 35.45 (CC-7) to 49.55 (CC-9), respectively. Maximum vine length was recorded in VRC-19 and minimum in CHC-1 while maximum and minimum number of branches per vine were recorded in CC-5 and CC-3 respectively. The present set of genotypes possessed an average of 3.95 node numbers bearing first male flower, which ranged from 2.91 (Swarna Ageta) to 4.94 (DR/NKV/02), while in case of nodes number

bearing first female flower 4.51 (Swarna Ageta) to 7.60 (CC-6) and its mean value was 6.03. The genotype CC-7 exhibited maximum length of edible fruit (24.94 cm) while it was minimum in CC-1 (13.80 cm). Average number of fruits/vine showed wide range (7.84-13.80). The maximum and minimum fruit diameter was recorded in BSC-1 and VRC-11-2. Node numbers bearing female flower/vine showed a wide range (9.49-16.25), with maximum and minimum in CC-1 and CHC-1, respectively. Days to first male flower anthesis was recorded maximum in CC-9 and minimum in CC-7, respectively. The minimum and maximum fruit yield/vine was recorded in CC-6 and CC-5, respectively.

Patel *et al.* (2013) analyse the performance of 20 cucumber hybrid for growth, yield and quality traits under agro-climatic conditions of Allahabad. Out of all the 20 hybrids Garima super recorded the highest vine length (249.17 cm), Number of branches/vine (11.42), number of fruits/vine (13.83), fruit weight (168.33 g), fruit length (168.33 cm), fruit diameter (4.03 cm), fruit yield (2.24 Kg/vine and 36.24 t/ha), TSS (5.50⁰ Brix), Vitamin C content (7.28 mg/100 g). So, hybrid Garima Super can be grown commercially under Allahabad agro climatic conditions for better returns.

Santi *et al.* (2013) studied the performance and growth conduction of Japanese cucumber in protected environment and found that the treatment with conduction of the main stem without removal of lateral buds had better performance with respect to total and marketable number of fruits per plant (19.4 and 16.0) and higher total and marketable yield of fruits. They further revealed that pruning of lateral buds leads to increase in length, diameter and average mass of cucumber fruits.

Monisha *et al.* (2014) screened five parthenocarpic varieties (Hilton, Kian, Isatis, PPC-2 and PPC-3) and five monoecious F₁ hybrids (Malini, Kamini, Sheetal, Alamgir CT-180 and NS-404) of cucumber in naturally ventilated polyhouse under tarai condition of Uttarakhand for rabi and summer seasons. They observed wide range of variability for most of the traits under study. They further revealed that during rabi season Kian (200.15 q), Isatis (188.78 q) and Hilton (144.30 q) were better in terms of fruit yield per hectare over the check variety PPC-3 (122.22 q) and during the summer season the genotype Malini (590.76 q), Hilton (572.80 q) and NS-404 (523.77 q) were found superior over check variety PPC-3 (449.02 q). F-1 hybrid Sheetal was reported as the least yielder during both seasons.

Rawat *et al.* (2014) studied different varieties of cucumber under protected environment and revealed that the varieties Kian, Malini and Alamgir CT-180 during rabi season and the variety Malini and Hilton during summer season were superior than the check variety PPC-3.

Iqbal *et al.* (2015) undertaken an investigation to study performance of five exotic cultivars of cucumber viz., CU-2833, CU-5555, GR-102, CFMC-0036, CFMC-0031 for earliness and yield attributes under tunnels in Faisalabad, Pakistan. They revealed that plastic tunnels gave early and higher production. Considering the overall performance, it is evident that CU-2833 and CU-5555 had potential for earliness and yield attributing characters.

Khan *et al.* (2015) conducted an experiment to study morpho-agronomic characterization in 24 genotypes of cucumber and observed significant variability in all the traits. Their study revealed that genotype USA Poinsett, Dargai Local and Mardan Local produced highest yield. They also observed that total number of fruits had positive correlation with vine length and fruit width. Early flowering was observed in two genotypes i.e. Haripur Local and 28293.

In a study, Lajurkar *et al.* (2015) evaluated the performance of different hybrids. They evaluated 17 cucumber hybrids for growth, yield and yield attributing traits under NVPH in Konkan region. The result revealed that the hybrid Swati was earliest to first flower initiation (36.30 days). The hybrid US-800 was recorded maximum values for vine length (7.30 m). The highest fruit length (19.10 cm) was recorded in hybrid Mahabharat. Malini recorded higher number of branches/vine (14), highest diameter of fruit (4.36 cm), maximum fruit weight (241.18 g), highest number fruits/vine (23.70), maximum yield/vine (4.92 kg) and highest yield/hectare (716.46 qt.) The lowest internode number at which first flower appears observed in hybrid Sahyadri. Hybrid Shighra was known for early maturity. So, hybrid Malini have the potential for cultivation under NVPH.

Four cucumber genotypes were studied by Umeh and Onovo (2015) for vegetative and productive traits in Nigeria. They revealed great variation in morphological traits among four genotypes for all traits under study and recorded the fruit yield per pickling ranged from 385.7 g in Nandini 732 F₁ to 190.5 g in Marketmore. Highest fruit yield was recorded in cultivar Nandini 732 F₁, distance of

internodes has also ample variation that ranged from 105.5 cm in Poinsett 76 to 78.25 cm in Marketmore.

Adesina and Benjamin (2016) assessed the performance of four cucumber viz., Ashley, Nonadini, Murano and Ande at Nigeria at different date of sowing (19th April, 26th April, 3rd May and 10th May) and recorded highest fruit yield from cultivar Nonadini and Ashley during 26th April and 10th May.

Adinde *et al.* (2016) evaluated four cucumber cultivars viz., Ashely, Marketer, Super-marketer and Poinsett-76 in Nigeria. The results showed great variation among the cultivars at 45 days after planting in vine length, number of leaves and branches per plant and leaf area index with Poinsett-76. They also revealed that Poinsett-76 is best cultivar than other cultivars as regard to days to first female flower initiation, number of fruits/plant, fresh fruit yield/plant.

Ene *et al.* (2016) evaluated 16 cucumber cultivars for their genetic variability and heritability. High significant variation was recorded for almost all traits with high variability among genotypes. They showed that cultivar Beit Alpha, Ashley, Straight 8 and Sumter from early planting group and Beit alpha and Ashley from late planting group shows the best morphological and yield attributes characteristics.

Prashar *et al.* (2016) conducted an field experiment at Central Institute of Arid Horticulture, Bikaner, Rajasthan to standardise the production practices for cucumber under polyhouse, nethouse and glasshouse on five cultivars viz., Isatish, Hilton, Alamgir CT-180, Poona Khira and Himangi. They revealed maximum vine length (3.26 m), number of leaves (29.96), number of branches (1.73) and leaf area 449.71 cm² and maximum total yield 86.78 t/ha in cultivar Isatish under glasshouse structure.

Shah *et al.* (2016) evaluated fourteen different strains for growth characters, yield characters and quality characters. Considering the overall performance, it is evident that the strain K-90 recorded maximum vine length (310.59 cm) and maximum TSS (6.84 °Brix). The strain HP-2 recorded maximum number of fruits/vine (20.00), minimum days to first female flower (43.21), 93% fruit setting. (The cultivar) The strain New Manipur-1 had high potential for yield contributing characters and observed maximum number of primary branches/plant (12.23), average fruit weight (205.05 g), maximum fruit diameter (6.59 cm), fruit yield/vine (3.61 kg),

maximum fruit yield/ha (49.42 t/ha), maximum vitamin C (7.63 mg/100g), minimum number of node at which first female flower (6.11).

Vian D Ali (2016) studied five cucumber hybrids viz., BARAA 138, Dalia, Faris, Sayff and Silyon RZ. Silyon RZ showed more vigour in plant height, fruit yield and total yield than rest of the varieties. Highest fruit diameter was noticed in cultivar Dalia whereas maximum fruit length and number of fruits/plant was recorded in Faris cultivar.

Chinatu *et al.* (2017) studied the yield and yield components of seven varieties of cucumber in south-eastern Nigeria for two years and revealed that significant variability **exist** among varieties for almost all the yield components (vegetative and reproductive characters). The varieties Regal and Market More was found superior in terms of fruit yield per hectare.

Kumar *et al.* (2017) evaluated 16 parthenocarpic cultivars of cucumber in naturally ventilated polyhouse (NVPH). They found that RS 03602833 was the earliest in first flowering (28.33 days) as well as picking (37.67 days). Maximum vine length of 4.56 m was exhibited by KUK 9. JSCU 01 had the better sensory parameters like flavour, colour and texture. Highest number of fruits per vine (34.77) were recorded in cv. Multistar whereas JSCU 01 expressed significantly highest fruit weight of 207.82 g. The highest fruit yield per 1000 m² was recorded in cultivar Oscar (13.34 tonnes). They observed very narrow variation for fruit length and fruit diameter among all the cultivars under study.

Sanjeev *et al.* (2017) evaluated 16 parthenocarpic cultivars of cucumber in naturally ventilated polyhouse (NVPH) at Regional Horticultural Research Station, Navsari Agricultural University, Navsari. They revealed that RS 03602833 was the earliest in first flowering (28.33 days) as well as picking (37.67 days) attributable to shortest inter-nodal length (8.12 cm) irrespective of the appearance of first pistillate flower in upper node. The vine length of 4.56 m was significantly exhibited by KUK 9 over all other cultivars. Sensory parameters like flavour, colour and texture perceived by heterogeneous panel of evaluators which was well supported by instrumental measurement of fruit firmness (4.22 kg/cm²) in JSCU 01. They further revealed that cv Multistar produced highest number of fruits per vine (34.77) with statistically close affinity in Kian and Valleysta whereas highest fruit weight of

207.82 g was observed in JSCU 01. The highest fruit yield per 1000 m² was recorded in cv. Oscar (13.34 tonnes) bearing 27.97 fruits per vine and possessing 162.23 g fruit weight having statistically similar results in RS 03602833, Kian, KUK 9, 52-23, Valleystar and Multistar. The cv. Oscar was found economically highly remunerative with 0.94 Benefit:cost ratio.

2.2 SPACING

Plant spacing is also an important factor of cucumber crop production because appropriate spacing of crops makes best utility of space and reduces the competition between plants. Plant spacing influences fruit length and diameter. It also shows high significant differences among early, late and total fruit numbers.

M. Kasrawi (1989) reviewed the response of plant density (2.4, 3.6, 4.8 and 5.4 plants/m²) in cucumber grown in greenhouse. He concluded that density of 5.4 plants/m² is best to get higher yields. He further revealed that the yield per unit area increased linearly with increase in plant density while yield per plant decreased linearly with increasing plant density.

Cook *et al.* (1991) studied the effect of inter-row spacing on growth and development in cucumber. They suggested that vine length, inter nodal length, fruits per plant, fruit weight and yield per plant increased significantly with increase in plant spacing. Likewise, El-Aidy (1991) evaluated 17 cucumber cultivars under tunnels and reported that the density of 2.0 or 2.5 plants/m² is optimum for obtaining good yield in cucumber.

Staub *et al.* (1992) evaluated three cucumber cultivars for growth and yield in a polyhouse for two years and noticed main effect of spacing in number of fruit per plant. Total number of fruit for cultivars Calypso and WI 50476 were highest at both plantings of 2,42,000 and 2,72,000 plants per hectare. They further observed increase in number and weight of fruit per hectare with increase in plant density, however, fruit weight per plant was decreased.

Wanna (1993) conducted an experiment to see the response of cucumber yield to plant density and spatial arrangement in eight cucumber cultivars. He found that 65000 to 87000 plants/acre and a spatial arrangement with rows spaced 15 in. Apart and plants spaced 4 in. Apart within rows was optimum for cucumber production.

Eatman (1995) reported that plant height, number of leaves/plant, fruit number and yield per plant decreases when increasing plant density. He further suggested that yield per unit area increases as the spacing among plants is reduced. Increase in yield was positively associated with fruit number. On the contrary, Young hah *et al.*(1999) revealed that increase in plant density of cucumber grown from 15000 plants/ha to 45000 plants/ha under greenhouse conditions gave 80 per cent more yield with 50 per cent enhanced net returns.

Ishii *et al.* (1997) observed that vegetative and reproductive yield (kg/plant) decreased with increase in plant density. Highest fruit yield was recorded at highest plant density. The net returns were more with plants grown under row covers at the highest population density in cucumber. Likewise, Schultheis (1997) evaluated four planting densities for little leaf cucumber and normal leaf cucumber and recorded highest yield at plant density of 3,30,000 plants per/hectare as compared to 37000, 75000 and 150000 plants/ha. They also observed that fruit quality of cucumber was superior at 2,40,000 plants per hectare as compared to 2,00,000 plants per hectare. Similarly, Serquen *et al.* (1997) observed that the number of fruits per plant, fruit length and fruit weight per plant increased significantly with increasing plant spacing but plant height, number of fruits per plant and fruit yield per hectare increased significantly with decreasing plant spacing.

Dobrzanska *et al.*(1998) studied the effect of plant density (1.5, 2.0 and 2.5 plants/m²) and effect of plant training systems (main stem, main stem topped at a wire-at 2.5 m, main stem modified and umbrella) on earliness of greenhouse cucumber and concluded that the plant density of 2 plants/m² is optimum and yield was highest when main stem of cucumber plant was topped at the wire.

Nerson (1998) investigated the effect of spacing on yield and quality of pickling cucumbers and recorded highest yield at the highest population of 20 plants per m² as compared to 5 and 10 plants per m². He further reported that wider spacing results in higher TSS content than the closer one.

Jovicich *et al.* (1999) conducted an experiment to determine the effect of plant population density (2, 3 and 4 plant.m⁻², as function of in-row plant spacing: 66.5, 44.3 and 33.3 cm, respectively), and shoot pruning (1, 2 and 4 main stems) on fruit yield, fruit quality and plant growth of greenhouse grown sweet pepper (*Capsicum*

annuum L. cv. Robusta). They found that marketable yield (number and weight) per m² increased linearly with plant density and was greater on plants with four stems than in those with two or one stem. The stem length and the number of nodes per stem increased linearly with the decrease in plant spacing. They concluded that 4 plant•m⁻² pruned to four stems increased marketable and extra large fruit yield in a short harvest period of a summer greenhouse sweet pepper crop in North central Florida.

Gebologlu and Saglam (2000) reported that bed spacing and the in-row plant spacings had significant effect on fruit quality and yield. Fruit quality was decreased with the increase in number of plants per plot. Also lowering in bed spacing and in row plant spacings delayed flowering and frutification.

Kanthaswamy *et al.* (2000) conducted an experiment on the effect of spacing on growth and yield of cucumber grown under polyhouse conditions and revealed that maximum yield (125.82 t/ha) was recorded at 60 cm x 60 cm spacing with pruning of all the primary branches after two nodes. Similarly, Quian (2000) studied the effect of plant geometry on yield and its attributes in cucumber grown under greenhouse and observed higher number of fruits per plant, fruit weight, yield per plant and yield per hectare at spacing of 45 cm x 60 cm.

Akintoye *et al.* (2002) reviewed the effect of six plant densities (10 000, 26 666, 66 666, 74 040 and 88 888 plants/ha) on yield of cucumber and found that with the increase in plant population there is reduction of size of plant canopy and vines overlaps between rows. Likewise, Choudhari and More (2002) studied three spacing (1.80 m x 0.30 m, 1.80 m x 0.45 m, 1.80 m x 0.60 m) in two gynoecious hybrids (Phule Prachi and Phule Champa) and observed that 1.80 m x 0.45 m spacing is optimal spacing to get highest number of fruits per vine, vine length and yield per hectare.

Echevarria and Castro (2002) observed the influence of four plant densities (2.0, 1.67, 1.43 and 1.25 plants/m²) on the yield and quality of greenhouse cucumbers grafted on 'Shintoza' (*Cucurbita maxima* x *cucurbita moschata*). They recorded highest yield (33.2 kg/m²) at plant density of 2 plants/m² while lowest yield (25.9 kg/m²) was recorded at 1.25 plants/m² plant density. However, production per plant increases with decrease in plant density (16.6, 19.2, 19.7 and 20.7 kg/plant). Fruit quality was not influenced with respect to different plant densities.

Peil and Lopez-Galvez (2002) studied the impact of two plant densities (1.8 and 2.3 plants/m²) on fruit growth and biomass allocation to the fruits. They found that the effects of increasing plant density on the decreasing growth rate of individual fruits were greater in terms of dry rather than fresh weight. They further revealed that the dry matter percentage of fruits and vegetative shoot parts decreased at plant density of 2.3 plants/m². They further revealed that the fruit biomass production and allocation to the fruits increases at triangle plant arrangement, but total and vegetative plant biomass, growth of individual fruits, dry-matter percentage and number of fruits per plant were not affected.

Yilmaz and Gebologlu (2002) studied the yield response to spacing in squash and cucumber. They recorded highest yield of 5.50 Kg/m² in cucumber at planting density of 100 cm x 50 cm as compared to other (100 cm x 100 cm and 150 cm x 50 cm). Likewise, highest yield in squash (5.42 Kg/m²) was obtained with plant density of 100 x 50 x 50 cm.

Devi and Gopalkrishnan (2004) revealed that fruit weight as well as productivity increased significantly when spacing is reduced. The closest spacing of 1.0 m x 0.30 m (trench method), accommodating 33,333 plants/ha, yielded 28.4 t/ha, which was 184 per cent greater than the yield obtained from the conventional pit planting method (2.0 m x 1.5 m). Likewise, Resende and Flori (2004) evaluated the effect of plant spacing on the yield and quality of five cultivars of pickling cucumber at three spacing (0.20 m, 0.30 m and 0.50 m). Negative linear effect on yield was observed with the increase of the inter-plant spacing.

Nerson (2005) conducted an experiment in two successive growing seasons to study the effect of plant density on yield and quality in cucumber and concluded that plant spacing had a major effect on seed yield per unit area by affecting the fruit number per unit area. He observed that number of fruits increases with increase in plant density.

Pant *et al.* (2005) conducted an experiment in greenhouse to access the suitable plant density for growing cucumber in re-circulating hydroponic system of cultivation and observed that an increase in plant density from 2 to 6 plants/m² significantly increased yield. However, declining trend in yield and fruit number was observed at more than 6 plants/m².

Jankauskiene and Brazaityte (2006) tested two hybrids for optimum plant density under protected environment and concluded that the cucumber hybrids grown at a density 2.0 plants/m² area produced highest marketable fruit yield than grown at a density 3.0 plants/m². A positive correlation was reported between plant density and yield and negative correlation between plant density and individual plant productivity, but maximum dry matter was recorded in lowest plant density

Maniutiu *et al.* (2006) observed increase in marketable fruit yield by 40.1% when plant population was increased from 18,000 to 27,000 plants/ha. Consequently, the significant increase in total fruit yield can be attributed to the interplay of factors, which resulted in significant increase in number of fruits per unit area and number of fruits/plant. Total fruit yield per plant and number of fruits per plant responded significantly to variation in plant population up to 27,000 plants/ha. Although the performance of the crop under spacing treatments was not consistent, however the number of fruits per plant, and fruit size were reduced at closer spacing.

Ngouajio *et al.* (2006) investigated the effect of two plant densities viz., 2,20,000, and 2,45,000 plants/ha on growth and yield of cucumber and found that plant density of 2,20,000 plants/ha was optimal for cucumber production.

Premalatha *et al.* (2006) while studying the influence of plant training and spatial arrangement for yield improvement in cucumber under protected environment revealed that close planting of 45 cm x 60 cm results in total high yield and marketable yield per unit area. They also reported that new system of lowering and coiling of the main stem showed better results than the conventional pruning systems in terms of total yield and marketable yield.

Shaheen *et al.* (2007) observed maximum vine length (168.33 cm), number of fruits per plant (15.99), weight of single fruit (122.33 g), vertical fruit diameter (9.65 cm) and horizontal fruit diameter (6.21 cm) at inter x intra row spacing of 60 cm x 80 cm. Whereas, maximum yield (14960.00 kg) was obtained at inter x intra row spacing of 40 cm x 100 cm

Kishor *et al.* (2010) conducted an experiment to study the effect of spacing on seed yield and quality in cucumber and observed that seed yield and number of seeds

per fruit increased with decrease in spacing up to (1.25 m x 0.30 m) but the number of fruits per plant and fruit weight increased with increase in spacing.

Khalid (2010) evaluated effect of plant densities (20000, 30000 and 60000 plants/fed) and reported that 30000 plants/fed density has significant effect on number of branches/plant, sex ratio percentage, early yield and total fruit yield as compared to other plant densities (20000 and 60000 plants/fed) in both the seasons.

The influence of plant spacing on yield and fruit nitrate concentration of cucumber in a greenhouse was studied by Abubaker *et al.* (2010). They observed significantly highest total yield at plant spacing of 30 cm x 45 cm. However fruit number was significantly higher at narrower spacing of 15 cm x 45 cm.

Maniutiu *et al.* (2010) studied the influence of plant density and pruning on yield of bell pepper grown under plastic tunnel. They studied two plant densities viz., 30000 plants/ha and 40000 plants/ha, with two pruning method viz., pruned with 2 shoots and pruned with 3 shoots. They revealed that plants density has affected both the early and the total yield. A density of 40000 plants/ha assured a significant yield increase comparative with 30000 plants/ha. The pruning method has influenced neither early nor total yield. Under the combined influence of plant density and pruning method best results were obtained when plant density of 40000 plants/ha and pruned with 2 shoots both the early and the total yield.

Bhatia *et al.* (2012) studied the training and pruning in cucumber and found that when cucumber plants were vertically trained upwards after pruning and pinching of auxiliary branches maximum fruit yield was recorded from Hilton (22.8 kg/m²), followed by NVH-2-26 (20.5 kg/m²) and Isetis (21.2 kg/m²) as compared to other gynoecious hybrids.

Johnson (2013) suggested that the plant density between 55,000 and 65,000 plants per acre optimizes yield and quality in the gynoecious hybrids of pickling cucumbers.

Nweke *et al.* (2013) studied the effect of staking and plant spacing in cucumber and reported that a plant spacing of 50 cm x 30 cm gave the highest values for number of fruits, number of marketable fruits and weight of fruits as compared to

50 cm x 40 cm or 50 cm x 50 cm spacing. Number of branches, vine length and number of flowers decreases with respect to increase in plant spacing.

Sabo *et al.* (2013) while studying the effect of NPK fertilizer and spacing on growth and yield of watermelon revealed that the highest yield with 150 Kg NPK per hectare at a spacing of 1.0 m x 1.5 m.

Bahlgardi *et al.* (2014) evaluated effect of plant densities (2, 3 and 4 plants/m²) and two methods of planting viz., transplanting and direct seeding, and reported that 2 plants/m² density has significant effect on the plant length, leaf number (21 leaf/plant), node number (12.83 nodes/main stem) and sub-branch number, number of fruits (2.07 fruits/plant) and fruit weight (1.76 kg) as compare to 3 and 4 plants/ m² .

Ningaraju and Joseph (2014) studied the effect of drip fertigation in pickling melon in summer season and reported that the maximum number of fruit and higher fruit weight was recorded at 100 percent Ep given through drip irrigation.

Mamnoie *et al.* (2014) evaluate the effect of plant density on yield and quantitative characteristics of two cucumber cultivars under protected environment and revealed that different densities has significant effect on yield traits. Fruit weight, number of fruits per plant and fruit yield was decreased with increasing plant density but number of fruits and fruit yield per m² increased significantly. Moreover, the fruit length to diameter ratio, number of fruits/m², yield of single plant and yield per m² were obtained in planting strip of 30 cm. So 25 cm x 30 cm is the optimum plant spacing.

Jaffer and Wahid (2014) reviewed the effect of row spacing of 1.0 m, 1.5 m and 2.0 m in three cultivars of cucumber. They recorded maximum fruit length and fruit yield at 1.5 m row spacing whereas minimum fruit length was recorded at 1.0 m row spacing. Similarly, Aniekwe and Anike (2015) evaluated the effect of plant population on growth and yield of cucumber and showed that plant spacing of 50 cm x 40 cm produces longer vines (144.7 cm) whereas fruit length of 20.4 cm and highest fruit diameter of 9.53 cm resulted from the widest plant spacing of 50 cm x 50 cm .

Oga and Umekwe (2015) investigated the effect of spacing on yield and yield attributing traits of cucumber under greenhouse. They observed that number of fruits, average fruit weight and yield per plant increased significantly with increase in

spacing while plant height was reduced. They recorded the highest fruit yield per plant in widest spacing of 50 cm x 60 cm and least was obtained in closest one (50 cm x 40 cm).

Khoshkam (2016) studied the effect of plant density on yield of cucumber under protected environment. He evaluates three plant densities (30 000, 35 000 and 40 000 plants per hectare) and recorded highest yield of fruit/plant, maximum number of fruits/plant and highest average fruit weight at 35 000 plants/hectare.

Sharma and Sharma (2015) studied the effect of spacing on productivity of hybrid cucumber. They found that widest spacing of 60 cm x 60 cm recorded higher fruit length (17.0 cm), fruit breadth (6.2 cm), fruit weight (189.5 g), number of fruits per plant (27.2) and fruit yield/plant (3.97 kg) than other two spacing viz., 60 cm x 30 cm and 60 cm x 45 cm.

Rodriguez *et al.*(2017) studied the effect of plant density (1.7, 2.5, 3.3, and 4.1 plants/m²) on yield, fruit quality, plant growth, and economic feasibility in muskmelons under greenhouse. They found that Plant density had no influence on the early or total number of fruit produced per plant. Marketable yields increased linearly from 11.0 to 20.0 kg·m⁻² in fall and from 21.9 to 48.3 kg·m⁻² in spring with increasing plant density. Average fruit size was unaffected by plant density during fall (mean weight, 1.0 kg), but was reduced linearly during spring from 1.8 kg at 1.7 plants/m² to 1.5 kg at 4.1 plants/m². Soluble solids content was not affected by plant density in either fall or spring, but internode length was increased at 4.1 plants/m² compared with plants from the other densities.

2.3 YIELD OF CUCUMBER/VEGETABLES AS AFFECTED BY FERTIGATION

Fertigation is method of applying soluble fertilizers with water through drip irrigation system. has the potential to ensure right proportion of fertilizers and water available at crop root zone and meet the crop water and nutrient requirements. The right combination of fertilizers along with irrigation is a key for higher production in vegetables and also other crops. For vegetables because of its short duration cycle, the nutrient demand and frequency of fertigation play an important role on getting higher yield and quality production. Fertigation is very efficient way of application in

vegetables as it permits applying fertilizers in small quantities as per plant nutrient demand on daily basis. Frequency of fertigation, combination and compatibility of different fertilizers are very important topics to understand and implement for better results. The short duration crops like cucumber are much more receptive to right combination of fertigation management. To get the full benefits of drip irrigation technology in vegetables fertigation is a key factor to understand and execute. Knowledge on crop and physiology and crop demand for various nutrients at different growth stages are very vital for a successful vegetable production. Other chemical aspects of fertigation like EC, pH of the nutrient solution are to be taken in to account for higher efficiency of application to get higher quality of production. Advantages of fertigation are given below:

- There is increase in yield by 20-30%.
- There is saving in fertilizers by 25-30%.
- It saves time, labour and energy.
- Light soil can be brought under cultivation
- Minimizes the loss of nutrient.
- Nutrients can be applied directly to root zone where active roots works.
- Helps in precise application and uniform distribution of fertilizers.
- Improves quality and optimizing yield.
- Minimizing soil pollution.
- Saves water and nutrients.
- 30% premium price in the market.
- Extended shelf life.

Bishop *et al* (1968) conducted fertilizer trials with pickling cucumber at four locations for 3 years and found that the effect of applied fertilizers on trends in the nutrient percentage on petioles and leaf laminae was similar at all the locations. They further advocated that yield response to applied fertilizers showed P to be of greater relative importance than N or K and indicated that N and P approximately 50 and 100 Kg/ha respectively, should be adequate. Likewise K at 50 kg/ha was recommended.

Parikh (1970) in cucumber, most female flowers were observed with application of 80 kg of nitrogen/ha in cultivar long Green whereas first female flower delayed with higher nitrogen rates.

Yukov (1984) observed during experiment of application of fertilizers in solution to the soil surface or by sub-soil drip irrigation that a dose of 20:16:10 of NPK kg/ha resulted better plant development when applied in sub-soil application. Likewise, Maurya (1987) obtained average yield of 24.26 q/ha with application of economic dose of 80 kg/ha in cucumber.

Rubeiz (1990) conducted a trial in cucumber cv. Lolita with fertilizer @ 200:85:150 kg of NPK/ha in combination of nitrogen alone, then nitrogen + potassium, then nitrogen + phosphorous + potassium and unfertilized as control. They started fertigation in four splits at weekly interval starting 30 days after planting. They revealed yields 57 t/ha, 55.0 t/ha, 54.0 t/ha and 39.5 t/ha in plots receiving nitrogen, nitrogen + potassium, nitrogen + phosphorous + potassium and control respectively.

Lakshmi (1997) studied the response of cucumber to drip irrigation under three levels of irrigation, four time of transplanting with one and two drippers per plant with three levels of nitrogen and potash and recorded maximum yield at 70 kg of nitrogen, 50 kg of potash with irrigation of 3 litre per plant per day. They further revealed highest water use efficiency at drip irrigation level of 3 litres per day. Likewise Sharma *et al.* (1997) found that increase in the level of nitrogen i.e. 125 kg/ha in three split doses brought about corresponding increase in all attributes under consideration for growth, yield and quality in cucumber.

Altunulu *et al.* (1999) studied three levels of nitrogen and potassium in various treatments @ 100, 200 and 300 PPM in cucumber cv. Alara in protected environment in Perlite. They concluded economic dose of fertigation in cucumber should be 200 PPM of nitrogen and potassium should be in range of 200-300 PPM at higher nitrogen 300 PPM there was decrease in plant growth.

Selvakumar *et al.* (2000) considered nitrogen as one of the critical nutrient to get healthy cucumbers. They studied the effect of different treatments of nitrogen viz., 0, 35, 70, 105 and 140 kg/ha on four cultivars of cucumber (Hosur, White Long, Chidambaram and Green Long) they further recorded increase in yield attributing components upto the level of 105 kg nitrogen/ha and after that there was reduction in yield.

Jaksungnaro and Seema (2001) studied the effect of sowing time (21st March, 5th April and 20th April) and nitrogen level viz., 0, 25, 50 and 75 kg/ha on growth, yield and quality of cucumber cv. AAUC2. They reported that vegetative growth, yield and quality of fruit was significantly influenced with application of nitrogen at higher end.

Choudhari and More (2002) revealed the maximum number of fruits/vine (14.1), fruit weight (180.0 g), yield/plant (2.538 kg) and yield (49.039 t/ha) was recorded when they apply 150:90:90 kg NPK/ha through fertigation in gynoecious cucumber hybrid Phule Prachi. They also found that application of fertilizer through drip irrigation was found superior than broadcast method. In another experiment with three fertilizer doses 100:75:75, 150:100:100 and 200:125:125 kg of NPK, maximum vine length (205 cm), fruit diameter (3.9 cm), fruit weight (237.3 g), number fruits per vine (13.4), yield per vine (3.19 kg) and total yield (33.06 t/ha) were recorded when 200:125:125 kg of NPK was applied.

Surve *et al.* (2002) conducted an experiment to study the effect of liquid fertilizer on growth and yield of cucumber when applied with drip irrigation and revealed length of vine (106.85 cm), number of branches (6.15) and number of leaves (74.50) was significantly superior under T₄ (125% RDF (150:50:50 NPK kg/ha)) out of which 50% through liquid fertilizer and 50% through FYM and T₃ (125% of RDF of liquid fertilizer through drip irrigation) over other treatments. The application of treatment 6 (100% RDF, 50% through drip irrigation and 50% through FYM) recorded significantly superior in maximum fruits (6.8/vine), fruit length (18.10 cm), diameter of fruit (13.30 cm), weight of fruit (305 g) and total yield (264.04 q/ha). They also observed 5.54% to 40.74% increase in yield in drip irrigation method over surface method.

Veesar (2004) conducted an experiment to determine the effect of varying level of NPK on growth and yield of cucumber on their local cultivar “Kheera”. They studied six levels of fertigation treatments. Application of highest level of NPK 125:80:65 kg/ha (T₄) exhibited vine length of 133 cm, 9.96 number of fruits/vine, average fruit weight of 169.25 g, horizontal diameter of fruit of 5.23 cm, vertical diameter of 8.07 and 32.537 mt total fruit yield. Application of NPK fertilizer @ 100:70:55 kg/ha (T₃) also showed at par results having vine length of 129 cm, 9.25 number of fruits/vine, average fruit weight of 164.25 g, horizontal diameter of 5.06 cm, vertical diameter

7.94 cm and 31.490 mt total fruit yield. So, the difference between their two treatments were non-significant. T₅ treatment is considered the best treatment because it minimizes the cost of inorganic fertilizers.

Umamaheswarappa *et al.* (2005) in cucumber application of 120 kg nitrogen/ha reduces the number of days for the first male (41.45 days) and female (45.75 days) flowers and increase the number of male flower per vine (112) and maximum number of female flower per vine (21.54). They also observed lesser number of days required for fruit setting (53.98 days) and highest fruit set percentage (71.25), highest sex ratio (5.91) at application of 120 kg nitrogen per ha. They also noticed the effect of phosphorous levels as highest number of male flower/vine (100.64) and high number of female flower per vine (19.82) at 50 kg/ha. Whereas Potassium has no significant effect on flowering, fruit set and sex ratio in cucumber.

Watcharasak and Thammasak (2005) studied the effect of nitrogen and potassium on growth and yield of cucumber by applying varying doses of nitrogen and potassium to the plants by drip irrigation. They reported highest leaf number, leaf area, fresh and dry weight of shoot and root with application of 150 mg nitrogen per litre of water on daily basis for 20 days. Fertigation with 300 mg of potassium per litre gave maximum number of fruits, maximum marketable fruits and maximum total yield per plant as compared to 200 and 250 mg of potassium per litre of water.

Al-Jaloud *et al.* (2006) conducted three experiments to determine the optimum dose of NPK on greenhouse cucumber. In first experiment nitrogen rates were 125, 150, 175 and 200 PPM nitrogen with basic fertigation of P₂O₅ 70 PPM and K₂O 200 PPM. In second experiment for P element rates were 40, 50, 60 and 70 PPM P₂O₅ with 200 PPM Nitrogen and Potash each. In 3rd experiment for K element, rates were 140, 160, 180 and 200 PPM K₂O with 200 PPM and 70 PPM for nitrogen and phosphorous respectively. They obtained the maximum yield of 49.5 t/ha with 150 PPM nitrogen + 70 PPM P₂O₅ + 200 PPM K₂O. They are also of opinion that high dose of nitrogen, phosphorous and potassium is required to get higher yield in cucumber under protected environment.

Guler *et al.* (2006) studied the effect of nitrogen concentration (0-100-150-200 mg of nitrogen/litre) and their frequency level (once a week and twice a week) on yield in cucumber under protected environment. Results shown that maximum number of fruit

(59.4 fruits/m²) and highest fruit yield (75.2 t/ha) was recorded with the application of 200 mg nitrogen/litre nitrogen concentration. They further concluded that cucumber can be grown successfully by applying 200 PPM of nitrogen twice in week and 200 PPM potassium, 40 PPM magnesium + 2.5 PPM iron once in week through drip irrigation.

Prabhu *et al.* (2006) obtained highest yield of 32.80 t/ha in cucumber cultivar green long with the application of 50% RDF (RDF 20:30:30 kg/ha) + vermicompost @ 2 t/ha + biofertilizers (2 kg of each azospirillum and phsphobacteria). They also recorded highest benefit:cost ratio of 2.24.

Ahmed *et al.* (2007) studied eight levels of nitrogen rates viz., 0, 30, 60, 90, 120, 150, 180 and 210 kg/ha with basal dose of 120 DAP/ha on growth and yield components in cucumber. They recorded highest vine length, mean fruit weight, fruit length and total yield were comparatively higher at nitrogen rates of 210 and 180 kg/ha.

Sumathi *et al.* (2008) they conducted field experiment in cucumber cv. NS404 to increase the growth and yield with fertigation. They revealed that the fertigation with 100% WSF in combination with calcium chloride recorded highest yield. Also, noticed improvement in physiological characteristics, fruit weight and fruit yield.

Waseem *et al.* (2008) tried six levels of nitrogen viz., 0, 20, 40, 60, 80 and 100 kg/ha to see the effect on growth and yield characters in cucumber. They observed that 100 kg nitrogen significantly increased vine length (3.08 m), fruit length (19.43 cm) and fruit weight (152.2 g). They also opinioned that nitrogen dose of 80 Kg/ha is appropriate dose for minimizing days to flowering (38.56), days to fruit setting (12.68) and days to maturity (7.03) with higher number of fruits (15.22) and higher total yield (13.9 t/ha).

Jilani *et al.* (2009) investigated the effect of different levels of NPK on the growth and yield traits in cucumber under plastic tunnel. Least days to flowering (39.33 days), least days to fruit setting (11.55 days), least maturity days (7.28), maximum fruit/plant (35.5), maximum fruit length (18.36 cm), maximum fruit weight (136.03 g) and highest yield 60.2 t/ha were recorded with application of NPK @ 100: 50:50

kg/ha. They also exhibited beneficial effect of NPK @ 120:60:60 kg/ha on fruit weight (150.69 g) and vine length (3.85 m).

Kade (2009) while working in Allahabad studied the treatments consists four levels of nitrogen (50,100,150 and 200 kg/ha), two levels of phosphorous (50 and 100 kg/ha) and two levels of potassium (50 and 100 kg/ha) and obtained maximum core diameter (3.01 cm) and rind thickness with the application of 200 kg nitrogen + 50 kg phosphorous + 100 kg potassium/ha over other NPK combination treatments.

Olaniyi *et al.* (2009) conducted a trial involving three varieties of cucumber (Ashley, Poinsett and Royal F1) with four levels of organomineral fertilizer (0, 2, 3 and 4 t/ha) and found that the growth parameters (vine length and number of leaves), yield and yield components show increasing response with increase in the rate of organomineral fertilizer from 0 to 4 t/ha. They further recommended the cultivation of variety Royal F1 and Poinsett in the southwestern region of Nigeria.

Eifediyi and Remison., (2009) conducted experiments for three years during the rainy season of 2006 to 2008 at the teaching and research farm of Ambrose Alli University. Compound fertilizer (N.P.K. 20:10:10) was applied at 0, 100, 200, 300 and 400 kg/ha to two cucumber varieties (Ashley and Palmetto) using 2 × 5 factorial scheme replicated three times. Results revealed significant difference ($P < 0.05$) among the varieties in terms of vine length, number of branches and leaf area. The growth and yield attributes of cucumber including the vine length, number of leaves per plant, number of branches, leaf area, number of fruits per plant, fruit length, fruit girth, fruit weight per plant, fruit number per plant and total yield per hectare increased significantly ($P < 0.05$) with increase in inorganic fertilizer application up to the highest level.

Sharma *et al.* (2009) studied about influence of NPK fertilizers on production of cucumber under protected conditions. Results showed that 300 kg of NPK/ha is optimum dose for producing good quality cucumbers.

Eifediyi and Remison., (2010 a) see the effect of NPK (20:10:10) a compound fertilizer and was applied @ 0, 100, 200, 300 and 400 kg/ha. They noticed longest vine length of 276.93 cm, maximum yield per plant (2.43 kg), highest yield of 46 t/ha at highest level of fertilizer 400 kg/ha. There was significant increase in vegetative

traits and yield attributing components in two cucumber cultivars (Ashley and Palmetto) at highest level of fertilizer. At 400kg of NPK per hectare yield was 166% higher than control.

Eifediyi and Remison., (2010 b) see the effect of NPK (20:10:10) a compound fertilizer and was applied @ 0, 100, 200, 300 and 400 kg/ha along with 10t/ha of farmyard manure. They observed that farmyard manure and 400 kg/ha of fertilizer gave the longest vine length of 276.93 cm and the highest number of leaves. Likewise, fruit weight and average yield per hectare was also highest. Fruit yield per hectare was 166.42% higher than the control.

Janpriya *et al.* (2010) found significant effect on plant height, flowering behaviour and yield/ha in protected environment and also in open field as compared with soilless media in treatment T₂F₁ (Peat : Vermicompost : Sand). They also obtained highest yield of 113.89 t/ha in T₂F₁ in greenhouse and 96.11 t/ha in open field. They observed 18.45% increase in treatment T₂F₁. They also recorded higher benefit:cost ratio 3.43.

Narayanamma *et al.* (2010) conducted a trial to see the effect of different organic manure and their combination with biofertilizers and inorganic fertilizers with RDF @ 100:50:50 kg NPK in cucumber. Results showed FYM 10 qtl + biofertilizers + 50% of RDF dose of fertilizers recorded significantly higher yield 111 q/ha. They also revealed highest b:c ratio 1:2.1 with this application. The quality parameters, vitamin C, total carotenoids and P-carotene were also higher under above given treatment. The NPK content in fruit and leaves were also high where integrated nutrient management treatment was given.

Shinde *et al.* (2010) under Rahauri conditions obtained maximum number of fruits/plant (10.40), maximum yield/plant (21.66 kg) and total yield of 255.03 q/ha with application of 100 kg nitrogen per hectare in 8 splits through drip irrigation. Also recorded increase in water use efficiency (10.13 q/ha cm). They observed B: C ratio of 3:34. Similarly, Abdrabbo (2011) evaluated that NPK in ratio of 180:15:120 mg/ha from transplanting to first harvest and then 270:35:240 mg/litre upto the end of season is most suitable for getting maximum returns from the cucumber.

Al-Sahaf (2011) conducted a field experiment at university of Baghdad to see the response of three cucumber hybrids namely Gazeer, Nujm and Babylon to chemical

and organic fertilizers. He studied that Gazeer hybrid gave the highest vegetative growth and highest yield 22.55 t/ha in fall season and 31.77 t/ha in spring season with fertilizers 260 kg urea + 40 kg SSP + 100 kg/ha. He also suggested that organic fertilizers also gave 20.22 t/ha in fall season and 29.07/ha in spring season.

Jokinen *et al.* (2011) compare the methods of fertigation in cucumber under polyhouse e.g. conventional fertigation and split root fertigation (SRF) and revealed 12% increase in yield and water use efficiency by 13% in SRF over the TF. They also observed that SRF method of fertigation also improves fruit set.

Sharma *et al.* (2011) compare the results of different methods for application of fertilization viz., (i) traditional method of fertilizer application where full Phosphorous, full potash and half dose of nitrogen will be broadcast in field before transplanting and rest of nitrogen applied at 30 DAT and 60 DAT (F₁) (ii) by method of fertigation (F₂). They observed maximum vine length (3.71 m), minimum intermodal distance (7.97 cm), maximum fruit set (55.14 %), maximum number of fruits/vine (36.00) and average fruit weight (115.23 g), maximum yield/vine (3.99 kg), maximum fruit length (19.84 cm) with F₂ application of fertilizers through drip irrigation at 60 x 50 cm plant spacing in Hilton cultivar. Likewise, Zhang *et al.*(2011) found that there was increase in the cucumber fruit yield, increase in number of fruits per plant, increase in weight of fruit with optimum dose of 450 and 600 kg of nitrogen per hectare. Also, concluded that 0.8 Ep as optimum irrigation level.

Dai *et al.* (2011) studied the effects of nitrogen on fruit growth and yield so as to facilitate the optimization of nitrogen management for cucumber (*Cucumis sativus*) crop in greenhouses. Four experiments with different levels of nitrogen treatments, substrates and planting dates on cucumber (cv. Deltastar) were conducted in greenhouses located at Shanghai during 2005 and 2007. Data on seasonal time courses of leaf nitrogen content (NL), leaf area per plant (LA), and the number of fruits growing per plant (nFG), as well as time course of the length of individual fruit growing on the plant (LF(i)) under different levels of nitrogen supply conditions were determined as functions of a photo-thermal index (PTI). The impact of NL on LA was determined by curve fitting to the experimental data. The source/sink ratio (LA/nFG), an indicative of the source size per fruit, was then derived from the seasonal time courses of LA and nFG. The impact of NL on LF(i) was indirectly quantified by the

relationship between source/sink ratio (LA/nFG) and the elongation rate of individual fruit (RFL(i)). Both the harvest date and fresh weight (WF(i)) of individual fruit growing at different node, and number of harvested fruits (nFH) were then calculated as functions of the fruit length. The coefficient of determination (r^2) and the relative root mean squared error (rRMSE) between the predicted and measured values are, respectively, 0.92 and 0.22 (r^2 , rRMSE) for leaf area per plant, 0.90 and 0.24 for the number of fruits growing on the plant, 0.91 and 0.22, 0.90 and 0.23, and 0.92 and 0.21, respectively, for the length, harvest date and fresh weight of individual fruit growing on the plant, 0.94 and 0.20 for yield.

Anjanappa *et al.* (2012) studied the effect of integrated nutrient management on growth, yield and quality of cucumber cv. Hassan local in protected environment. The results revealed the treatment of 75% RDF + 75% FYM + Azotobacter + Phosphobacteria + Trichoderma recorded significantly superior. Mean vine length (250.3 and 255.16 cm), mean number of leaves (93.26 and 96.50), mean number of branches/plant (7.23 and 7.78) and maximum number of fruits/vine (2.42 and 2.45 kg), total fruit yield 62.76 and 63.68 t/ha during summer and rabi season respectively.

Shehata *et al.* (2012) investigated the effect of magnetic iron, humic acid, compost and amino acids on growth and yield attributes of cucumber plant. They suggested that vegetative growth and yield production in cucumber was improved with 15-20 ton fedan of compost and 300 kg per feddan of magnetic iron. They further observed highest fruit weight by humic acid, amino acid and compost treatment. They reported that the amino acid and humic acid treatments showed significant difference in the average fruit yield per plant as compared to control. Likewise, Seo *et al.* (2012) investigated that 108.8g/l. of nitrogen, 54g/l of phosphorus and 158g/l of potassium resulted in maximum yield of oriental melon(2966 kg) compared to conventional practice. Fertigation increased fruit yield, uptake of N, K by plant to 23.0%, 33.3% and 15.7% respectively.

Amabdas (2013) studied five fertigation levels viz., F₁= 100% RD of nitrogen and potassium at alternate day upto 60 days, F₂= 100% RD of RD of nitrogen and potassium at every week upto 60 days, F₃= 80% RD of nitrogen and potassium at alternate day upto 60 days, F₄= 80% RD of nitrogen and potassium at every week upto 60 days, F₅= 100% RD of nitrogen and potassium through straight fertilizers +

drip fertigation of 100% of nitrogen and potassium at every alternate day upto 60 days after sowing recorded significantly higher growth, yield contributing characters and overall fruit yield (28.51 ton/ha). The quality parameters viz., density of fruit was significantly maximum (6 g/cm³). The uptake of N,P and K by cucumber was also significantly higher. Water use efficiency was also higher (71.99 kg/ha mm). Benefit cost ratio (B:C) was also higher (1:3.21).

Gheorghe *et al.* (2013), standardized the fertilization with soluble complex fertilizers in addition with fertigation for better growth and fructification of cucumber. The Presence of chemical fertilizers do not influence in a negative way the nitrates, phosphorus and potassium contents and quality of consumption of cucumbers were assured. Regarding the cultivars the best yield and quality results were obtained to "Mirabelle" F1.

Ghehsareh *et al.* (2013) revealed that No 3 nutrient solution significantly affected the intensity of the leaf color, stem diameter, plant height and leaf area index as compared to No 2 nutrient solution had its major effect on the weight of plant dry matter, weight of fruit dry matter and stiffness of fruit tissue.

Hafeez and Ali (2013) investigated that nitrogen @ 90 kg/fed has significant effect on number of fruits/plant, yield (kg/plant) and total yield (t/fed) whereas phosphorous @ 9.8 kg to 13.5 kg/fed has no significant effect on yield parameters. They further concluded that nitrogen @ 70 kg/fed + phosphorous 6.8 kg/fed + biofertilizers (biogen + phosphorien) is the best treatment for all parameters under study.

Hegde *et al.* (2013) observed that drip fertigated cucumber plants gave a highest yield (175.65 t/ha), fruit yield/plant (949 kg), number of fruits per plant (75.75), maximum number of female flowers (301.25), highest fruit set (25.0%), minimum days to first female flower (29.00) and minimum days to 50% flowering (34.15) with application of 120% RDF (RDF 72:60:90 kg/ha) in European cucumber with benefit:cost ratio 1:3.72.

Mariana *et al.* (2013) observed the effect of organic fertilizers over chemical fertilizers on cucumber fruit quality for three consecutive years. They concluded that both chemical and organic fertilizers had positive effect on the production of

cucumber for sale in all three experimental years. Likewise, Hassan *et al.* (2013) evaluated the fertilizer compounds to minimize the cost of production cucumber. They found that the cost of production of cucumber was minimized when NPK Biasa and NPK Green having 80 kg/ha of N, 75 kg/ha P and 60 Kg/ha of P were used.

Kolekar (2013) while studying a field experiment on sandy loam soil at college of Agriculture, Dapolli, to study the effect of different levels of NPK on the growth and quality of watermelon with four levels of fertilisers. The results revealed that the treatment drip, 125% of RDF and 125% of manure recorded significantly superior mean length of vine and mean number of branches per hill over rest of treatments. the treatment drip, 125% of RDF and 125% of manure recorded significantly superior average circumference of fruit (56.78 cm), average fruit weight of fruit (3.01 kg), and fruit yield (52.35 t/ha) over rest of treatments. The treatment drip, 125% of RDF and 125% of manure recorded significantly superior available nitrogen, available phosphorous and available potassium, organic carbon (per cent) and organic matter (per cent) in soil over rest of treatments.

Tiwari *et al.* (2013) assessed the impact of five fertigation levels viz., 60%, 80%, 100%, 120% and control fertigation under protected environment. Results revealed that the fertilization with 100% RDF showed maximum values for vine length, vine girth, fruit length, fruit diameter, fruit weight, fruit yield with minimum values for days to flowering and days to first fruiting. Similarly, Yang *et al.* (2013 a) investigated the effect of four nitrogen fertilizers in cucumber for yield and water use efficiency and concluded that a higher nitrogen dose of 550 kg urea per hectare may increase yield by 41.5% and water use efficiency by 15.2%.

Yang *et al.* (2013 b) studied the adequacy of amount of irrigation water in combination with combination of three nitrogen fertilizers including urea, urea containing nitrification inhibitors and coated urea. They showed that among various treatments under study 109000 kg/ha production was observed by treatment of 550 kg/ha urea containing inhibitors, which could increase 41.5% of a yield, 15.2% of a cumulative water consumption (462.0 mm) and 44.7% of a water use efficiency that is at 14.11 kg (dry matter)/(mm · ha) as compared to control.

Arshad *et al.* (2014) investigated about the effect of different levels of NPK fertilizers viz., 500 g/fertigation, 750 g/fertigation, 1000 g/fertigation (20:20:20), 1250

g/fertigation through drip irrigation and control in five plots and found that 1000 g/fertigation is best suitable dose as it takes less days to flowering 31.464, days taken to fruit setting (9.24) , days taken to fruit maturity (6.304), number of fruit/plant (34.435), maximum fruit length 18.176 cm, maximum vine length (2.50 m), fruit weight (134.670 g) and yield /hectare (58.820 g).

Arun and Kumar (2014) noted maximum fruit length 16.8 and 18.2 cm, maximum fruit diameter 4.6 and 5.3 cm and maximum number of fruits 39.1 and 37.2 with the application of 125% RDF applied through water soluble fertilizers and foliar application micronutrients during the year 2011 and 2012 respectively. Likewise, Chand (2014) conducted an experiment in NVPH with four levels of fertigation viz., 110, 100, 90 and 80% RDF to determine best fertigation dose for salad cucumber. They acknowledged maximum number of fruit/plant (48), yield per plant (7.215 kg) and total yield of 89.06 t/ha and higher water use efficiency (6167.78 kg/ha/cm) with application of 100% RDF of NPK (175:125:300 kg/ha) B : C ratio of 3:42

Feleafel *et al.* (2014) studied the effect of NPK fertilizer with starter fertilizer on growth and yield of cucumber in protected environment. Results showed that increase plant height and number of leaves at (30, 50 and 70 days after sowing) with the application 125 percent RDF and number of branches, fruit weight, number of fruits and total yield at (30 DAS). They also noticed significant increase in fruit setting percentage and number of fruits/plant at fertigation 125 per cent RDF with starter fertilizer (7-14-7). Whereas 125 per cent RDF + SF₂ (7-28-7) gave the highest yield.

Hakkim *et al.* (2014) studied the yield response of salad cucumber under different drip irrigation levels to determine the most suitable irrigation requirement grown under naturally ventilated polyhouse. The maximum fruit number (49), fruit weight(7.94 kg. per plant) and fruit yield (88.8 tonnes per hectare) were obtained from drip irrigation level of 65% (1.3 ltr. per plant per day).

Kang *et al.* (2014) achieved maximum yield of cucumber fruit by supplying 1320-150 mg/litre/week of nitrogen by fertigation. However, growth in cucumber was non-significant at highest dose of nitrogen i.e. 400 mg/litre/week. They further opined that green values of cucumber leaves may be used to diagnose the optimum rate of nitrogen for cucumber under fertigation system. Similarly, Kuranga (2014) studied the effect of five levels of NPK fertilizer (0, 25, 50, 75 and 100 kg/ha) on three cultivars

of cucumber namely Marketer, Market More and Poinsett. However variety x fertilizer interaction revealed that 100 kg NPK/ha gave the best results in all three cultivars for maximum cucumber production.

Natsheh and Mousa (2014) studied the impact of organic and inorganic fertilizers on yield of cucumber and found higher productivity of 7000 kg/dunnum by using organic fertilizers as compared with chemical fertilizer (6017 kg/dunnum). They also noticed saving of water and improvement in productivity of soil by using organic fertilizers. 180 m³/season of water is required in organic fertilizer whereas with inorganic fertilizer 213 m³/season of water is required.

Patwardhan (2014) evaluated the effect of fertigation and irrigation levels on growth and yield components in cucumber. They studied four levels of irrigation and four levels of fertigation and found maximum average yield of 20.83 t/ha in irrigation level I₂ (195.28 mm) and 21.62 t/ha in fertigation level F₁ 80% RDF (RDF NPK 100:50:50 kg/ha). They revealed 30.69% increase in yield and 20% saving in fertilizers with I₂F₁ treatment. There was also 65.93% saving of water in drip irrigation system over conventional method of irrigation.

Tekale *et al.* (2014) showed that 125% RDF coupled with fertigation of nitrogen and potassium at every two day interval on 52 slit doses and phosphorous as basal dose in soil application recorded maximum vine length, maximum number of branches/vine, higher fruit length, higher fruit girth, maximum number of fruit per vine, high average fruit weight and ultimately maximum total yield as compared to other fertigation levels of 75% and 100% RDF. They standardize a dose of NPK (125:62.5:62.5 kg/ha) is appropriate to get maximum yield and maximum gross monetary returns.

Umekwe *et al.* (2014) studied the impact of different doses of NPK (15:15:15) on morphological and yield traits. Results showed an increase in number of vines (2.96), vine length (73.0 cm), number of flowers (49.68), number of fruits (3.80) and number of marketable fruits (2.83) at the dose of 60 kg/ha. Likewise, Fang *et al.* (2015) studied the effect of two irrigation levels (100% and 75%) and four fertigation levels (100%, 66.6%, 33.3% and 0% of total amount of fertilizer (360:180:540 kg hm(-2)) of N: P₂O₅:K₂O. Highest yield (67760 kg hm(-2)) was recorded at 100% irrigation level and fertigation level respectively. Results also showed significant correlation with

plant height, leaf areas, dry mass, yield and quality of cucumber with irrigation and fertigation levels.

Sahin *et al.* (2015) evaluated the effect of different irrigation quantities on the fruit yield, yield components (fruit length, diameter, weight and number), irrigation water use efficiency (IWUE) and fruit quality (minerals, phenolic content and antioxidant activity) of drip-irrigated cucumbers. They found that among different treatments under evaluation the treatment T1 was suitable in semi-arid areas with cool climate for obtaining higher yield. Likewise, treatment T2 was found suitable for obtaining higher IWUE and fruit quality.

Nweke and Nsoanya (2015) evaluated the effect of cow dung and urea fertilization on soil properties, growth and yield of cucumber. They found that the combination of cow dung manure and urea fertilizer could increase yield, yield quality and soil fertility. Similarly, Nwofia *et al.* (2015) suggested that fertilizer dose 120kg/ha of NPK (15:15:15) is a economical dose to get maximum yield thereafter there is no significant increase in yield upto 300 kg/ha/NPK. Pearson correlation indicated a highly significant and positive correlation between fruit yield and weight of fruit as well as number of fruits per plant.

Mali *et al.* (2016) studied four levels of fertigation of NPK in ratio of 50:30:30 (F₁), 100:60:60 (F₂), 120:90:90 (F₃) and 150:120:120 (F₄) kg/ha and recorded higher yield of 35.1 t/ha at F₃. Maximum vine length was recorded in F₄. Similarly, Patil and Gedge (2016) reported that fertigation with 125% of RDF of NPK through drip irrigation produces maximum yield of 21.87 t/ha in cucumber cv. Gypsy. They also revealed that drip irrigation with fertigation of nitrogen and soil application of Phosphorous and Potassium as basal dose showed significant advantages in terms of yield and maximum net income return.

Sikarwar and Hardaha (2016) studied from levels of fertigation viz., 60 %, 80%, 100%, 120% RDF 150:70:160 kg/ha and found that Sandya F1 hybrid of cucumber resulted in highest plant height of 431.3 cm at 120% RDF treatment whereas maximum number of fruit (14) and highest total yield 54.43 t/ha was recorded at 100% RDF. Therefore they conclude the fertigation dose of 150:70:160 kg of NPK is suitable to achieve maximum yield in Madhya Pardesh.

Sufia Akter (2016) studied about influence of phosphorous on the growth and yield of cucumber. Results showed that maximum number of fruits/plant (23.86), maximum fruit weight (192.58 g) and total yield (51.4 t/ha) was recorded at P₂ level of fertilizer (60 kg P₂O₅/ha) as compared to P₁ 30 kg P₂O₅/ha and P₃ 90 kg P₂O₅/ha. Likewise, Wahocho *et al.* (2016) reported that application of 150 kg of nitrogen/hectare produced maximum vine length (198.57 cm), maximum leaves/vine (93.333), less days to flower initiation (46.12 days), maximum fruit length (16.147 cm), maximum number of fruits/vine (14.227) and maximum fruit yield (16.025 t/ha) as compared over other three levels of nitrogen(0, 50, 100 kg/ha) and concluded that 150 kg of nitrogen per hectare produces higher values for all growth and yield parameters.

Al-Moshileh (2017) conducted an experiment to evaluate an optimum dose of potassium to be supplied to tomato and cucumber plants. They fertigated four levels of Potassium sulphate (100, 150, 200 and 250 PPM to both tomato and cucumber. They found significant increase in the leaf potassium concentration (4.19 mg/kg), chlorophyll content of leaf (46.03), TSS (4.80%), firmness 9.19 lbs/inch² and total marketable yield of 78.89 t/ha with the application of 250 PPM potassium sulphate in tomato. Similarly in Cucumber they recorded significant increase in the leaf potassium concentration (4.43 mg/kg), chlorophyll content of leaf (49.14), TSS (4.14%), firmness 17.42 lbs/inch² and total marketable yield of 34.19 t/ha with the application of 250 PPM potassium sulphate.

2.4 QUALITY PARAMETERS OF CUCUMBER UNDER DIFFERENT ENVIRONMENTS

According to Arnon's criteria of essentiality, a plant is unable to complete its life cycle in the absence of essential nutrients. Moreover, deficiency of one element cannot be overcome by supplying another element. So far about 16 essential nutrients have been identified which are responsible for plant growth. Apart from contributing to plant growth these elements are also responsible for improving the fruit quality and parameters concerned with fruit quality. Ejaz *et al.* (2011) studied the influence of macro and micro nutrients on different quality parameters viz., Total soluble solids (TSS), titeratable acidity and Vitamin C content, in tomato. They found satisfactory results on individual application of nutrients than control. However, they observed

that the Total soluble solids (TSS), titeratable acidity and Vitamin C content in tomato were greatly enhanced when mixture of nutrients were applied. They observed positive effect on quality parameters of tomato when N, Zn and B were applied in combination.

Cimpeanu *et al.* (2013) studied the influence of three fertilization systems (organic with manure, classic with chemical fertilizers and soluble complex fertilizers with fertigation) on the quality of two cucumber cultivars viz., Trium F1 and Mirabelle F1. They revealed that fertilization with soluble complex fertilizers in addition with fertigation had positive effect on growth and fructification. The cultivar Mirabelle F1 had the best yield and quality results. Likewise, Keerthika *et al.* (2016) studied the nutritional and quality characteristics of some cucumber varieties (English, Holenarasipur, Dotted, Zucchini, Gherkin, Armenian, Organic Zucchini, Organic Regular, Regular and Pranic healed cucumber) Highest moisture content was observed in English, Zucchini and Pranic healed cucumbers, and the lowest moisture content was found in two varieties, viz, Holenarasipur and dotted variety. Zucchini, organic variety had the highest vitamin C, antioxidant activity and total polyphenol content and was lowest found in Holenarisupur variety.

2.4.1 Total soluble solids (⁰ Brix)

Faustino *et al.* (2008) evaluated the performance of six hybrids of melon. They found that the hybrid, AF5114 surpassed the Vera Cruz in all variables, except in the content of soluble solids. The other hybrids did not show better results, except the AF3187 and AF5121 that only obtained slightly higher values of soluble solids.

Patel *et al.* (2013) assessed twenty hybrids of cucumber (*Cucumis sativus* L.) for quality (TSS) characteristic. They found significantly maximum Total soluble solids in hybrid Garima Super (5.50°Brix) followed by Prasad-10 (5.36°Brix) and US-249 (5.33°Brix). The minimum TSS value was found with Noori (4.08°Brix). Likewise, Kumar *et al.* (2013) evaluated thirty diverse genotypes of cucumber for determining the variability in total soluble solids content in fruits and recorded highest total soluble solids in (4.07°Brix) LC-28 and lowest TSS was recorded in LC-13 (2.03°Brix).

2.4.2 Ascorbic acid (Vitamin-C)

Rahayu *et al.* (2011) conducted an experiment for selection and evaluation of six candidate varieties of cucumber and found that the variety H3 had highest vitamin 'C' (20.06 mg) followed by H1 variety (19.16 mg per 100 g fresh fruit weight) and lowest vitamin 'C' recorded in H4 variety.

Patel *et al.* (2013) assessed twenty cucumber hybrids for growth, yield and fruit quality traits in Allahabad agro-climatic conditions and recorded maximum vitamin 'C' (per 100 g fresh fruit weight) in Garima Super (7.28 mg) followed by LG-40 (7.23 mg) and US-249 (7.25 mg). The lowest vitamin 'C' was recorded in hybrid Dash (6.25 mg).

2.4.3 Acidity (%)

Chisholm and David (1986) studied two cultivars (Charleston Gray and Jubili) of watermelon for different quality attributes at different regions of fruit. They found that the acidity was highest in Jubili (0.29%) and Charleston Gray (0.24%) at heart region while low acidity was observed in Jubili (0.22%) and Charleston Gray (0.18%) at top region. Likewise, thirty cultivars of muskmelon were evaluated for quality (total sugars and organic acids) traits by Leach *et al.* (1989). They recorded highest acidity in Lividia 148.9 mg 100g⁻¹ and lowest in Sunrise 36.8 mg 100g⁻¹ flesh

Pardo *et al.* (2000) evaluated nine cultivars of melon (*Cucumis melo* L.) and found that the ACL, a yellow type showed the highest pH and soluble solids content whereas Berger *et al.* (2002) studied three lines and their cross combinations of sweet melon for quality characteristics and the results revealed that the line, A6 had high sugars and high acidity. The level of both malic acid and citric acid content was 4.8 and F63 recorded low level of acidity 1.8 % (malic+citric acid).

MATERIALS AND METHODS

A field experiment entitled “**Effect of Crop Geometry and Fertigation on Quality and Yield of Parthenocarpic Cucumber Cultivars Under Protected Conditions**” was conducted at Centre of Excellence for Vegetables, Kartarpur, Jalandhar during 2014-2015 and 2015-2016. The detail of the material used and the techniques employed in the experiment are given in this chapter.

3.1 EXPERIMENTAL SITE

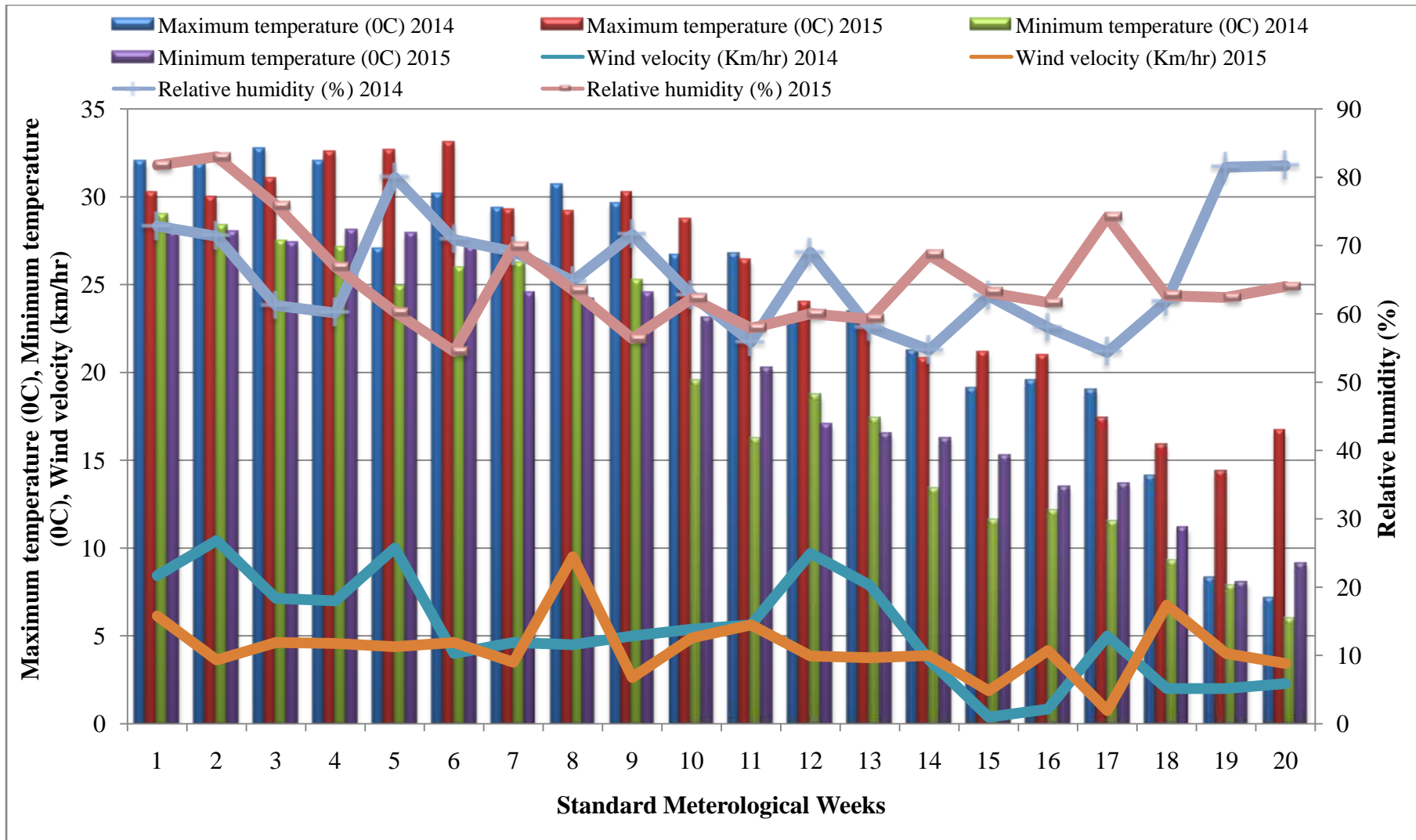
Location

The experiment was conducted in Naturally Ventilated polyhouse at Centre of Excellence for Vegetables (Kartarpur) Jalandhar during September to December in 2014-15 and 2015-16. The experimental site is located at 31.44⁰N latitude, 75.45⁰E longitude with an elevation of 230 m above sea level.

Climate

Cucumber is especially a warm season crop. This is sensitive to frost. Excess humidity promotes diseases like powdery mildew and downy mildew. The optimum temperature for cucumber production is 26.4 °C. Seed of cucumber germinates well at 25 °C. The data regarding weather parameters viz., temperature, humidity and rainfall was recorded for the crop period (September to December) during 2014 and 2015. During 2014 the average maximum day and night temperature was recorded as highest (31 °C and 27 °C, respectively) in the month of September while minimum day and night temperature was recorded (7 °C and 5 °C, respectively) in the month of December. Likewise, during 2015 the average maximum day and night temperature was recorded as highest (34 °C and 29 °C, respectively) in the month of September while minimum day and night temperature was recorded (12 °C and 6 °C, respectively) in the month of December. A little variation was observed in humidity level during both the years.

During 2014 total annual rainfall of 586 mm was recorded with maximum in the month of July-August being 155 mm and 183 mm, respectively. A total of 80 mm rainfall was recorded during the crop period i.e. from September to December, at the experimental site. Likewise, during 2015 total annual rainfall of 647 mm was recorded with maximum in the month of July-August being 156 mm and 170 mm, respectively. A total of 114 mm rainfall was recorded during the crop period i.e. from September to December.



Soil

Cucumbers are adapted to a wide variety of soil types which have good drainage and adequate water holding capacity. Cucumbers do not perform well on acid soil but do well in slight acidity. The optimum pH is 5.5-7.0. However, micronutrient availability may be reduced at a pH above 6.5. The soil of the experimental site was sandy loam.

3.2 EXPERIMENTAL DETAIL

The experiment was conducted in Naturally Ventilated polyhouse in an area of 2000 m² with a length 62.5 m and breadth of 32 m in which 27 beds were prepared.

3.2.1 Treatment Detail

Sr. No.	Factor	Treatments Details	Symbol used
1.	Cultivars/ Hybrid (Five)	Multistar	V ₁
		Hilton	V ₂
		Isatis	V ₃
		Kian	V ₄
		KUK-9	V ₅
2.	Spacing (Three)	40 × 30 cm	S ₁
		40 × 40 cm	S ₂
		40 × 50 cm	S ₃
3.	Fertilizers (Two)	70:40:90 Kg of N:P:K + 20 Kg Ca NO ₃ per acre	F1
		100:50:125 Kg of N:P:K + 40 Kg Ca NO ₃ + 50 Kg MgSO ₄ per acre	F2

3.2.2 Location: Centre of Excellence for Vegetables (Kartarpur) Jalandhar, Punjab.

3.2.3 Experiment Design: Factorial Randomized Block Design (FRBD).

No. of treatment combinations	:	30
No. of replications	:	3
Season	:	September-December 2014 and September-December 2015

3.2.4 Treatment combinations

R-1	R-2	R-3
V1 S1 F1	V3 S1 F1	V5 S1 F1
V1 S1 F2	V3 S1 F2	V5 S1 F2
V1 S2 F1	V3 S2 F1	V5 S2 F1
V1 S2 F2	V3 S2 F2	V5 S2 F2
V1 S3 F1	V3 S3 F1	V5 S3 F1
V1 S3 F2	V3 S3 F2	V5 S3 F2
V2 S1 F1	V4 S1 F1	V3 S1 F1
V2 S1 F2	V4 S1 F2	V3 S1 F2
V2 S2 F1	V4 S2 F1	V3 S2 F1
V2 S2 F2	V4 S2 F2	V3 S2 F2
V2 S3 F1	V4 S3 F1	V3 S3 F1
V2 S3 F2	V4 S3 F2	V3 S3 F2
V3 S1 F1	V5 S1 F1	V2 S1 F1
V3 S1 F2	V5 S1 F2	V2 S1 F2
V3 S2 F1	V5 S2 F1	V2 S2 F1
V3 S2 F2	V5 S2 F2	V2 S2 F2
V3 S3 F1	V5 S3 F1	V2 S3 F1
V3 S3 F2	V5 S3 F2	V2 S3 F2
V4 S1 F1	V2 S1 F1	V1 S1 F1
V4 S1 F2	V2 S1 F2	V1 S1 F2
V4 S2 F1	V2 S2 F1	V1 S2 F1
V4 S2 F2	V2 S2 F2	V1 S2 F2
V4 S3 F1	V2 S3 F1	V1 S3 F1
V4 S3 F2	V2 S3 F2	V1 S3 F2
V5 S1 F1	V1 S1 F1	V4 S1 F1
V5 S1 F2	V1 S1 F2	V4 S1 F2
V5 S2 F1	V1 S2 F1	V4 S2 F1
V5 S2 F2	V1 S2 F2	V4 S2 F2
V5 S3 F1	V1 S3 F1	V4 S3 F1
V5 S3 F2	V1 S3 F2	V4 S3 F2

3.3 CROP RAISING

The seeds of all five cultivars were sown in plastic plug trays having 99 cells using soilless media having Cocopeat : Vermiculite : Perlite in ratio of 3:1:1, respectively in Hi-tech polyhouse on August 20 of every year in 2014 and 2015. The seedlings were ready for transplanting in 15 days. The seedlings were transplanted on 5th September inside the Naturally Ventilated Polyhouse equipped with drip irrigation facility.

3.4 CULTURAL PRACTICES

3.4.1 Preparation of Beds

The land was thoroughly dug up by harrows and tillers and brought to fine tilth. Raised beds of 1.0 metre width and 27 metre length were prepared at 2 m

spacing from bed to bed. Then these beds were sterilised with 4% formalin and covered with polythene sheet for 15 days. After removing sheet, beds are raked with triphali to remove fumes of formalin.

3.4.2 Irrigation

Cucumber plants were fertigated one hour daily with drip irrigation system with emitters of 2.4 litres per hour discharge each and spacing of 40 cm.

3.5 OBSERVATIONS RECORDED

Observations were recorded from experimental plots to assess the effect of treatments on growth, quality and yield of the product.

3.5.1 No. of branches per vine

Total number of branches produced per vine were counted and recorded at final harvest of the fruit and the average was calculated.

3.5.2 Internode Distance (cm)

Distance between two nodes was measured at base in middle, at top node at the final harvest and average internode distance was calculated.

3.5.3 Vine Girth (cm)

Vine girth of randomly taken plants from each treatment was recorded at third, fourth and fifth inter nodal portion of the stem during vegetative growth period with the help of digital vernier caliper and the average was calculated.

3.5.4 Vine length (m)

Five plants were randomly taken from each plot and tagged. The length of vine was measured from the base upto the tip of vine and recorded at the final harvest. It was measured in metres, then mean length of vine was worked out.

3.5.5 Node number at which first female flower appear

The node number at which first female flower appeared was recorded from the base of vine from tagged plants. The average of each plant under observation was computed.

3.5.6 Days to first female flower

The number of days counted from transplanting to the appearance of first female flower from tagged plants and averaged to record the days taken to first female flower and the average was calculated.

3.5.7 Days to first fruiting / picking

Number of days taken from transplanting to first fruit harvest was counted from tagged plants and the average was calculated.

3.5.8 Fruit length (cm)

The fruit length was measured from five fruits at each picking taken randomly at maturity from tagged plants. It was measured with scale from stalk end to styler end. The average was worked out later on.

3.5.9 Number of fruits per vine

All harvested fruits from five tagged plants were pooled at every picking, counted then divided by 5.

3.5.10 Fruit weight (g)

The weight of five randomly taken fruits harvested at maturity stage was recorded. Their mean weight was recorded in grams. Fruit weight was calculated by dividing the total weight by number of fruits.

3.5.11 Fruit Diameter (cm)

Five fruits taken at random from each treatment was cut and the diameter was measured. The fruit was cut half and the diameter was measured with scale in centimetres.

3.5.12 Marketable number of fruits per vine

The marketable number of fruits were estimated by counting all the marketable fruits. The damaged, misshapen and diseased fruits were discarded.

3.5.13 Total fruit yield per vine (Kg)

The fruits harvested from each tagged plant were weighed at every harvest and total yield of fruits/plant under different treatments computed in kilograms.

3.5.14 Fruit drop (percentage)

The fruit drop percentage was estimated by taking into consideration the initial fruit set and the final harvest. The final harvest fruits were subtracted from the total initial fruit set and the percentage was calculated.

3.5.15 Total soluble solids (TSS)

Total soluble solids (TSS) of five randomly taken fruits of each cultivar was determined by using refractometer and was denoted in percentage.

3.5.16 Acidity

Acidity was determined by taking 2 ml of the juice in conical flask and adding 2-3 drops of phenolphthalein solution and then the titration was carried out by N/10 NaOH solution (taken in a burette) till the appearance of pink colour. The results are expressed as percentage of citric acid.

$$\text{Acidity (percentage)} = 0.0064 \times \frac{\text{Volume of N/10 NaOH used}}{\text{Volume of the juice taken}} \times 100$$

3.5.17 Fruit firmness (lbf)

Fruit firmness of five randomly taken fruits of each cultivar was determined by using penetrometer and was denoted in lbf.

3.5.18 Vitamin C (mg)

Vitamin C calculation in fruit juice was carried out by taking 2 ml of fruit juice in a conical flask and adding 5 ml of reagent No.1 (Metaphosphoric acid-acetic acid extracting solutions) and then titrate it with reagent No. 2 (dye used) (Standard indophenol solution) and expressed as mg/100 ml juice.

$$\text{Vitamin C (mg/100 ml juice)} = \frac{\text{Dye factor} \times \text{volume of Dye used}}{\text{Volume of the juice taken}} \times 100$$

*Preparation of Reagent No.1(Metaphosphoric acid-acetic acid extracting solutions): Dissolve by shaking 15 g of glacial metaphosphoric acid (HPO₃) pellets or sticks in 40 ml of glacial acetic acid and 200 ml of distilled water. Dilute it to 500 ml and filter the solution. Keep this reagent in the refrigerator where it can be stored for 7-10 days.

* Preparation of Reagent No. 2 (Standard indophenol solution): Dissolve 50 mg of 2,6 dichlorophenol indophenol dye and 42 mg of NaHCO₃ in distilled water and make the volume 200 ml. Filter it rapidly through fluted paper. Store this solution in the refrigerator for not more than three days.

3.6 STATISTICAL ANALYSIS

The standard statistical techniques as developed by Steel and Torrie (1981) adopted for statistical analysis of data recorded and comparison was made at 5% significant level of significance by using CPCS1 software. The degree of freedom for source of variation for experiments for first and second year tables are given as

Analysis of Variance (ANOVA)

Sr. No.	Source of variation	Degree of freedom
1.	Replication	2
2.	(Variety) A	4
3.	(Spacing) B	2
4.	(Variety X Spacing) AB	8
5.	(Fertilizer) C	1
6.	(Variety X Fertilizer) AC	4
7.	(Spacing X Fertilizer) BC	2
8.	(Variety X Spacing X Fertilizer) ABC	8
9.	Error	58
	TOTAL	89

RESULTS AND DISCUSSION

The results of the present investigation entitled “**Effect of Crop Geometry and Fertiligation on Quality and Yield of Parthenocarpic Cucumber Cultivars Under Protected Conditions**” have been presented in this chapter. An attempt has been made to establish the cause and effect relationship of experimental findings justifying by giving possible scientific explanation and supportive evidences based on the available literature. The data were subjected to statistical analysis and the results have been discussed under following heads:

4.1 Vegetative Parameters

4.1.1 Number of branches

4.1.2 Internode distance (cm)

4.1.3 Vine girth (cm)

4.1.4 Vine length (m)

4.2 Flowering Parameters

4.2.1 Node number at which first female flower appears and days to first female flower

4.3 Fruit Parameters

4.3.1 Number of days to first fruiting

4.3.2 Fruit length (cm)

4.3.3 Number of fruits per vine

4.3.4 Fruit weight (g)

4.3.5 Fruit diameter (cm)

4.3.6 Marketable number of fruits per vine

4.3.7 Total fruit yield per vine

4.3.8 Fruit drop (%)

4.4 Quality Parameters

4.4.1 Total Soluble solids (%)

4.4.2 Juice Acid content (%)

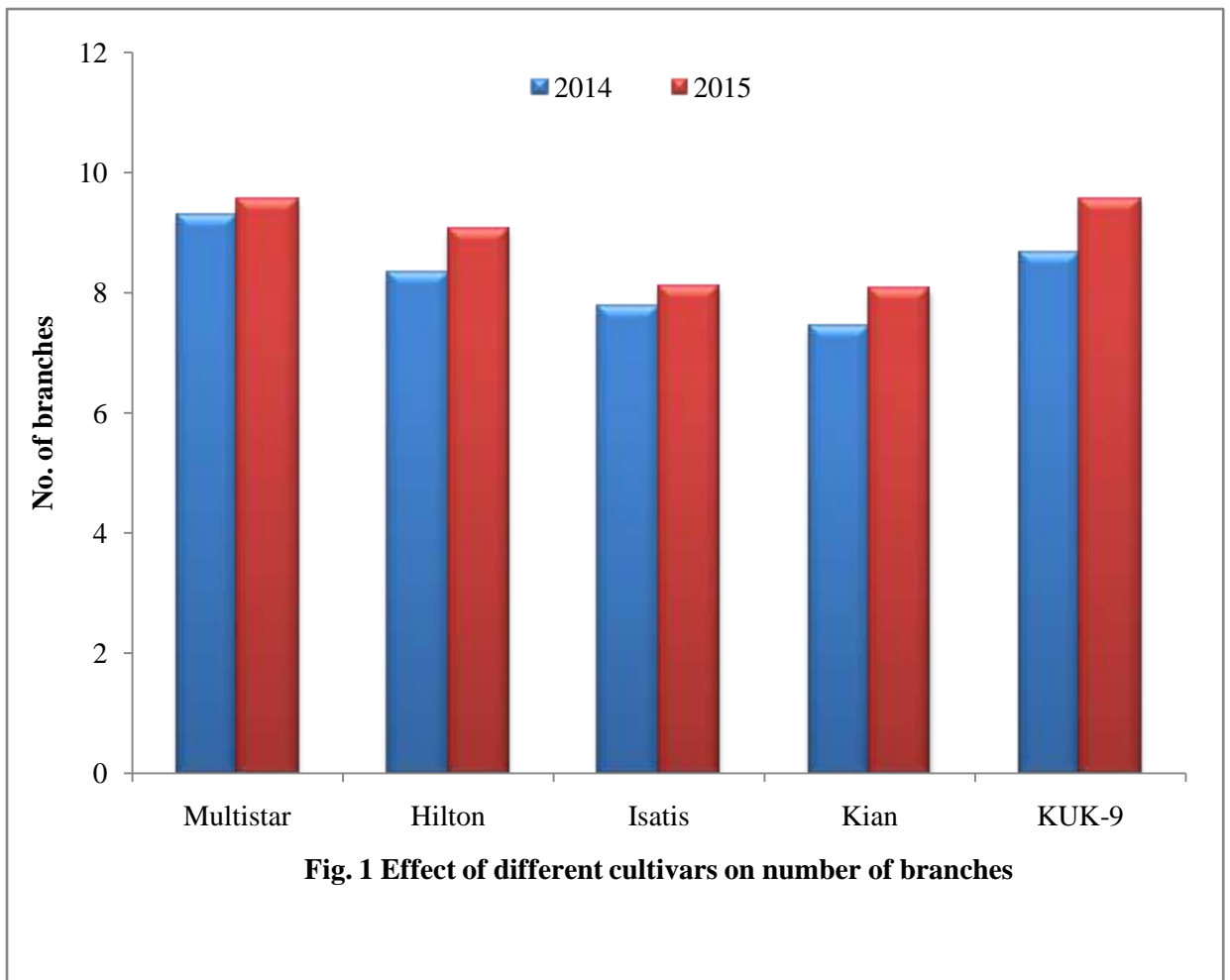
4.4.3 Firmness (lbf)

4.4.4 Vitamin C (mg/100 ml juice)

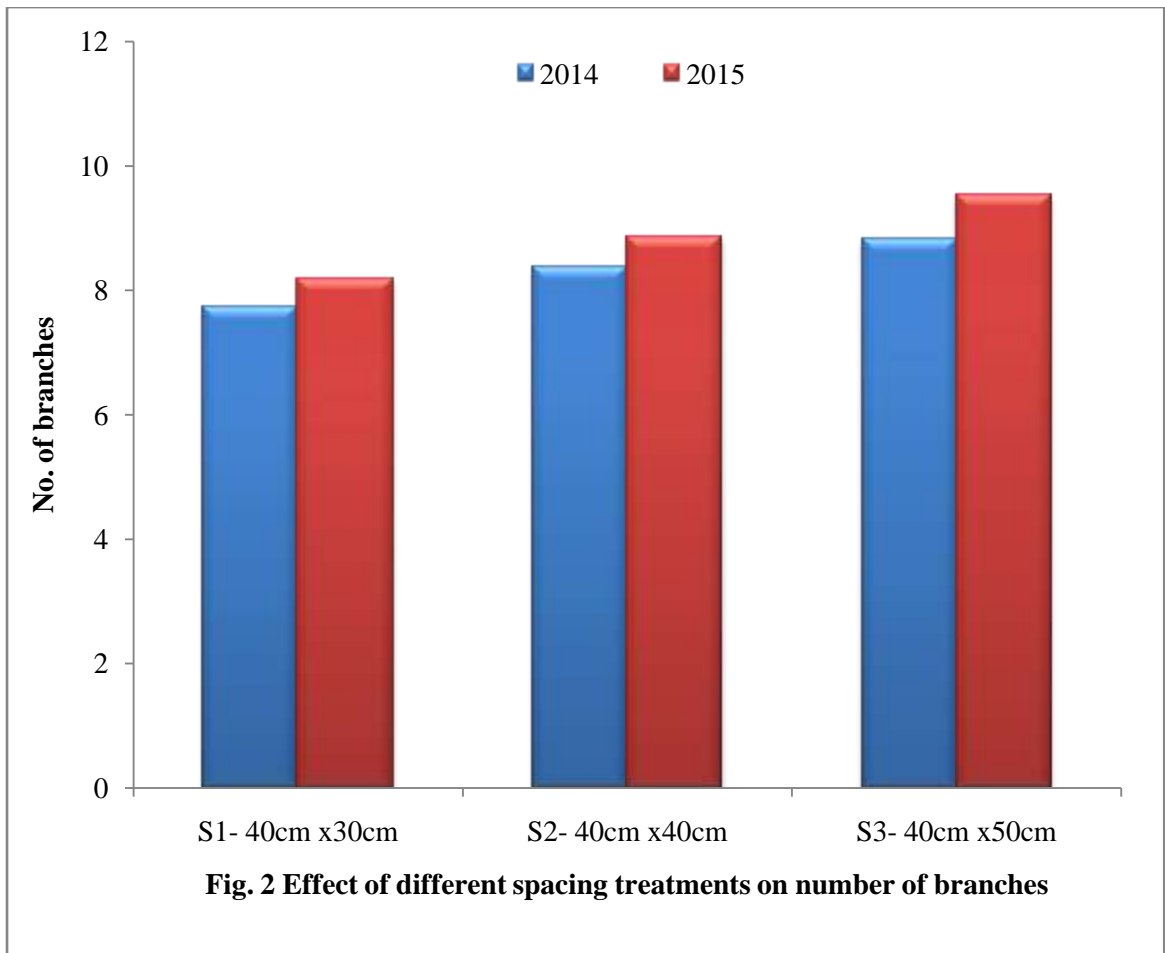
4.1 Vegetative Parameters

4.1.1 Number of branches

The different cucumber cultivars viz., Multistar, Hilton, Isatis, Kian and KUK-9 respond differently under different spacings and fertilizer treatments. The data presented in Table 1 revealed that number of branches were significantly higher (9.29) in Multistar (V₁) during 2014 and in KUK-9 (V₅) to the tune of (9.56) during 2015 as compared to the other cultivars except V₁ and V₅ during 2015. However, cultivars viz. Hilton (V₂) and KUK-9 (V₅); Isatis (V₃) and Kian (V₄) were statistically non significant with each other in 2014. During 2015, maximum (9.56) was noted in cucumber cultivar 'KUK-9' closely followed by 'Multistar' (9.54), Hilton (9.05), Isatis (8.11) and Kian (8.06); whereas Multistar and KUK-9; Isatis and Kian were statistically at par with each other; however, least number of branches were recorded in Kian cultivar (7.43 and 8.06) during both the years. Multistar, KUK 9 and Hilton cultivars were statistically at par with each other. Similarly cultivar Isatis (V₃) and Kian (V₄) were also statistically at par with each other. . These results are in line with the findings of Kumar *et al* (2008); Vijaya Kumari *et al* (1991); Rawat *et al* (2014) and Sanjeev *et al* (2017) reported similar findings with respect to vegetative and yield component of cucumber.

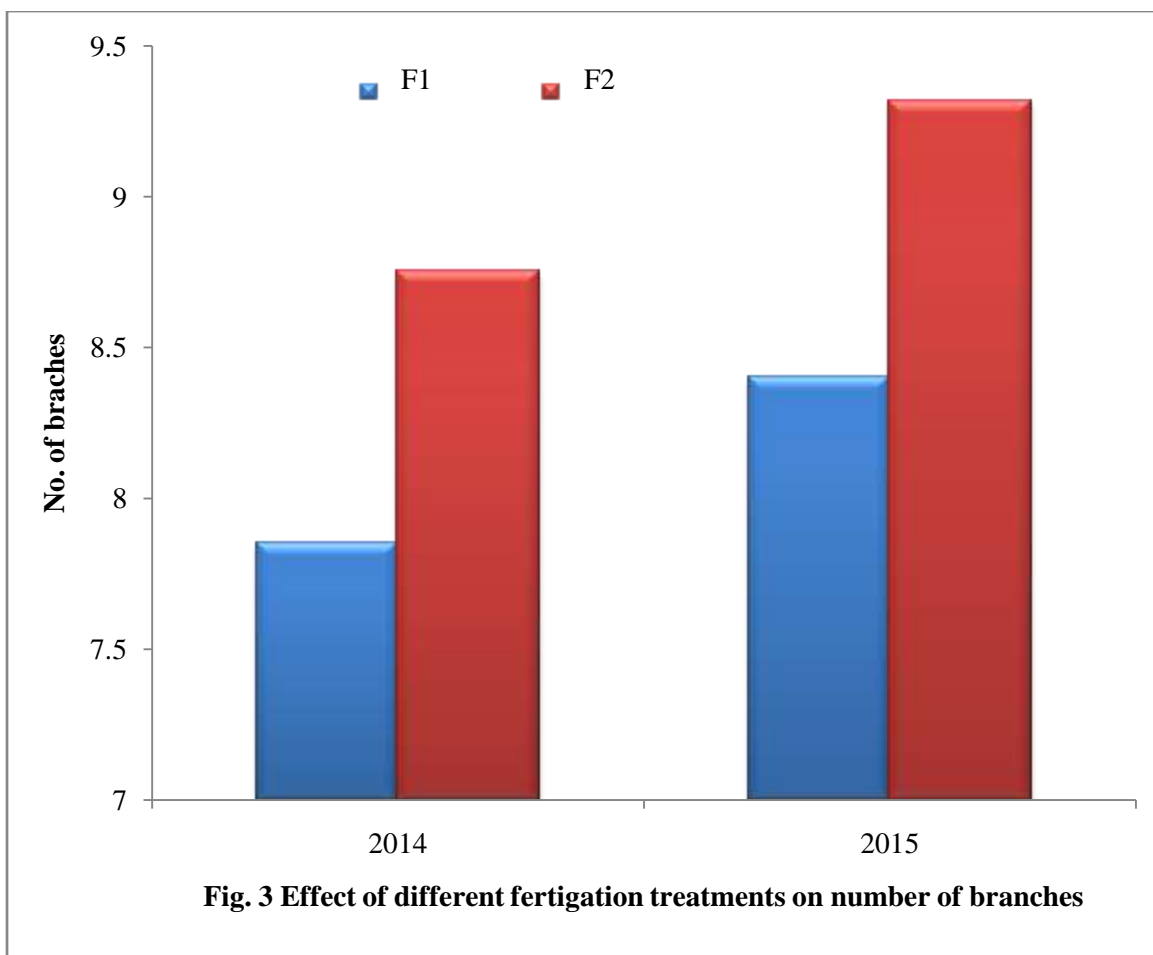


Among different spacing treatments, significantly highest numbers of branches were produced under wider spacing i.e. 40 cm x 50 cm (8.81 and 9.53) in 2014 and 2015 respectively as compared to other spacings. Number of branches in 40 cm x 40 cm and 40 cm x 50 cm were significantly higher over 40 cm x 30 cm (7.72 and 8.19) during both the years. Similarly findings were also reported by Jaffar and Wahid 2014; Khalid 2010 and Aniekwe and Anike (2015).



In different fertilizer treatments, more numbers of branches (8.75 and 9.32) were produced in treatment (F2) 100:50:125 Kg of NPK per acre which was significantly higher than treatment (F1) 70:40:90 Kg of NPK per acre (7.85 and 8.40) during both the years of study. Similar trends was also found by Lakshmi (1997); Eifediyi and Remison (2010); Tekale *et al* (2014). The significant interactions between cultivars and fertilizer doses; spacing and fertilizers treatments during both the years.

The variation in number of branches might have been due to number of nodes in vine because branches rise from nodes of vine



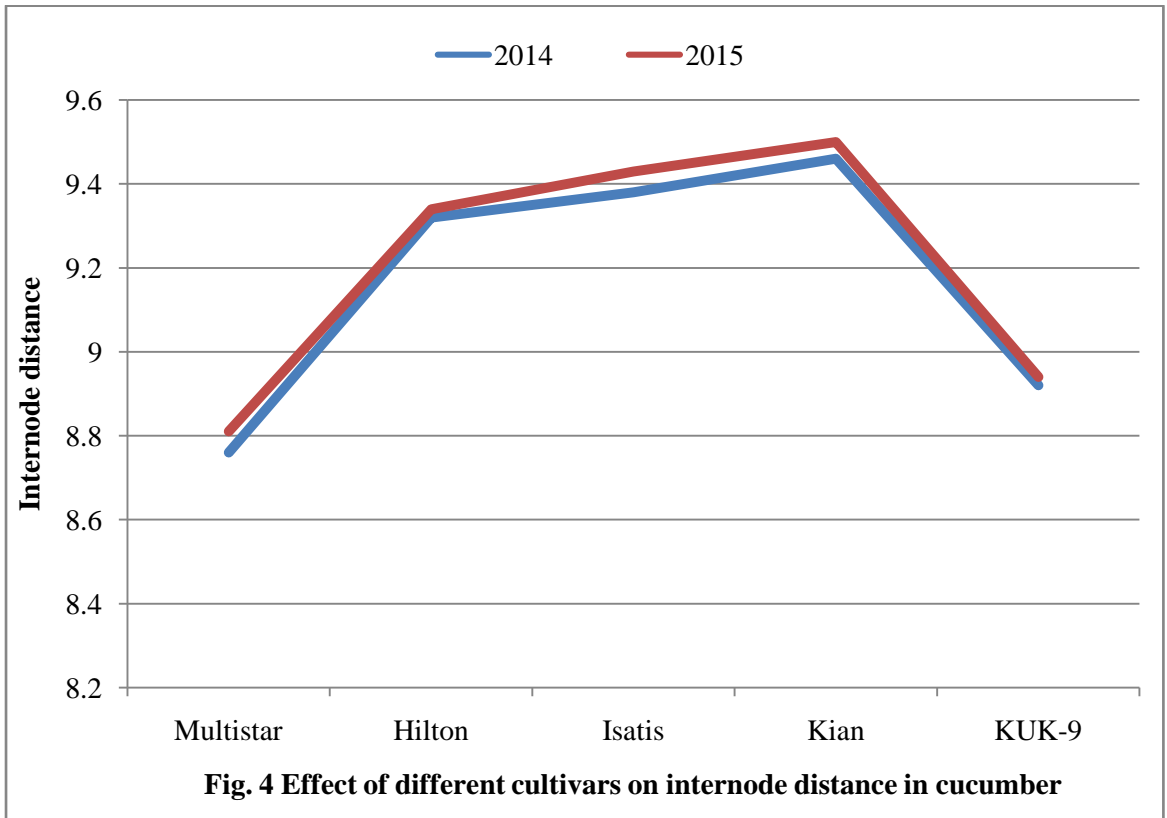
4.1.2 Internode distance (cm)

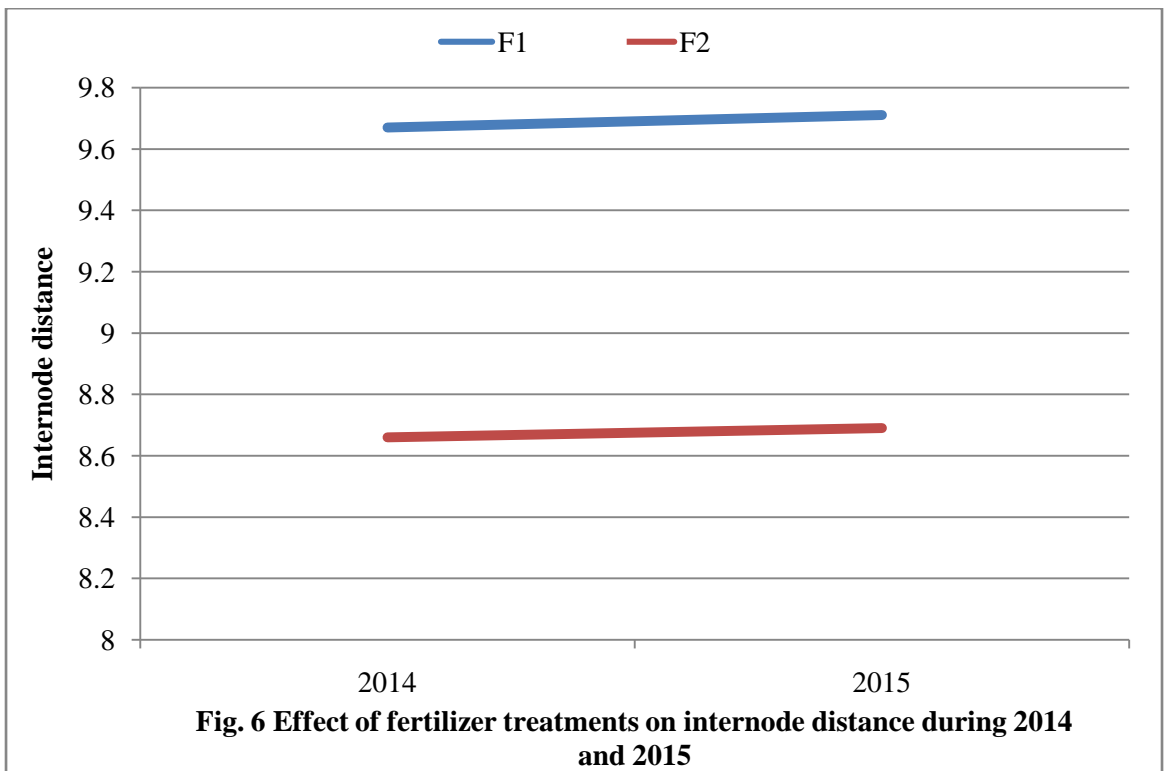
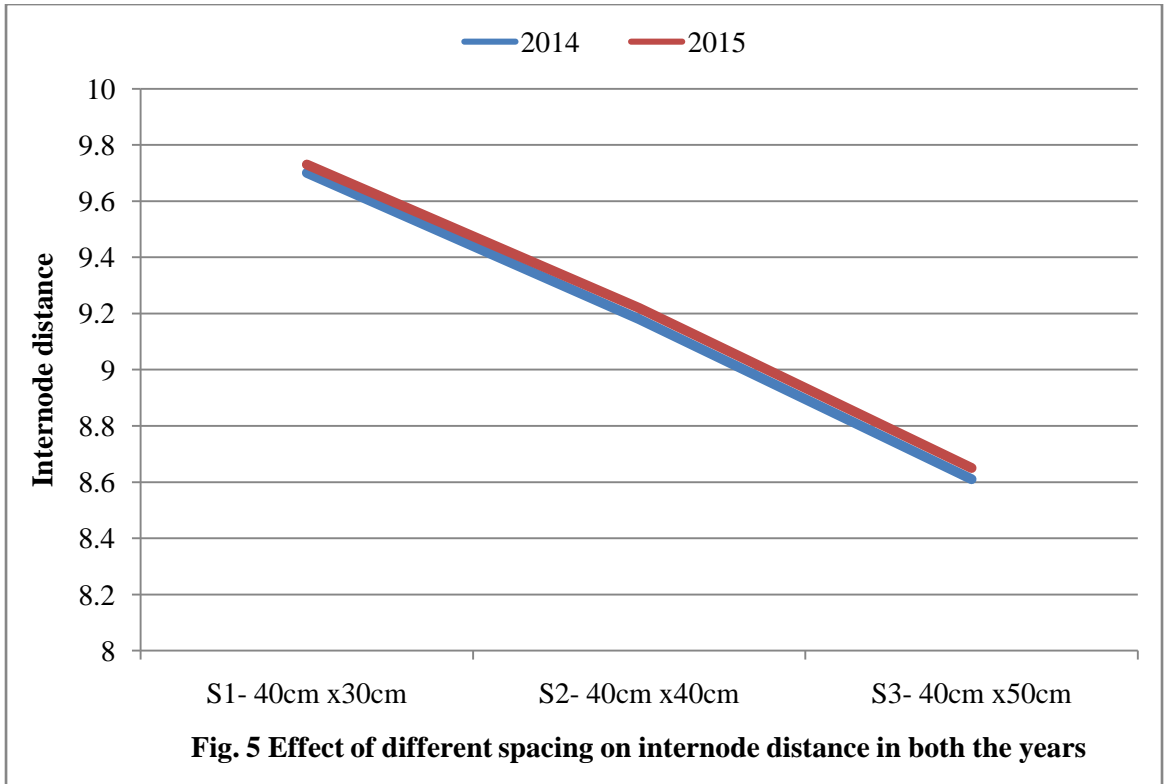
The internode distance in cucumber plant was influenced by cultivars, spacing and fertilizer treatments is presented in Table 1. This parameter plays a vital role in the number of branches and flower appearance because branches and flowers emergence was near to node. Internode distance also signifies the number of nodes/plant and determines the plant height. The parthenocarpic cucumber cultivars bear fruits at almost every node. Therefore, plants with less internode distance produce higher number of nodes/plant which are desirable to get higher fruit yield. The different cucumber cultivars had significant effect on internode distance. During 2014, significantly lesser internode distance was recorded in Multistar (8.76 cm) followed by KUK-9 (8.92 cm) as compared to Hilton (9.32 cm), Isatis (9.38 cm) and Kian (9.46 cm). Similar trend was also found during 2015; however, Hilton, Isatis and KUK-9 cultivars were statistically at par with each other, it might be due to the varietal characteristics of each cultivar. These results were similar to the studies of Kumar *et al* 2008; Umeh and Onovo (2015) and Chinnatu (2017).

Table 1: No. of branches and internode distance as influenced by different treatments.

Treatments	No. of branches		Internode distance (cm)	
	I st Year	II nd Year	I st Year	II nd Year
Cultivars				
V ₁ -Multistar	9.29	9.54	8.76	8.81
V ₂ -Hilton	8.35	9.05	9.32	9.34
V ₃ -Isatis	7.78	8.11	9.38	9.43
V ₄ -Kian	7.43	8.06	9.46	9.50
V ₅ -KUK-9	8.66	9.56	8.92	8.94
C.D at 5 %	0.44	0.45	0.52	0.49
Spacing				
S ₁ - 40cm x 30cm	7.72	8.19	9.70	9.73
S ₂ - 40cm x 40cm	8.37	8.87	9.18	9.22
S ₃ - 40cm x 50cm	8.81	9.53	8.61	8.65
C.D at 5%	0.34	0.35	0.40	0.38
Fertilizer				
F1-70:40:90 Kg of NPK per acre	7.85	8.40	9.67	9.71
F2-100:50:125 Kg of NPK per acre	8.75	9.32	8.66	8.69
C.D at 5%	0.28	0.29	0.33	0.31
Interaction (C.D at 5%)				
Vx _F	0.62	0.64	NS	NS
Sx _F	0.48	0.50	NS	NS

Plant spacing between row to row and plant to plant also had significant effect on the internode distance. It is confirmed from Table 1 that wider spacing (40 cm x 50 cm) resulted in shorter internode distance (8.6 cm and 8.65 cm) over the rest of the spacing treatments during both the years. Plants spaced at 40 cm x 40 cm also significantly had smaller internode distance (9.18 cm and 9.22 cm) as compared to 40 cm x 30 cm (9.70 cm and 9.73 cm). Similar findings were also reported by Cook *et al* (1991) and M. Kasrawi (1989).



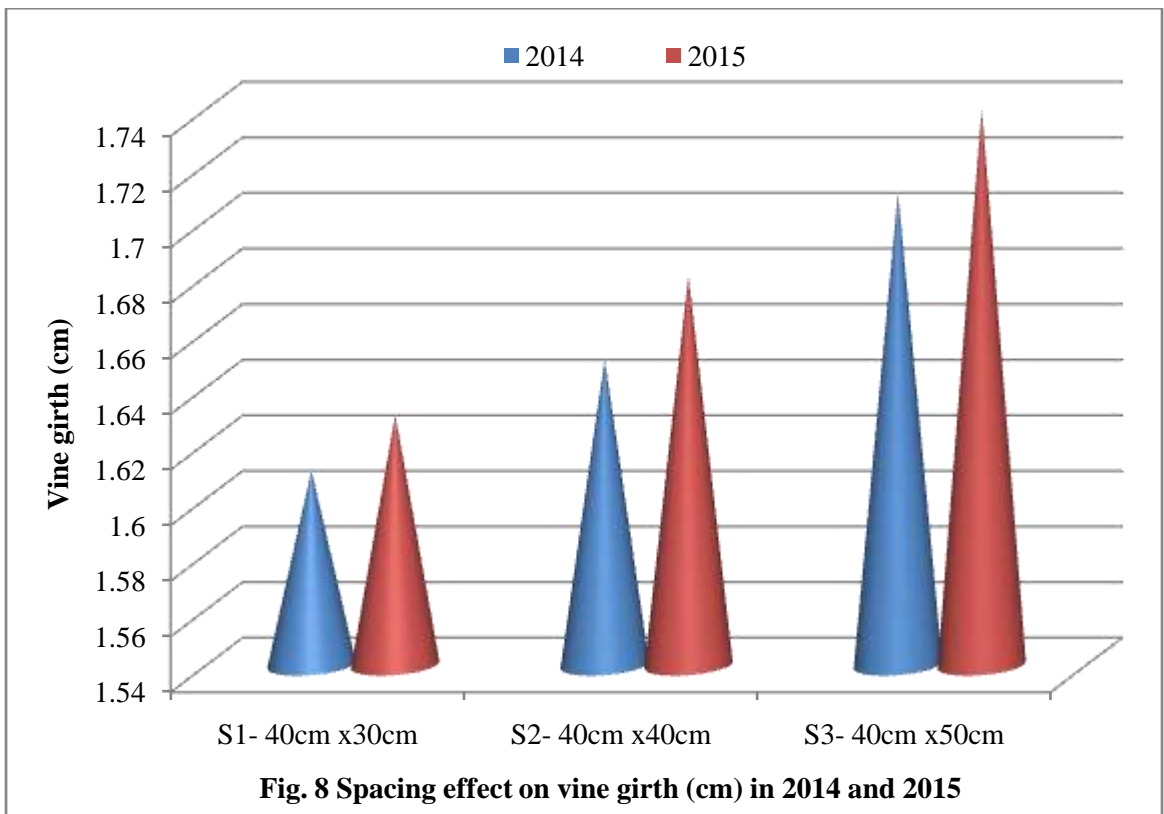
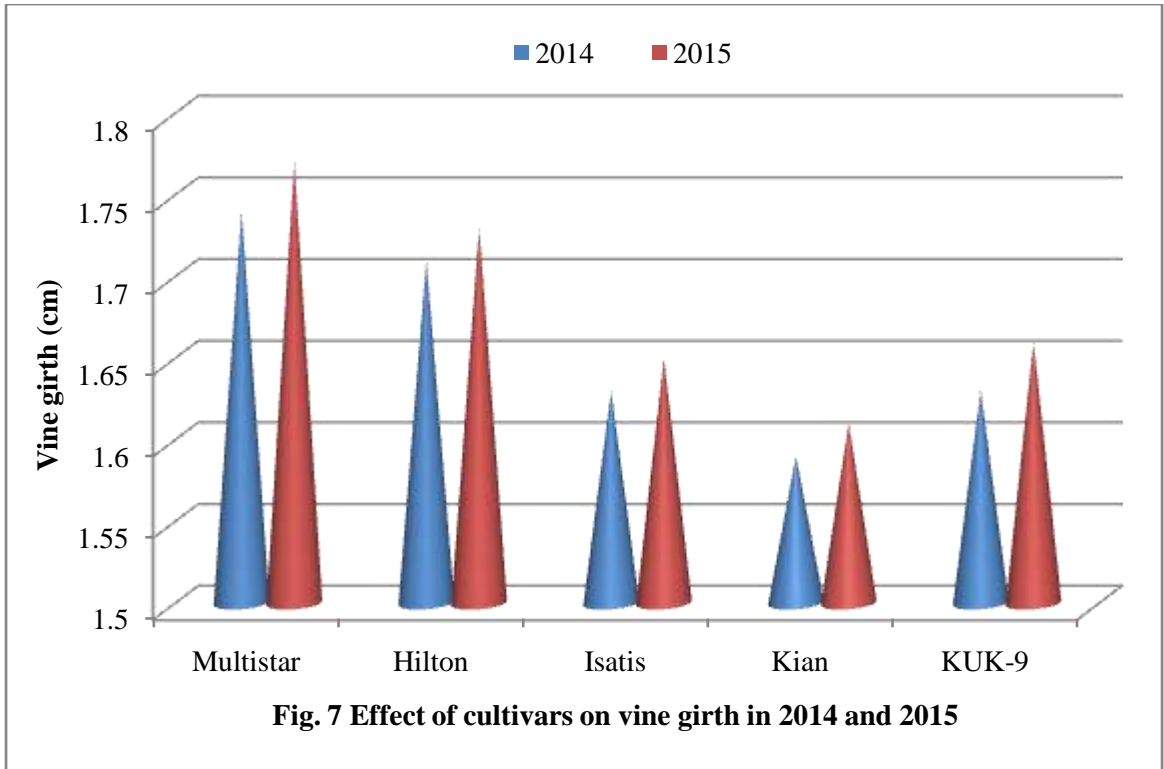


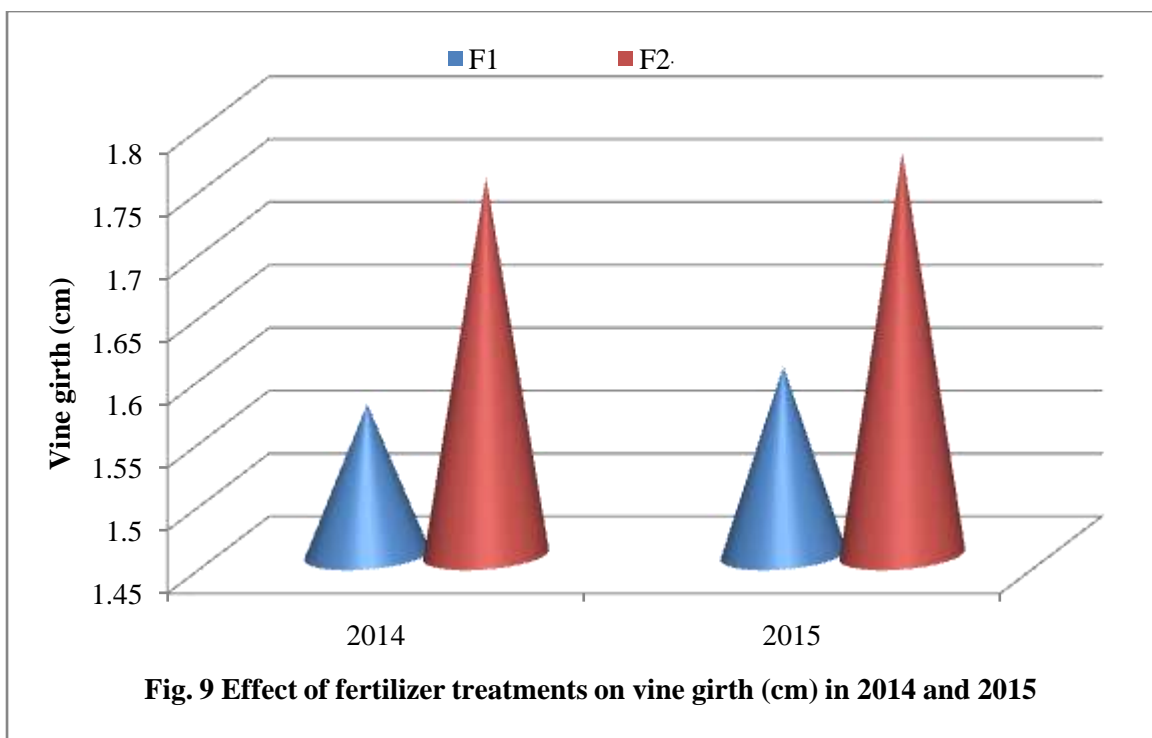
The effect of different fertilizer treatments also showed statistically significant effect on internode distance and treatment (F2) 100:50:125 Kg of NPK per acre produced significantly shorter internode distance (8.66 cm and 8.69 cm) over treatment (F1) 70:40:90 Kg of NPK per acre (9.67 cm and 9.71cm) during 2014 and 2015, respectively. Similar findings were also reported by Lakshmi (1997) and Sharma *et al* (2011).

Interaction effects between cultivars, spacing and fertilizer treatments were found statistically non-significant with each other.

4.1.3 Vine girth

Mean vine girth at physiological maturity of crop was influenced by different cultivars, plant spacing and fertilizer doses as presented in Table 2. It is pertinent to mention that vine girth was significantly influenced by cultivars (Table 2); being maximum in Multistar cultivar (1.74 cm and 1.77 cm) which was statistically at par with cultivar Hilton (1.71 cm and 1.73 cm), Isatis (1.63 cm and 1.65 cm) and KUK-9 (1.63 cm and 1.66 cm) during both the years. The variation might be due to genetic make up of the cultivar. Similar findings were also earlier reported by Kumar *et al* (2008) and Rawat *et al* (2014).





The vine girth also increased significantly when plants were planted at different spacing, out of which the maximum vine girth was recorded at the wider spacing of 40 cm x 50 cm (1.71 cm and 1.74 cm), followed by 40 cm x 40 cm (1.65 cm and 1.67 cm) and 40 cm x 30 cm (1.61 cm and 1.63 cm) in both years of investigation; however, 40 cm x 30 cm (S1) and 40 cm x 40 cm (S2) were statistically at par with each other. The vine girth is more at wider spacing this might be due to availability of more space for plant growth, proper moisture, nutrients and less competition for light, air and water. Similarly trend was also observed by Khalid (2010).

Table 2: Vine length and vine girth as influenced by different treatments.

Treatments	Vine girth (cm)		Vine length (m)	
	I st Year	II nd Year	I st Year	II nd Year
Cultivars				
V ₁ -Multistar	1.74	1.77	3.63	3.69
V ₂ -Hilton	1.71	1.73	3.41	3.45
V ₃ -Isatis	1.63	1.65	3.14	3.19
V ₄ -Kian	1.59	1.61	2.81	2.85
V ₅ -KUK-9	1.63	1.66	3.31	4.11
C.D at 5 %	0.11	0.29	0.20	0.22

Spacing				
S ₁ - 40cm x 30cm	1.61	1.63	3.15	3.34
S ₂ - 40cm x 40cm	1.65	1.67	3.24	3.44
S ₃ - 40cm x 50cm	1.71	1.74	3.39	3.59
C.D at 5%	0.05	0.05	0.15	0.17
Fertilizer				
F1-70:40:90 Kg of NPK per acre	1.57	1.60	3.12	3.32
F2-100:50:125 Kg of NPK per acre	1.75	1.77	3.39	3.59
C.D at 5%	0.15	0.11	0.13	0.14
Interaction (C.D at 5%)				
VxF	0.15	0.11	0.29	0.32
SxF	0.12	0.32	0.22	0.24
VxSxF	0.02	0.15	0.50	0.55

Fertilizer treatments also showed significant effect on vine girth (cm) during the study. Treatment (F2) 100:50:125 Kg of NPK per acre recorded significantly maximum vine girth (1.75 cm and 1.77 cm) in comparison to treatment (F1) 70:40:90 Kg of NPK per acre (1.57 cm and 1.60 cm) during both the years of study. Interaction effect between cultivars, spacing and fertilizer treatments was found to be significant. Results obtained are in line with the findings of Tiwari *et al* (2013).

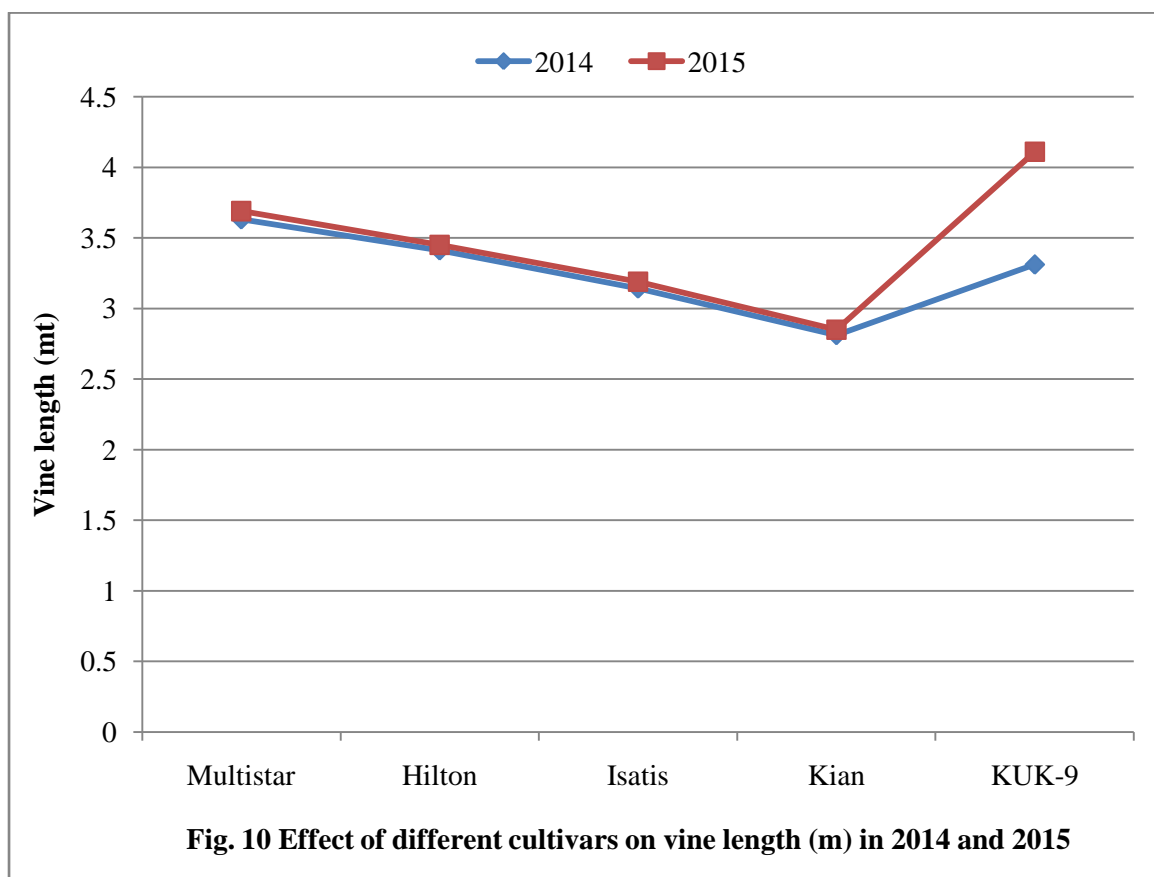
4.1.4 Vine length (m)

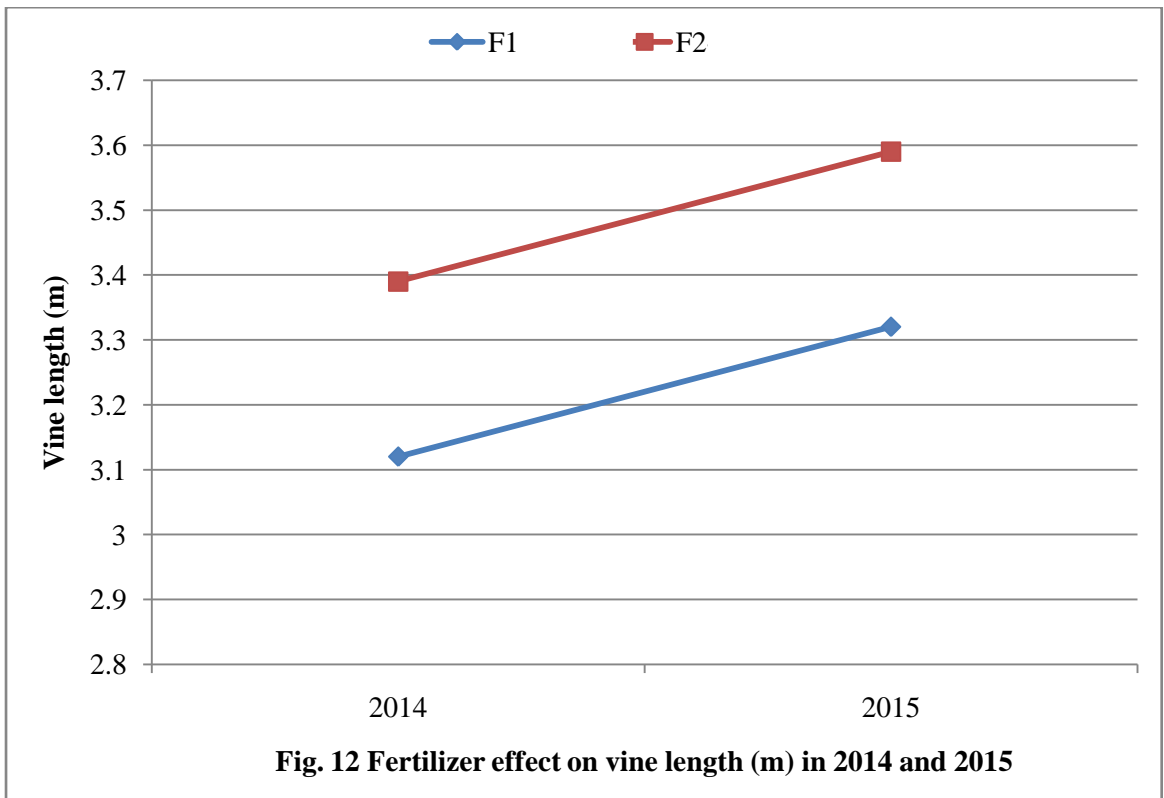
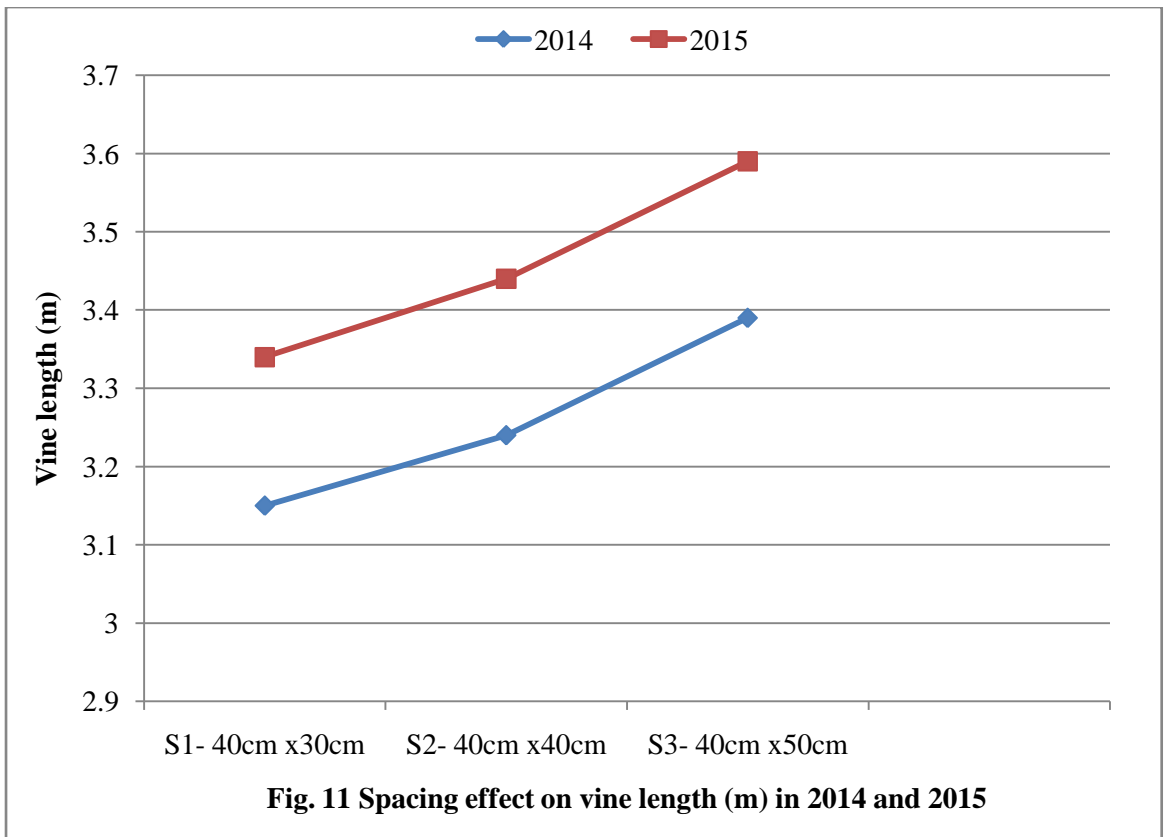
It is cleared that vine length at the final fruit harvest was influenced by different treatments viz. cultivars, spacings and fertilizers (Table 2).

Significantly maximum vine length was recorded in cultivar Multistar (3.63 m) in 2014 whereas in 2015 maximum vine length was recorded in cultivar KUK-9 (4.11 m) as compared to other cultivars such as Hilton (3.41 m and 3.45 m), Isatis (3.14 m and 3.19 m), Kian (2.81 m and 2.85 m) in both the years of investigation. This maximum vine length in Multistar cultivar as compared to other cultivars might be due to genetic potential of cultivar, wider spacing and availability of macro nutrients through fertigation. Similar findings earlier reported by Solanki and Seth (1980); Sanjeev *et al* (2017) and Kumar *et al* (2017).

Plant spacing also had the significant effect on vine length and it was recorded maximum at spacing of 40 cm x 50 cm (3.39 m and 3.59 m) as compared to rest of the spacing treatments but statistically at par with the spacing of 40 cm x 40 cm (3.24 m and 3.44 m) during 2014 and 2015, respectively. Similarly, spacing of 40 cm x 40 cm was statistically at par with 40 cm x 30 cm during both the years. This might be due to the availability of more space for growth. Similar observations were also reported by Shaheen *et al* (2007).

Maximum vine length (3.39 m and 3.59 m) was observed when fertilizer dose of 100:50:125 (F2) of NPK was applied over (F1) 70:40:90 Kg of NPK (3.12 m and 3.32 m) during both the years of study. Interaction effects were found to be significant during both the years. During the study it has been observed that vegetative growth was more at higher doses of NPK which resulted maximum vine length. Similarly findings were also confirmed by Choudhari and More (2002) and Veesar (2004) also reported significant increase in vine length with fertigation technique at higher doses of fertilizers.





4.2 Flowering Parameters:

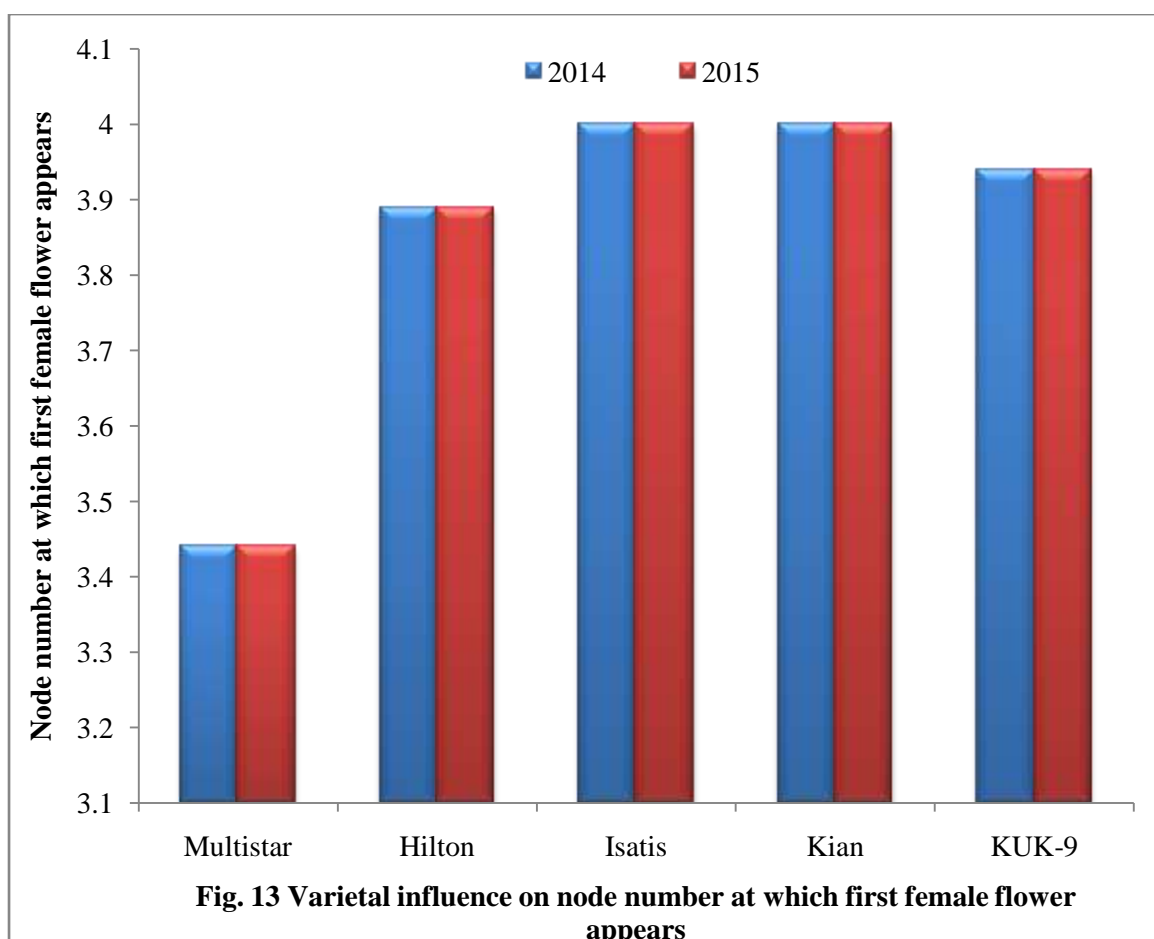
4.2.1 Node number at which first female flower appears and days to first female flower

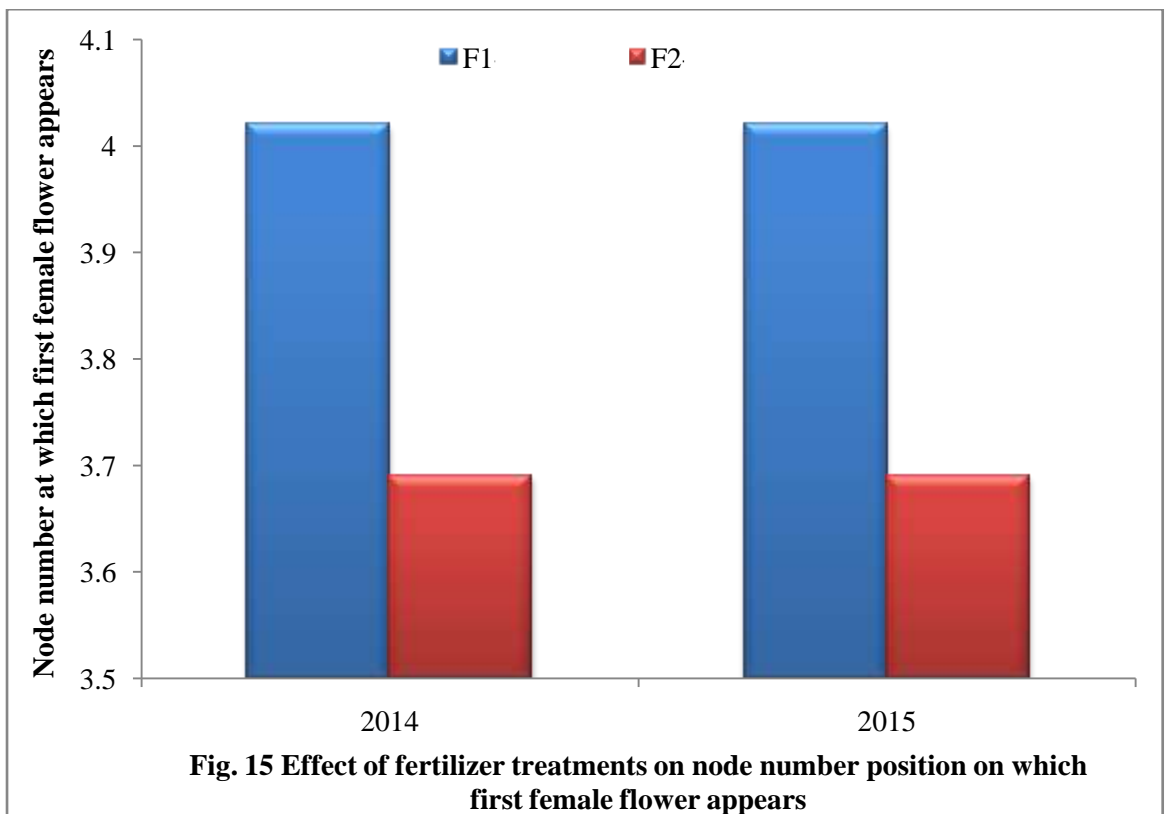
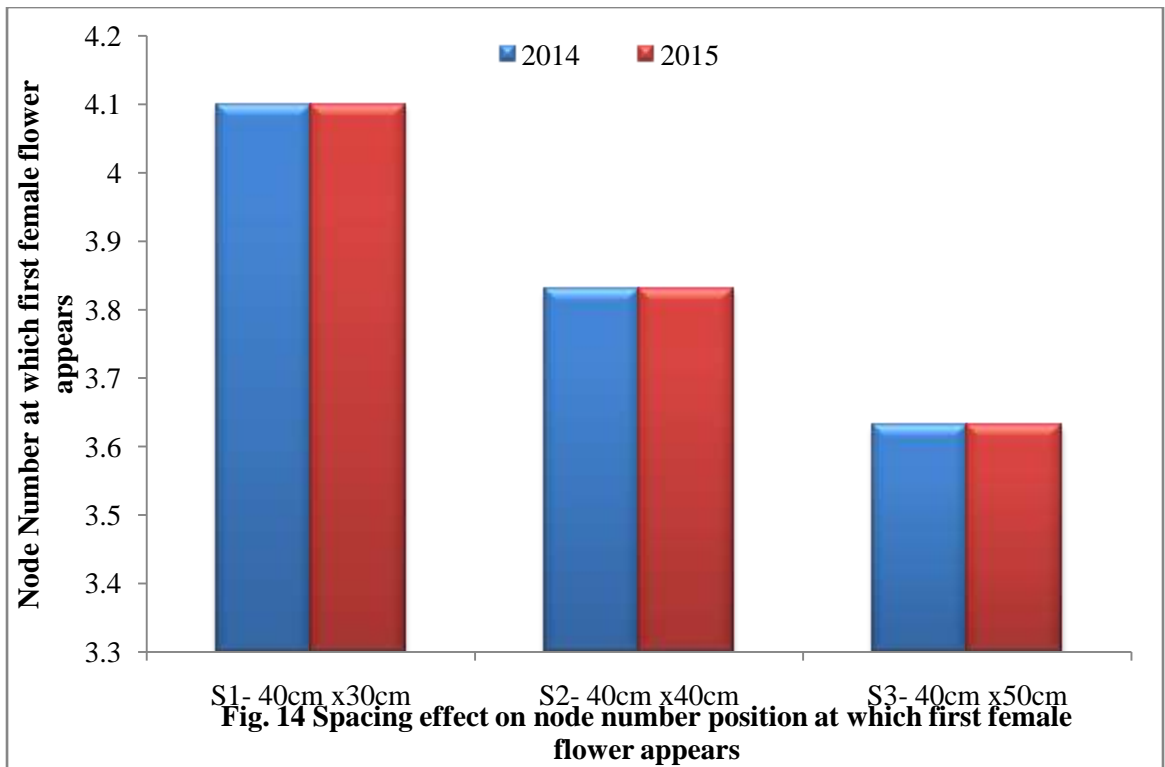
Node number at which first female flower appears is influenced by different treatments are presented in table 3. Node number at which first female flower appears is an important character and an indicator of getting early and more yield of cucumber grown under different treatments.

Table 3: Node number at which first female flower appears and days to first female flower as influenced by different treatments.

Treatments	Node number at which first female flower appears		Days to first female flower	
	I st Year	II nd Year	I st Year	II nd Year
Cultivars				
V ₁ -Multistar	4.00	4.07	27.38	27.33
V ₂ -Hilton	3.94	4.03	28.61	28.38
V ₃ -Isatis	3.89	3.90	29.77	29.72
V ₄ -Kian	3.44	3.50	30.83	30.88
V ₅ -KUK-9	4.00	4.12	29.22	29.27
C.D at 5 %	0.10	0.13	0.36	0.36
Spacing				
S ₁ - 40cm x 30cm	3.63	3.70	29.30	29.13
S ₂ - 40cm x 40cm	3.83	3.90	29.03	29.13
S ₃ - 40cm x 50cm	4.10	4.17	29.16	29.10
C.D at 5%	0.21	0.15	NS	NS
Fertilizer				
F1-70:40:90 Kg of NPK per acre	3.70	3.76	29.06	29.13
F2-100:50:125 Kg of NPK per acre	4.00	4.08	29.26	29.11
C.D at 5%	0.17	0.12	NS	NS
Interaction (C.D at 5%)				
Vx _F	NS	NS	NS	NS
Sx _F	NS	NS	NS	NS

The perusal of data in Table 3 depict that cucumber cultivars produced first female flower was varied in term of position of node. Cultivar Kian recorded better position of node number at which first female flower appears (3.44 and 3.50) followed by Isatis (3.89 and 3.90), Hilton (3.94 and 4.03), Multistar (4.0 and 4.07) and KUK-9 (4.0 and 4.12) during both the years. However, Multistar, KUK-9, Hilton were statistically at par with each other in both the years of study. Such variation of nodes of female flower appearance in different cultivars is due to genetic constitution of different cultivars. Similar findings were also reported by Yadav *et al* (2012); Lajurakar *et al* (2015) reported that appearance of first female flower at early node is a good character in cucumber. Earliness and lateness of the crop production depends upon the days taken to appearance of first female flower. This might be due to genetic property of the cultivars as the environment conditions were same. Multistar took lesser days (27.38 and 27.33) to first female flower appearance during both the years whereas cultivar Kian took maximum number of days (30.83 and 30.88) to first female flower appearance during both the years. Influence of spacing and Fertilizer treatments showed no variability with respect to days to first female flower appears.





The plants planted at different spacing had significantly affect on the position of node number at which first female flower appeared. The closer spacing of 40 cm x 30 cm

was observed to flower at node number 3.63 and 3.70 followed by spacing of 40 cm x 40 cm (3.83 and 3.90) and 40 cm x 50 cm (4.10 and 4.17) during 2014 and 2015, respectively. Whereas at wider spacing of 40 cm x 50 cm took lesser days to first female flower (29.16 and 29.10) followed by rest of the treatments. This might be due to availability of good sunshine and nutrients in the soil as the results more accumulation of photosynthates and induction of early flowering in comparison to close spacings were noted. The results are corroborated with the findings of El-Aidy (1991) and Dobrzanska *et al* (1998).

The plants applied with fertilizer treatment (F2) 100:50:125 Kg of NPK per acre, significantly produced female flower at node number 4.0 and 4.08 during 2014 and 2015 respectively as compared to treatment (F1) 70:40:90 Kg of NPK per acre (3.70 and 3.76). So, treatment (F1) 70:40:90 Kg of NPK per acre was better over treatment (F2) 100:50:125 Kg of NPK per acre. The different interactions between various factors did not show significant impact on number of days taken to first female appearance in both the years. Umamaheswarappa *et al* (2005) also reported maximum number of female flower at higher dose of nitrogen.

4.3 Fruit Parameters:

4.3.1 Number of days to first Fruiting/picking

It is mentioned that number of days taken for first fruiting/picking in cucumber cultivars is presented in Table 4. The least days taken to first picking are beneficial for getting early yield in cucumber. The least days to number of days to first fruiting was taken by cultivar Multistar (35.61 and 35.11), followed by cultivar KUK-9 (36.78 and 37.28) over Hilton (36.78 and 36.28) and Isatis (37.89 and 38.39) in 2014 and 2015 respectively. Badgujar and More (2004) and Kumar *et al* (2017) also reported earliness in first picking in some cucumber cultivars.

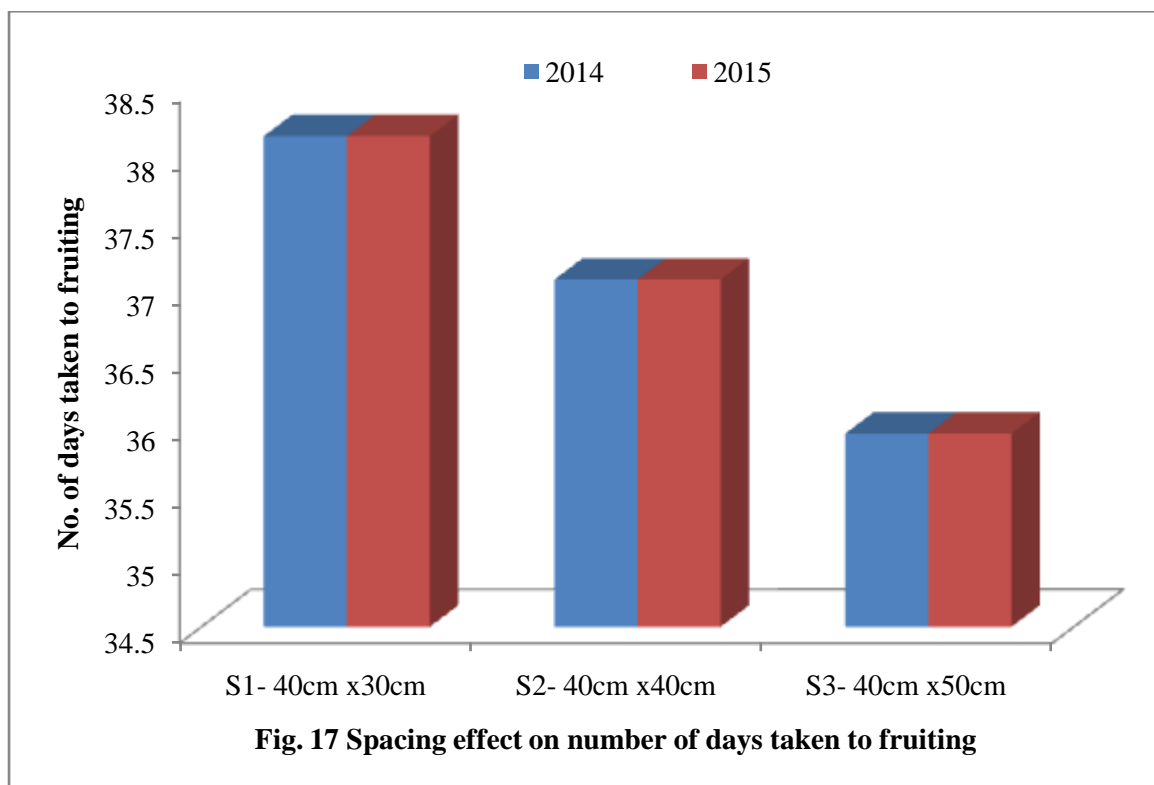
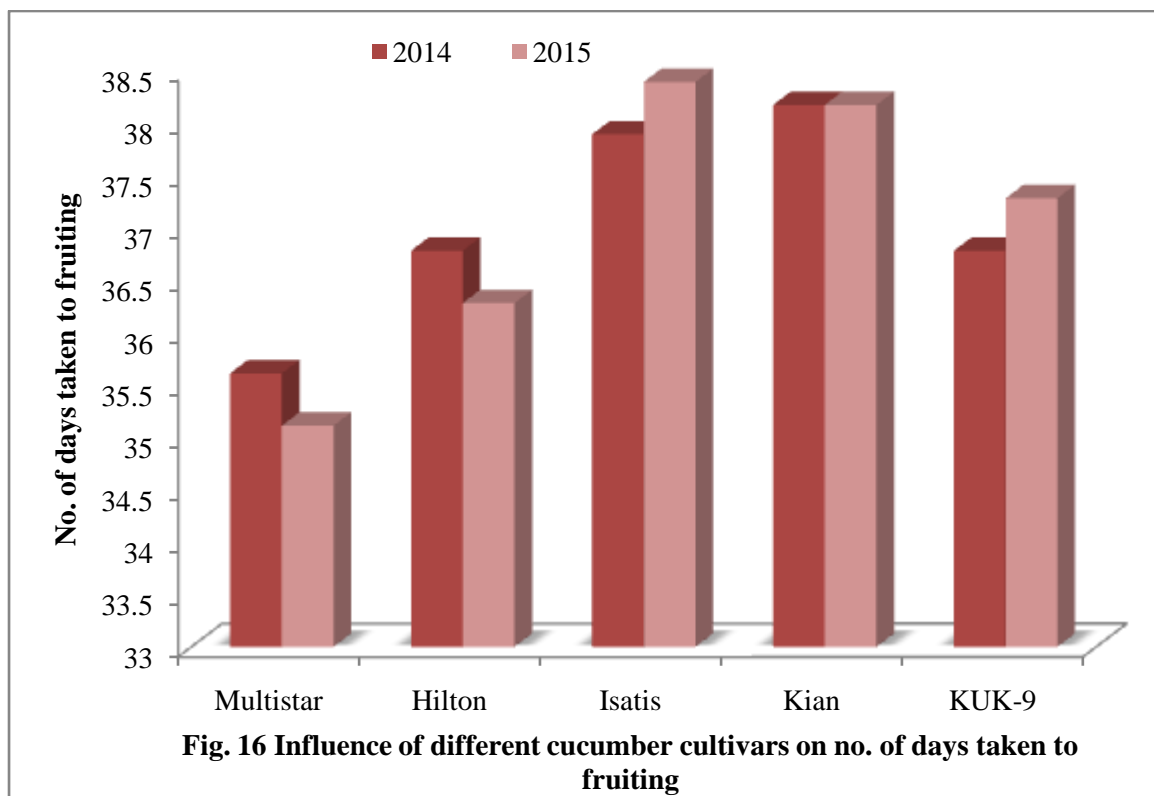
Among different plant spacing, 40 cm x 50 cm spacing showed significantly lesser number of days (35.93 and 35.93) to produce first fruit as compared to 40 cm x 30 cm (38.13 and 38.13) but spacing of 40 cm x 30 cm and 40 cm x 40 cm were statistically at par with each during both the years of the study. These results are in close conformity with the findings of Dobrzanska *et al* (1998).

Similarly, in treatment (F2) 100:50:125 Kg of NPK per acre, number of days taken for first fruit harvest was significantly less (35.98 and 36.38) as compared to treatment (F1) 70:40:90 Kg of NPK per acre (38.11 and 37.71) which took more number of days to first fruiting, respectively, during both the years of study. Similar results were reported by Tiwari *et al* (2013) and Waseem *et al* (2008).

Table 4: No. of days to first fruiting and fruit length as influenced by different treatments.

Treatments	Number of days to first fruiting		Fruit length (cm)	
	I st Year	II nd Year	I st Year	II nd Year
Cultivars				
V ₁ -Multistar	35.61	35.11	15.51	16.27
V ₂ -Hilton	36.78	36.28	14.58	14.81
V ₃ -Isatis	37.89	38.39	14.55	14.90
V ₄ -Kian	38.17	38.17	13.70	13.99
V ₅ -KUK-9	36.78	37.28	15.21	15.88
C.D at 5 %	1.81	1.86	0.84	0.93
Spacing				
S ₁ - 40cm x 30cm	38.13	38.13	14.17	14.63
S ₂ - 40cm x 40cm	37.07	37.07	14.77	15.23
S ₃ - 40cm x 50cm	35.93	35.93	15.20	15.66
C.D at 5%	1.40	1.44	0.65	0.72
Fertilizer				
F1-70:40:90 Kg of NPK per acre	38.11	37.71	13.84	14.30
F2-100:50:125 Kg of NPK per acre	35.98	36.38	15.58	16.04
C.D at 5%	1.15	1.18	0.53	0.59
Interaction (C.D at 5%)				
Vx _F	NS	NS	1.18	1.30
Sx _F	NS	NS	0.91	1.01
VxSx _F	NS	NS	2.05	2.26

The interaction effect was found to be non-significant between cultivars, plant spacing and fertilizer treatments during both the study years.



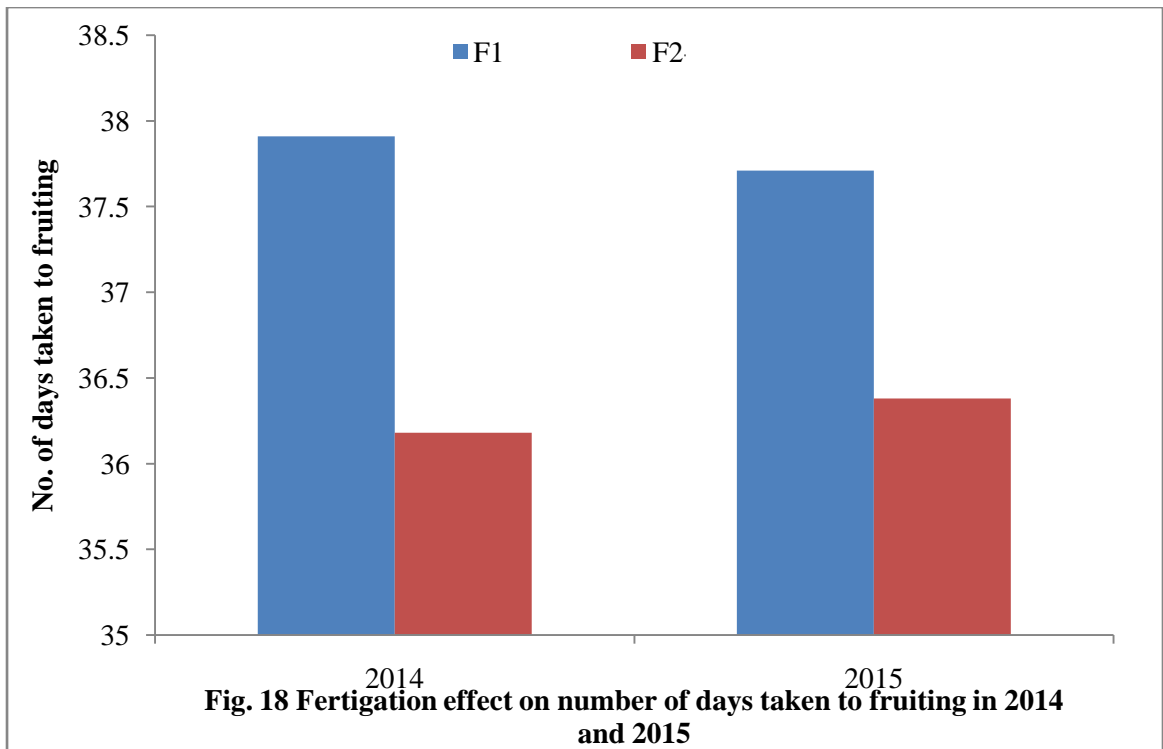


Fig. 18 Fertilization effect on number of days taken to fruiting in 2014 and 2015

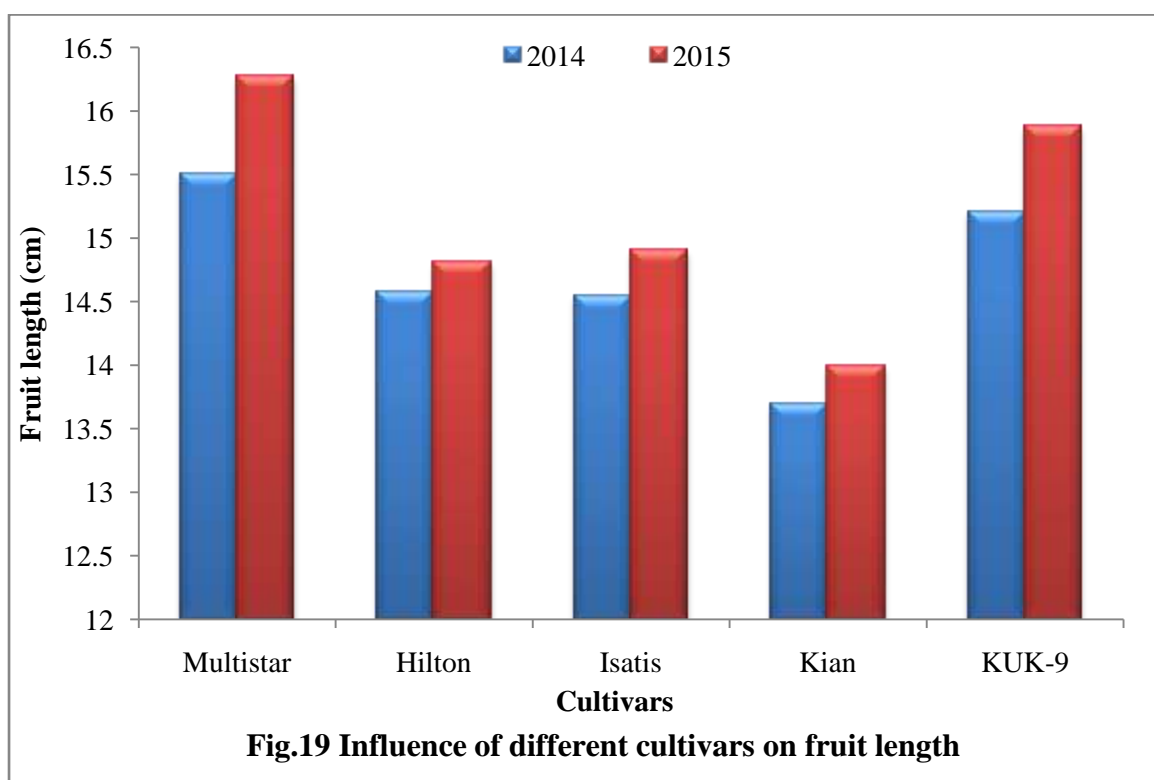
4.3.2 Fruit length (cm)

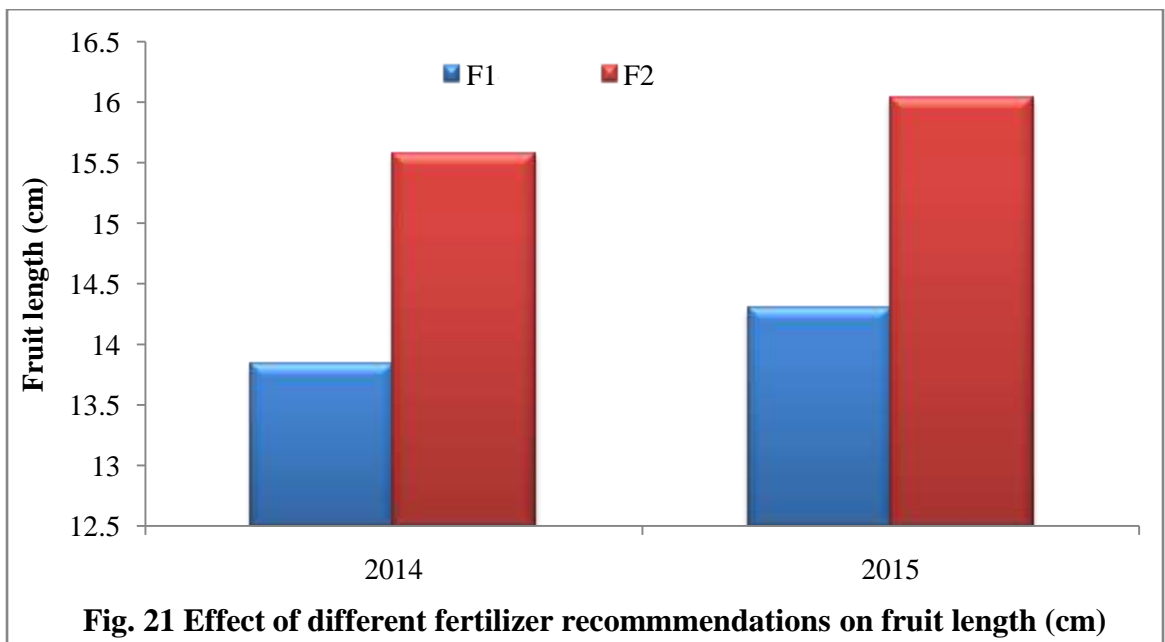
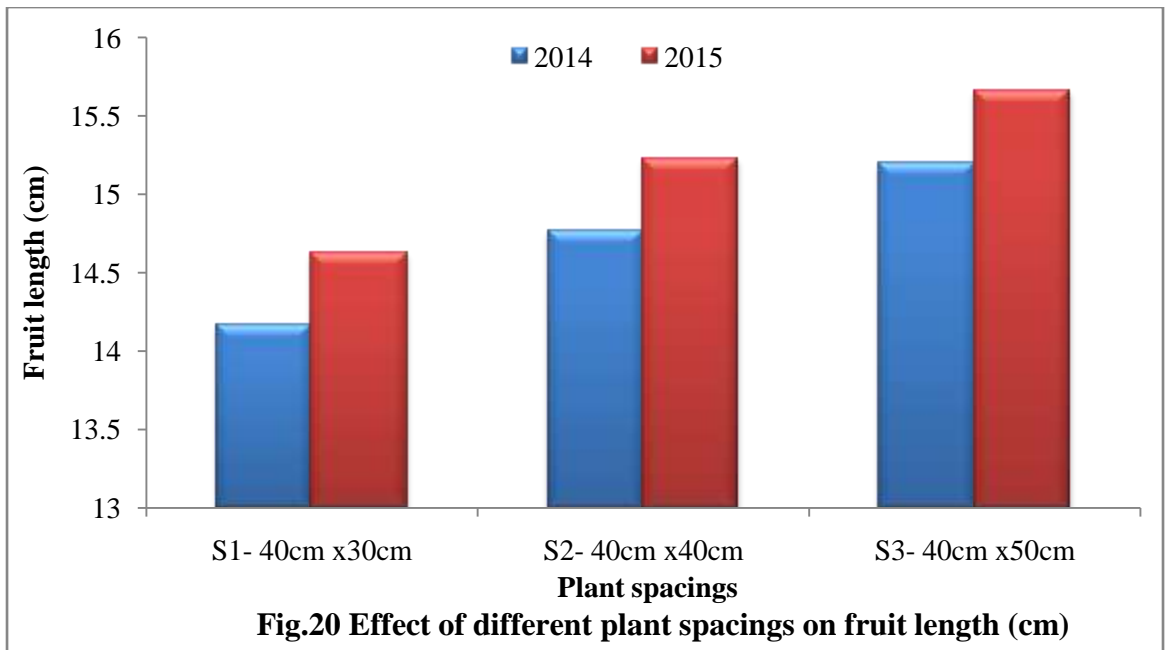
Fruit length is another important character in cucumber crop which is considered a crucial component that markedly effected the fruit yield. Fruit length as affected by different treatments is presented in Table 4. Maximum fruit length was recorded in cultivar Multistar (15.51 cm and 16.27 cm) which was significantly higher than Hilton (14.58 cm and 14.81 cm), Isatis (14.55 cm and 14.90 cm), Kian (13.70 cm and 13.99 cm) and was statistically at par with cultivar KUK-9 (15.21 cm and 15.88 cm) during both the years of experiment. Similarly, cultivar Kian, Isatis and Hilton were statistically at par with each other and cultivars Multistar and KUK-9 were also statistically at par with each other. These results are in line with the findings of Hochmuth *et al* (1996); Patel *et al* (2013) and Monisha *et al* (2014) reported significant variation in fruit length among different cucumber hybrids.

Maximum fruit length of 15.20 cm and 15.66 cm was recorded in plant spacing of 40 cm x 50 cm (S₃); followed by 14.77 cm and 15.23 cm in plant spacing of 40 cm x 40 cm (S₂) and 14.17 cm and 14.63 cm in 40 cm x 30 cm (S₁) of during 2014 and 2015, respectively. Whereas, S₁ and S₂ spacings were statistically at par with each other during both the years. These results are in conformity with the findings of Serquen *et*

al (1997) and Sharma and Sharma (2015) who also reported an enhancement in fruit length with the increased in plant to plant spacing distance.

The plants applied with different fertilizer treatments also significantly influenced fruit length during both the years (Table 4). Treatment (F2) 100:50:125 Kg of NPK per acre produced significantly more fruit length (15.58 cm and 16.04 cm) as compared to treatment (F1) 70:40:90 Kg of NPK per acre (13.84 cm and 14.30 cm) during both the years of experimentation. From the data it is revealed that higher the fertilizer dose, more will be the fruit length. Similar results were recorded by Surve *et al* (2002); Ahmed *et al.*(2007); Jilani *et al* (2009) and Arshad *et al* (2014) who reported higher fruit length in cucumber at higher doses of NPK.





The interaction effect was found to be significant between all the factors during both the years of experiment.

Table 5: Interaction effect for fruit length between cultivar and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	13.51	14.27	17.50	18.24	15.51	16.27
V ₂ - Hilton	13.94	14.17	15.23	15.46	14.58	14.81
V ₃ - Isatis	14.08	14.43	15.03	15.38	14.55	14.90
V ₄ - Kian	13.00	13.29	14.39	14.68	13.70	13.99
V ₅ - KUK-9	14.67	15.34	15.76	16.43	15.21	15.88
Mean for F	13.84	14.30	15.58	16.04	CD at 5% 1 st yr = 1.18 2 nd yr = 1.30	

Maximum fruit length was found in treatment combination of V₁F₂ (17.50 cm in 2014 and 18.24 cm in 2015) which was significantly higher as compared to rest of the combinations. The least value of fruit length was found in combination of V₄F₁ i.e. (13.00 cm and 13.29 cm) during both the years of study. These results are in line with the findings of Waseem *et al* (2008).

Table 6: Interaction effect for fruit length between spacing and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
S ₁ (40 cm x 30 cm)	12.63	13.09	15.70	16.14	14.17	14.63
S ₂ (40 cm x 40 cm)	14.26	14.72	15.28	15.74	14.77	15.23
S ₃ (40 cm x 50 cm)	14.63	15.09	15.77	16.23	15.20	15.66
Mean for F	13.84	14.30	15.58	16.04	CD at 5% 1 st yr = 0.19 2 nd yr = 0.07	

The interactions of S x F combinations had shown significantly effect on fruit length and it was improved at higher spacing and fertilizer doses. Maximum was found in S₃F₂ (15.77 cm in 2014 and 16.23 cm in 2015) which was significantly higher than rest of the combinations. Minimum fruit length was recorded in S₁F₁ (12.63 cm and 13.09 cm) during both the years.

Table 7: Interaction effect for fruit length among cultivar, plant spacing and fertilizer treatments

Factors	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)	
	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ S ₁	9.72	10.48	22.27	20.97
V ₁ S ₂	15.48	16.24	15.88	16.64
V ₁ S ₃	15.34	16.10	16.36	17.12
V ₂ S ₁	13.32	13.55	14.73	14.96
V ₂ S ₂	13.99	14.22	15.32	15.55
V ₂ S ₃	14.49	14.72	15.65	15.88
V ₃ S ₁	13.70	14.05	14.24	14.59
V ₃ S ₂	14.02	14.37	15.13	15.48
V ₃ S ₃	14.51	14.86	15.71	16.06
V ₄ S ₁	12.32	12.61	13.93	14.22
V ₄ S ₂	13.01	13.30	14.34	14.63
V ₄ S ₃	13.69	13.98	14.90	15.19
V ₅ S ₁	14.12	14.79	15.31	15.98
V ₅ S ₂	14.77	15.44	15.74	16.41
V ₅ S ₃	15.11	15.78	16.23	16.90
Mean of F	13.84	14.30	15.58	16.04
CD at 5% = 2.05 (1 st yr) and 2.26 (2 nd yr)				

The interaction among cultivar, spacing and fertilizers (V x S x F) had significant influenced on fruit length in all the treatment combinations. The maximum fruit length was found in treatment combination of V₁S₁F₂ i.e. (22.27 cm and 20.97 cm) and the minimum in V₁S₁F₁ (9.72 cm and 10.48 cm) during both the years of experimentation.

4.3.3 Number of Fruits per vine

The emphasis is given to select the cultivar having higher fruit yield potential and also possess higher photosynthates assimilation by the plants during the growth period and the data on fruit per vine is presented in Table 8. Maximum fruit number per vine was recorded in Multistar cultivar (43.0 and 44.5) followed by KUK-9 (41.61 and 42.74), Hilton (40.67 and 41.45), Isatis (37.50 and 38.35) and Kian (36.50 and 37.06).

Multistar and KUK-9; Isatis and Kian in 2014 and in 2015 Isatis and Kian; Hilton and KUK-9 were statistically non significant with each other. More number of fruits per vine and comparatively better performance of cultivar Multistar over other cultivars could be ascribed to its better performance . These results are in close conformity with Lebedeva and Turlakova 1985; Mohamedien *et al* (1993); Saikia *et al.* (2001) and Kumar *et al* (2017).

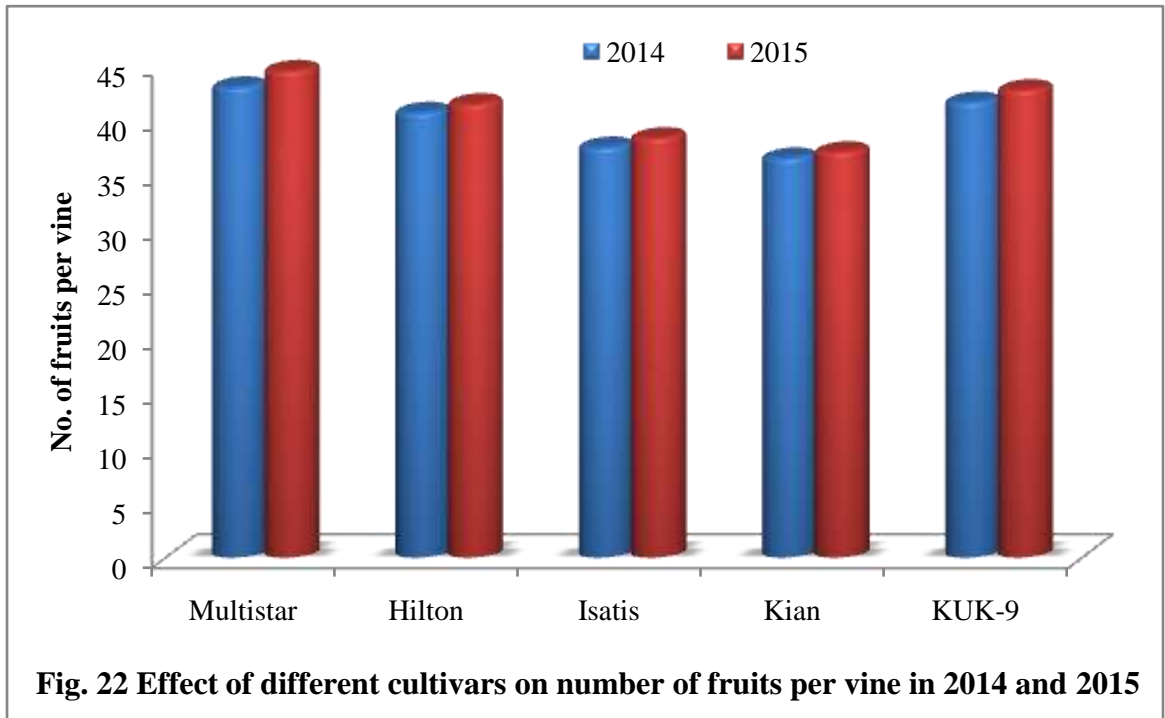


Fig. 22 Effect of different cultivars on number of fruits per vine in 2014 and 2015

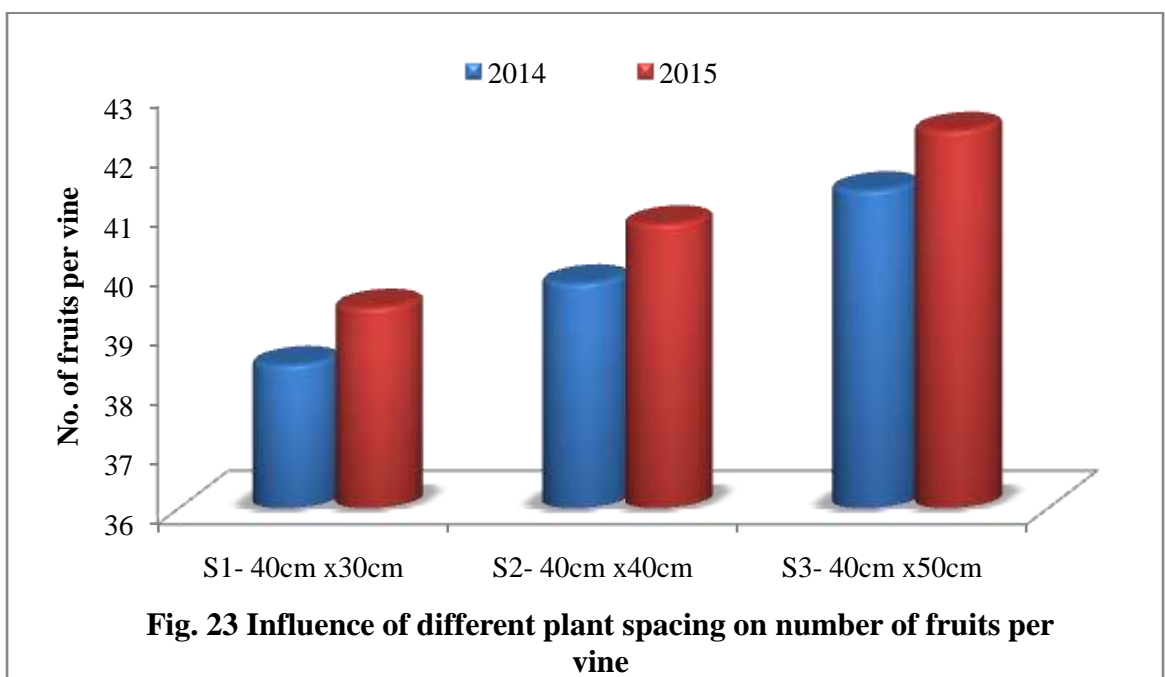


Fig. 23 Influence of different plant spacing on number of fruits per vine

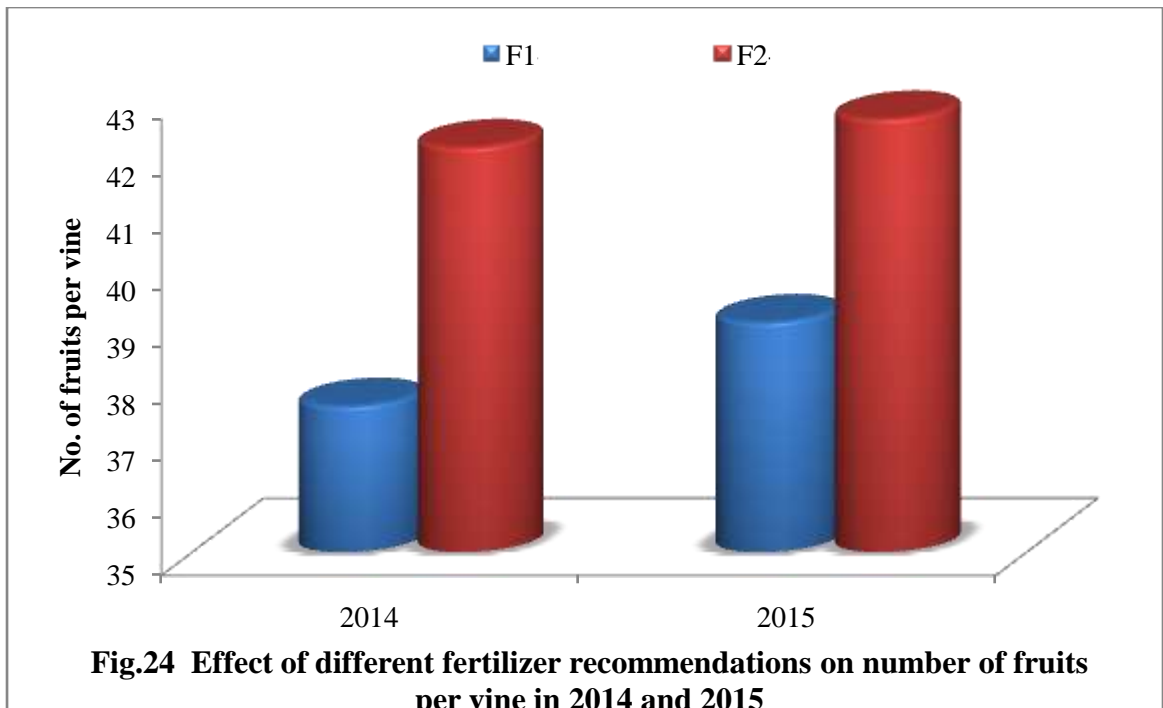


Table 8: No. of fruits per vine and fruit weight as influenced by different treatments.

Treatments	Number of Fruits per vine		Fruit weight (g)	
	I st Year	II nd Year	I st Year	II nd Year
Cultivars				
V ₁ -Multistar	43.00	44.50	117.08	118.65
V ₂ -Hilton	40.67	41.45	108.29	109.72
V ₃ -Isatis	37.50	38.35	107.32	108.71
V ₄ -Kian	36.50	37.06	100.97	102.99
V ₅ -KUK-9	41.61	42.74	108.33	109.22
C.D at 5 %	2.04	1.85	4.79	4.98
Spacing				
S ₁ - 40cm x 30cm	38.40	39.36	105.72	107.18
S ₂ - 40cm x 40cm	39.77	40.76	108.52	109.98
S ₃ - 40cm x 50cm	41.33	42.33	110.95	112.41
C.D at 5%	1.58	1.43	3.71	3.86
Fertilizer				
F1-70:40:90 Kg of NPK per acre	37.56	39.03	104.84	106.30
F2-100:50:125 Kg of NPK per acre	42.10	42.60	111.95	113.41

C.D at 5%	1.29	1.17	3.03	3.15
Interaction (C.D at 5%)				
VxF	2.88	2.61	6.77	7.04
SxF	2.23	2.02	5.25	5.45
VxSxF	5.00	4.53	11.74	12.19

The plants spaced at treatment S₃ (40 cm x 50 cm) recorded significantly maximum number of fruits per vine (41.33 and 42.33) in comparison to treatment S₂ (40 cm x 40 cm) (39.77 and 40.76) and treatment S₁ (40 cm x 30 cm) (38.40 and 39.36) during 2014 and 2015, respectively might be due to less competition for light, more nutrients, right amount of water and optimum space in wider row spacing as compared to closer spacing. Similar results were also reported by More *et al* (1990); Quian (2000) and Oga and Umekwe (2015) to get more number of fruits per vine at wider spacing.

The fertilizer treatments also showed significant effect on number of fruit per vine which is presented in Table 8. Treatment F2 (100:50:125) of NPK per acre gave significantly more number of fruits per vine (42.10 and 42.60) as compared to treatment F1 (70:40:90) of NPK per acre having 37.56 and 39.03 number of fruits per vine during both the years. This might be due to the application of right amount of fertilizers that boost up the growth of cucumber. Similar results were also reported by Choudhari and More (2002); Veesar (2004); Surve *et al* (2002) and Sharma *et al* (2011). The interaction effect was found to be significant during both the years of experiment.

The interaction effect was found to be significant during both the years of experiment.

Table 9: Interaction effect for Number of fruits per vine between cultivar and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	36.28	40.28	49.50	48.73	43.00	44.50
V ₂ - Hilton	39.39	41.16	41.94	42.72	40.67	41.45
V ₃ - Isatis	35.72	36.57	39.28	41.13	37.50	38.35
V ₄ - Kian	35.28	35.83	37.72	38.28	36.50	37.06
V ₅ - KUK-9	41.17	42.29	42.06	43.19	41.61	42.74
Mean for F	37.56	39.03	42.10	42.60	CD at 5% 1 st yr = 2.88 2 nd yr = 2.61	

Number of fruits per vine was significantly different in cultivars and fertilizer combinations. The maximum number of fruits per vine was found in V₁F₂ (49.50 and 48.73) which was significantly higher as compared to rest of the combinations. The least number of fruits per vine was found in combination of V₄F₁ (35.28 and 35.83) during both the years. Similar findings were also reported by Dhillon and Ishiki (1998).

Table 10: Interaction effect for Number of fruits per vine between spacing and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for S	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
S ₁ (40 cm x 30 cm)	34.03	36.43	42.77	42.30	38.40	39.36
S ₂ (40 cm x 40 cm)	38.03	39.03	41.50	42.49	39.77	40.76
S ₃ (40 cm x 50 cm)	40.63	41.63	42.03	43.08	41.33	42.33
Mean for F	37.56	39.03	42.10	42.60	CD at 5% 1 st yr = 2.23 2 nd yr = 2.02	

Spacing and fertilizer treatment combination significantly influenced number of fruits per vine in all the treatment combinations (Table 10). In spacing and fertilizer (S x F) interaction combinations, maximum number of fruits per vine was found in S₁F₂ (42.77) in first year and treatment combination of S₃F₂ i.e. (43.08) in second year which was significantly higher than rest of the combination and the least value of

Number of fruits per vine was found in treatment combination of S₁F₁ (34.03 and 36.43) during both the years of experimentation.

Table 11: Interaction effect for Number of fruits per vine among cultivar, spacing and fertilizer treatments

Factors	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)	
	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ S ₁	23.17	31.84	57.50	51.84
V ₁ S ₂	40.50	42.17	42.83	44.50
V ₁ S ₃	45.16	46.84	48.17	49.84
V ₂ S ₁	38.50	39.28	40.83	41.61
V ₂ S ₂	38.83	39.61	43.17	43.95
V ₂ S ₃	40.83	41.61	41.83	42.60
V ₃ S ₁	34.50	35.25	38.50	39.35
V ₃ S ₂	35.17	36.01	39.83	40.68
V ₃ S ₃	37.50	38.35	39.50	40.35
V ₄ S ₁	34.50	35.05	37.50	38.06
V ₄ S ₂	33.83	34.39	37.83	38.37
V ₄ S ₃	37.50	38.06	37.83	38.39
V ₅ S ₁	39.50	40.63	39.50	40.61
V ₅ S ₂	41.83	42.96	43.83	44.95
V ₅ S ₃	42.17	43.29	42.83	43.96
Mean of F	37.56	39.03	42.10	42.60
CD at 5% = 5.00 (1 st yr) and 4.53 (2 nd yr)				

The interactions among cultivars, spacing and fertilizer had significant effect on number of fruits per vine in all the combinations. The maximum number of fruits per vine was found in V₁S₁F₂ (57.50 and 51.84) which was significantly higher than rest of the combination and the minimum was recorded in V₁S₁F₁ (23.17 and 31.84) during both the years of experimentation. The results are in accordance with the findings of Dhillon and Ishiki (1998) who reported significant interaction.

4.3.4 Fruit weight (g)

The fruit weight in cucumber was influenced by cultivar, spacing and fertilizer treatments at maturity stages and other environmental conditions presented in Table 8. It is observed that Multistar cultivar gave significantly maximum fruit weight (117.08 g and 118.65 g) as compared to the rest of the cultivars during both the years of study. Cultivars Hilton (108.29 g and 109.72 g), Isatis (107.32 g and 108.71 g) and KUK-9 (108.33 g and 109.22 g) were statistically at par with each other during 2014 and 2015, respectively. The significantly lesser fruit weight was recorded in cultivar Kian i.e. 100.97 g and 102.99 g during both the years of experiment. Varietal difference for this character have also been reported by Solanki and Seth (1980); Singh *et al* (2012) and Shah *et al* (2016).

With respect to different plant spacing treatments, plant spacing of 40 cm x 50 cm recorded significantly more fruit weight (110.95 g and 112.41 g) as compared to plant spacing 40 cm x 30 cm (105.72 g and 107.18 g) and was statistically at par with plant spacing 40 cm x 40 cm (108.52 g and 109.98 g) during 2014 and 2015, respectively. Similarly, plant spacings treatments 40 cm x 30 cm (S₁) and 40 cm x 40 cm (S₂) were also statistically at par with each other. Higher fruit weight may be due to less competition among plants for growth factors in wider spacing as reported by Kishor *et al* (2010).

The effect of fertilizer treatments which is presented in table 8 showed significant effect on fruit weight. The significantly maximum fruit weight was recorded in treatment F₂ (100:50:125) of NPK (111.95 g and 113.41 g) as compared to treatment F₁ (70:40:90) of NPK (104.84 g and 106.30 g) during both the years of experiment. The results obtained are in line with findings of Veesar (2004) and Ahmed *et al* (2007).

The interaction effect was found to be significant during both the years of experiment.

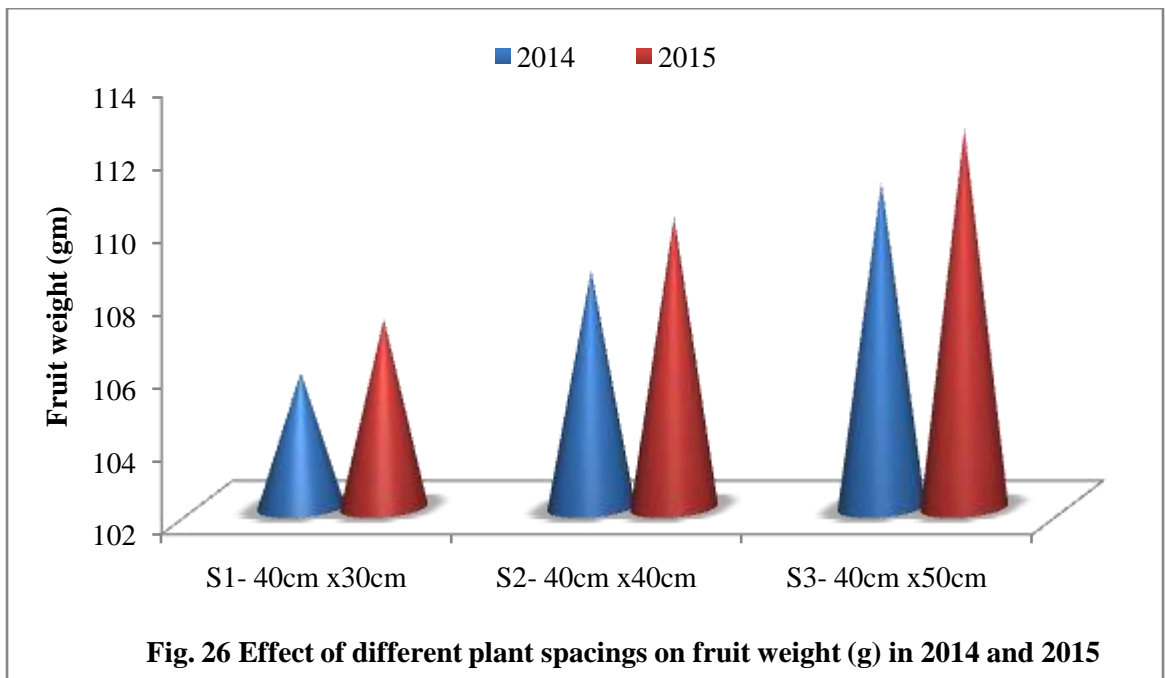
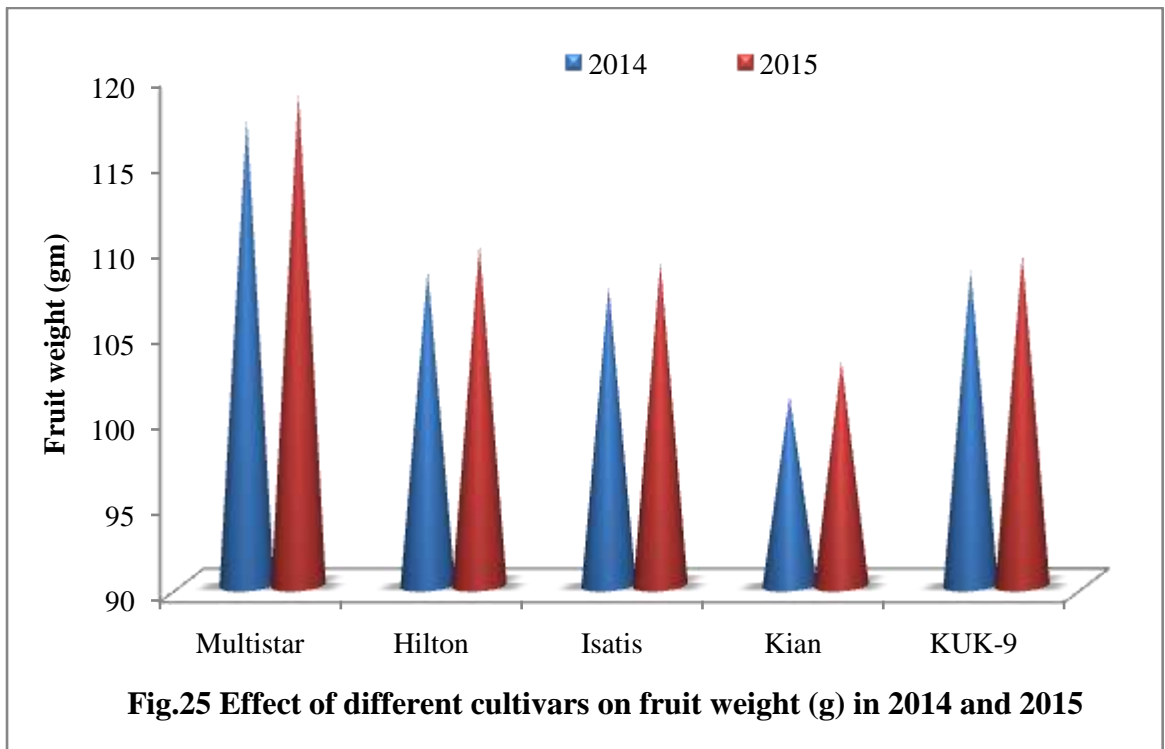


Table 12: Interaction effect for Fruit weight between cultivar and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	107.03	108.60	127.13	128.71	117.08	118.65
V ₂ - Hilton	106.41	107.83	110.17	111.61	108.29	109.72
V ₃ - Isatis	104.68	106.06	110.00	111.40	107.32	108.71
V ₄ - Kian	98.67	100.72	103.26	105.30	100.97	102.99
V ₅ - KUK-9	107.46	108.36	109.21	110.11	108.33	109.22
Mean for F	104.84	106.30	111.95	113.41	CD at 5% 1 st yr = 6.77 2 nd yr = 7.04	

Fruit weight (g) was significantly influenced in cultivars and fertilizer treatment combination. Average fruit weight (g) was maximum found in treatment combination of V₁F₂ i.e. (127.13 g and 128.71 g) which was significantly higher as compared to rest of the combinations. The least was found in V₄F₁ (98.67 g and 100.72 g) during both the years. These results are in line with the findings of Choudhari and More (2002); Veesar (2004); Surve *et al* (2002).

Table 13: Interaction effect for Fruit weight between spacing and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for S	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
S ₁ (40 cm x 30 cm)	98.98	100.46	112.45	113.93	105.72	107.18
S ₂ (40 cm x 40 cm)	106.24	107.71	110.80	112.27	108.52	109.98
S ₃ (40 cm x 50 cm)	109.31	110.77	112.61	114.07	110.95	112.41
Mean for F	104.84	106.30	111.95	113.41	CD at 5% 1 st yr = 5.25 2 nd yr = 5.45	

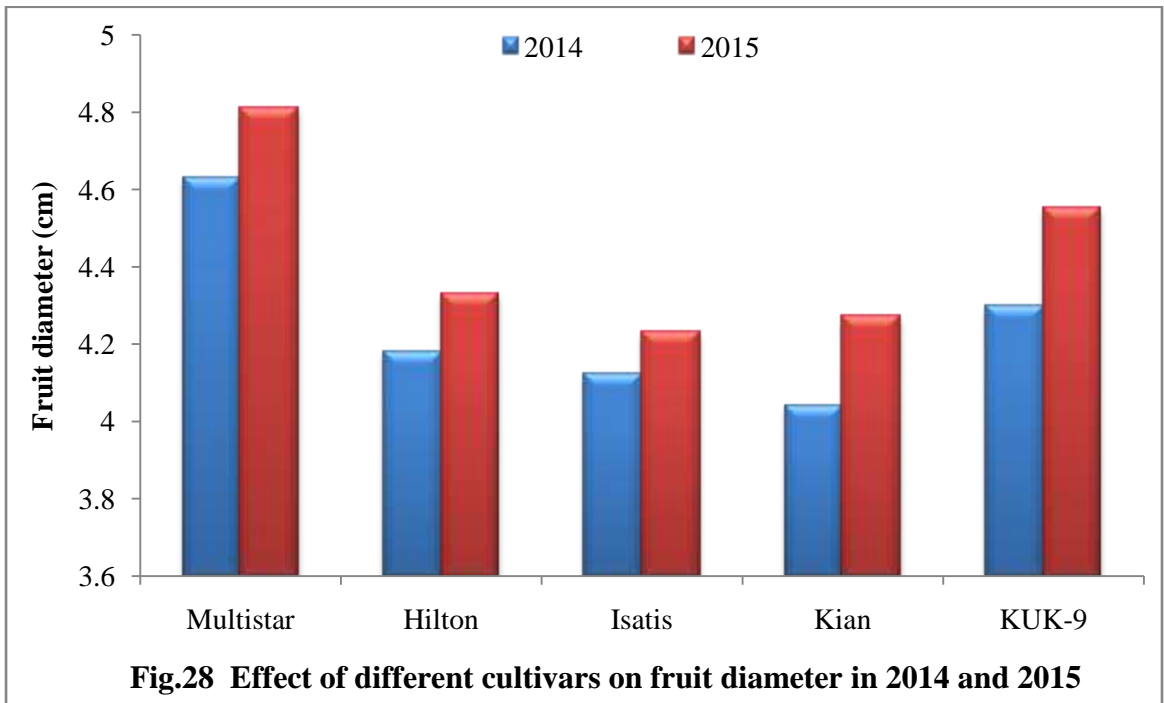
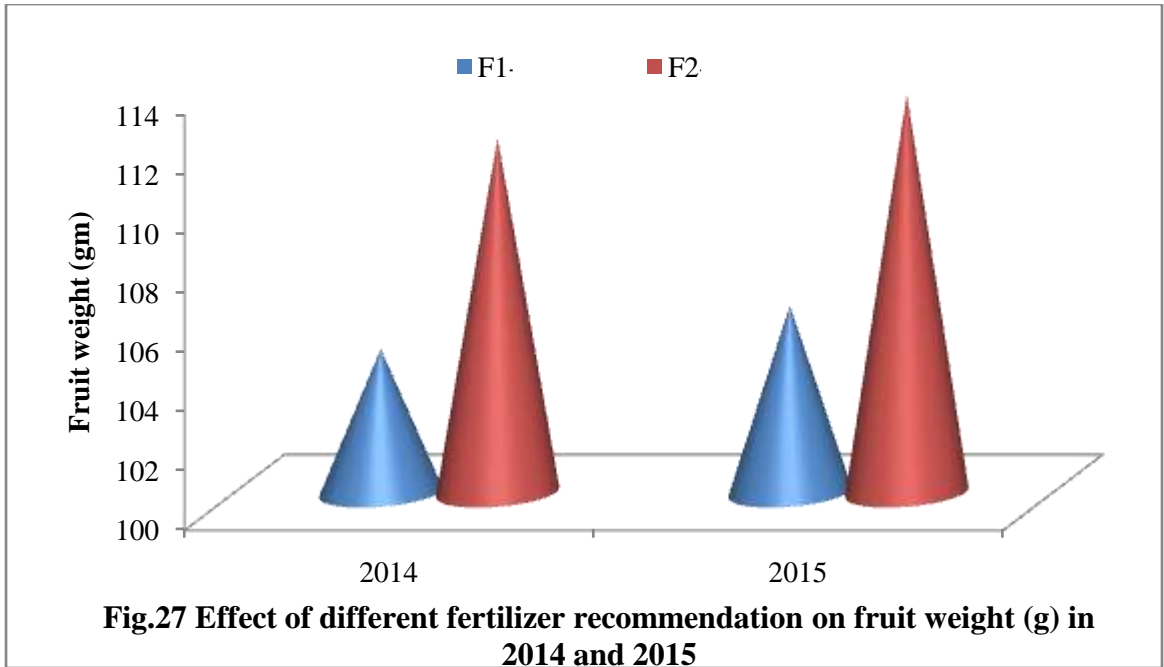
Spacing and fertilizer treatment combination significantly influenced fruit weight in all the treatment combinations. The maximum fruit weight was noted in S₃F₂ (112.61

g and 114.07 g) which was significantly higher than rest of the combination and the minimum in S₁F₁ (98.98 g and 100.46 g) during both the years.

Table 14: Interaction effect for Fruit weight among cultivars spacing and fertilizer treatments

Factors	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)	
	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ S ₁	88.82	90.40	138.03	139.63
V ₁ S ₂	116.07	117.63	120.17	121.70
V ₁ S ₃	116.20	117.77	123.20	124.80
V ₂ S ₁	102.53	103.97	107.80	109.27
V ₂ S ₂	106.93	108.37	112.00	113.47
V ₂ S ₃	109.76	111.17	110.70	112.10
V ₃ S ₁	102.60	103.97	107.83	109.33
V ₃ S ₂	102.33	103.70	109.00	110.40
V ₃ S ₃	109.10	110.50	113.16	114.57
V ₄ S ₁	95.50	97.60	101.66	103.70
V ₄ S ₂	98.97	101.00	102.67	104.73
V ₄ S ₃	101.53	103.57	105.43	107.47
V ₅ S ₁	105.46	106.37	106.93	107.83
V ₅ S ₂	106.93	107.83	110.17	111.06
V ₅ S ₃	109.97	110.86	110.53	111.43
Mean of F	104.84	106.30	111.95	113.41
CD at 5% = 11.74 (1 st yr) and 12.19 (2 nd yr)				

The interactions of V x S x F had significantly influenced the fruit weight (Table 14). Higher fruit weight was recorded in V₁S₁F₂ (138.03 g and 139.63 g) which was significantly higher than rest of the combination and the lowest in V₁S₁F₁ (88.82 g and 90.40 g) during both the years.



4.3.5 Fruit diameter (cm)

The data on fruit diameter as influenced by various treatments presented in table 15.

A perusal of the data in Table 15 revealed that cultivars had significant effect on fruit diameter. Fruits obtained from the cultivar Multistar had significant higher

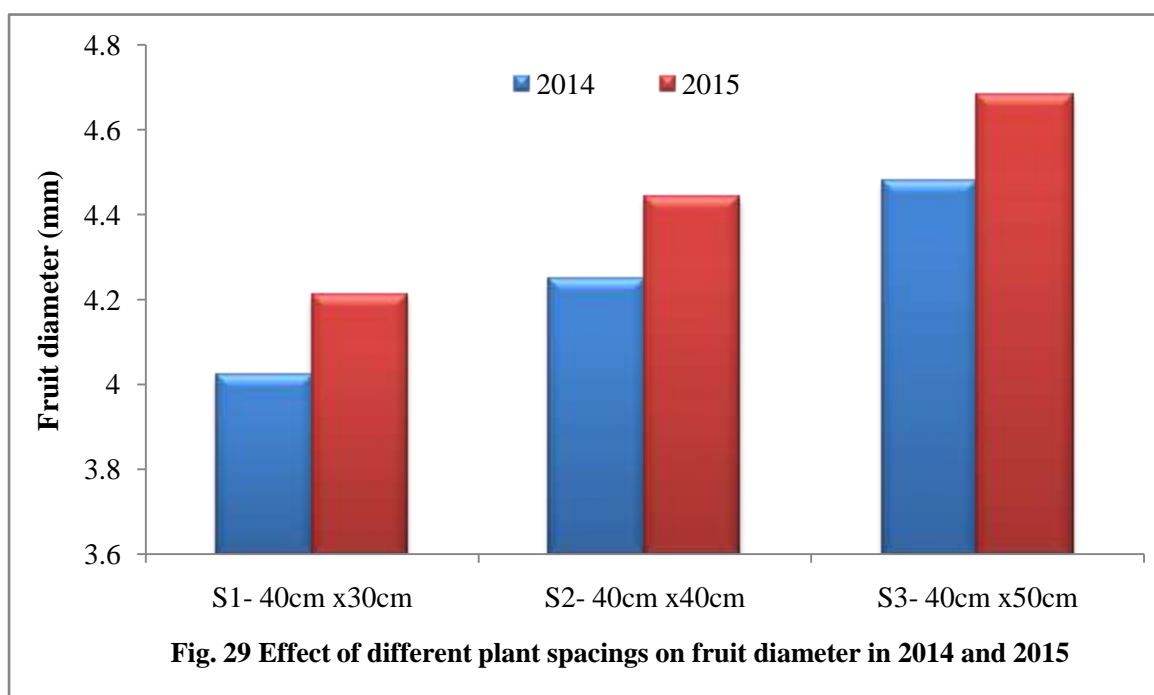
fruit diameter (4.63 cm and 4.81 cm) as compared to other cultivars under study during 2014 and 2015. Cultivar Kian had smaller fruit diameter (4.04 cm and 4.27 cm) than all other cultivars under study. The variation for this parameter was due to genetic differences. The varietal differences for this character was also earlier reported by Solanki and Seth (1980) and Vian D Ali (2016).

Table 15: Fruit diameter and Marketable number of fruits per vine as influenced by different treatments.

Treatments	Fruit diameter (cm)		Marketable number of fruits per vine	
	I st Year	II nd Year	I st Year	II nd Year
Cultivars				
V ₁ -Multistar	4.63	4.81	34.50	41.25
V ₂ -Hilton	4.18	4.33	29.44	35.22
V ₃ -Isatis	4.12	4.23	29.39	35.44
V ₄ -Kian	4.04	4.27	28.56	34.53
V ₅ -KUK-9	4.30	4.55	31.00	37.24
C.D at 5 %	0.26	0.23	1.66	1.83
Spacing				
S ₁ - 40cm x 30cm	4.02	4.21	29.26	35.43
S ₂ - 40cm x 40cm	4.25	4.44	30.33	36.49
S ₃ - 40cm x 50cm	4.48	4.67	32.13	38.29
C.D at 5%	0.20	0.18	1.28	1.42
Fertilizer				
F1-70:40:90 Kg of NPK per acre	3.97	4.17	29.43	35.46
F2-100:50:125 Kg of NPK per acre	4.54	4.70	31.72	38.01
C.D at 5%	0.17	0.14	1.05	1.16
Interaction (C.D at 5%)				
Vx _F	0.37	0.32	2.34	2.58
Sx _F	0.29	0.25	1.81	2.00
VxSx _F	0.64	0.55	4.06	4.47

Cucumber plants planted under different plant spacings also influenced the fruit diameter significantly during both the years of investigation. Fruits produced at spacing of 40 cm x 50 cm gave significantly maximum fruit diameter to the tune of 4.48 cm in 2014 and 4.67 cm in 2015 than other spacing treatments under investigation. The lowest fruit diameter was recorded at 40 cm x 30 cm (4.02 cm and

4.21 cm) during 2014 and 2015, respectively is might be due to less competition among plants for growth attributes in wider spacing. These results were also earlier reported by Shaheen *et al* (2007) and Aniekwe and Anike (2015).



Fruit diameter was also influenced by different fertilizer treatments significantly. The maximum (4.54 cm and 4.70 cm) fruit diameter was recorded in treatment F2 (100:50:125Kg) of NPK per acre as compared to treatment F1 (70:40:90Kg) of NPK per acre (3.97 cm and 4.17 cm) during both the years. Choudhari and More (2002); Arun and Kumar (2014) reported similar results with respect to fruit diameter in different cucumber cultivars.

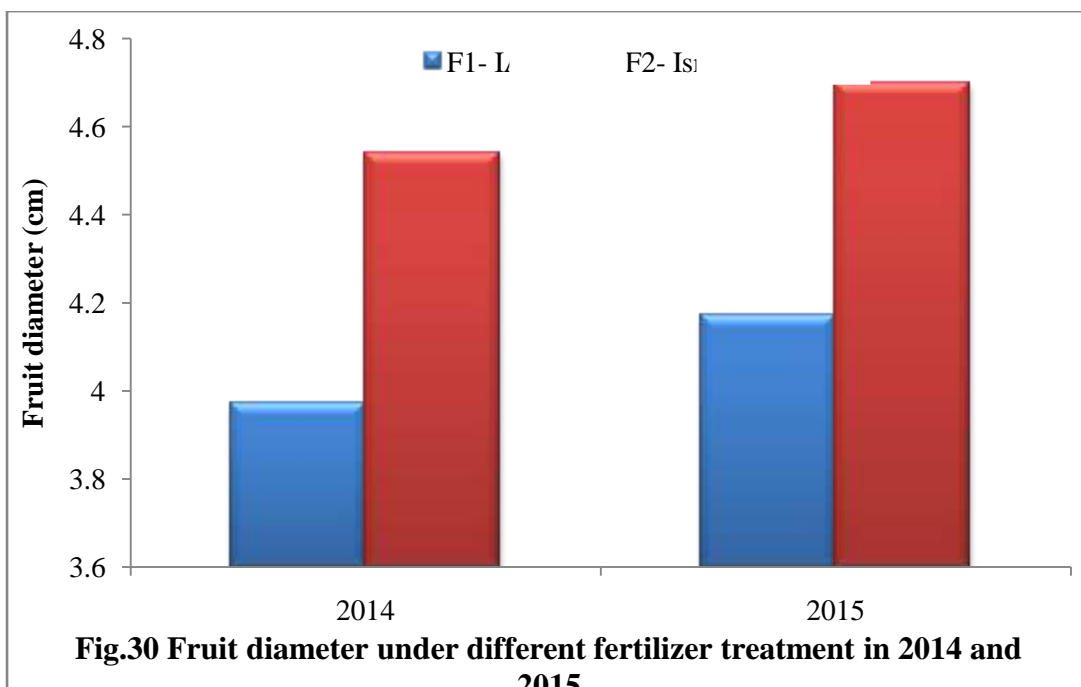


Fig.30 Fruit diameter under different fertilizer treatment in 2014 and 2015

Table 16: Interaction effect for Fruit diameter between cultivar and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	3.91	4.19	5.35	5.43	4.63	4.81
V ₂ - Hilton	4.03	4.18	4.34	4.49	4.18	4.33
V ₃ - Isatis	3.96	4.07	4.27	4.38	4.12	4.23
V ₄ - Kian	3.86	4.09	4.22	4.45	4.04	4.27
V ₅ - KUK-9	4.10	4.35	4.51	4.76	4.30	4.55
Mean for F	3.97	4.17	4.54	4.70	CD at 5% 1 st yr = 0.37 2 nd yr = 0.32	

It is cleared from Table 16 that interactions between V x F significantly influenced fruit diameter being maximum in V₁F₂ (5.35 cm in 2014 and 5.43 cm in 2015 which was significantly higher as compared to rest of the combinations. The minimum fruit diameter (3.86 cm) was recorded in V₄F₁ in first year (2014) and V₃F₁ (4.07 cm) in second year (2015). These results are in line with the findings of Veesar 2004; Eifediyi and Remison 2009; Surve *et al* 2002.

Table 17: Interaction effect for Fruit diameter between spacing and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for S	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
S ₁ (40 cm x 30 cm)	3.56	3.80	4.49	4.61	4.02	4.21
S ₂ (40 cm x 40 cm)	4.07	4.25	4.44	4.62	4.25	4.44
S ₃ (40 cm x 50 cm)	4.29	4.48	4.68	4.86	4.48	4.68
Mean for F	3.97	4.17	4.54	4.70	CD at 5% 1 st yr= 0.29 2 nd yr = 0.25	

The cucumber plants planted at different spacing under various fertilizer treatment combinations significantly influenced fruit diameter (Table 17). The maximum fruit diameter was observed in treatment combination of S₃F₂ (4.68 cm and 4.86 cm) which was significantly higher than rest of the combinations under study and the minimum fruit diameter was recorded in S₁F₁ (3.56 cm in 2014 and 3.80 cm in 2015).

Table 18: Interaction effect for Fruit diameter among cultivar, spacing and fertilizer treatments

Factors	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)	
	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ S ₁	2.63	3.11	6.00	5.88
V ₁ S ₂	4.37	4.55	4.81	4.99
V ₁ S ₃	4.72	4.90	5.24	5.42
V ₂ S ₁	3.89	4.04	4.21	4.37
V ₂ S ₂	4.06	4.21	4.26	4.41
V ₂ S ₃	4.14	4.29	4.53	4.68
V ₃ S ₁	3.82	3.93	4.02	4.13
V ₃ S ₂	3.94	4.05	4.31	4.42
V ₃ S ₃	4.13	4.24	4.47	4.58
V ₄ S ₁	3.59	3.82	3.96	4.19
V ₄ S ₂	3.81	4.04	4.18	4.40
V ₄ S ₃	4.18	4.41	4.52	4.75
V ₅ S ₁	3.86	4.11	4.26	4.51
V ₅ S ₂	4.15	4.40	4.63	4.89
V ₅ S ₃	4.28	4.54	4.62	4.87
Mean of F	3.97	4.17	4.54	4.70
CD at 5% = 0.64 (1 st yr) and 0.55 (2 nd yr)				

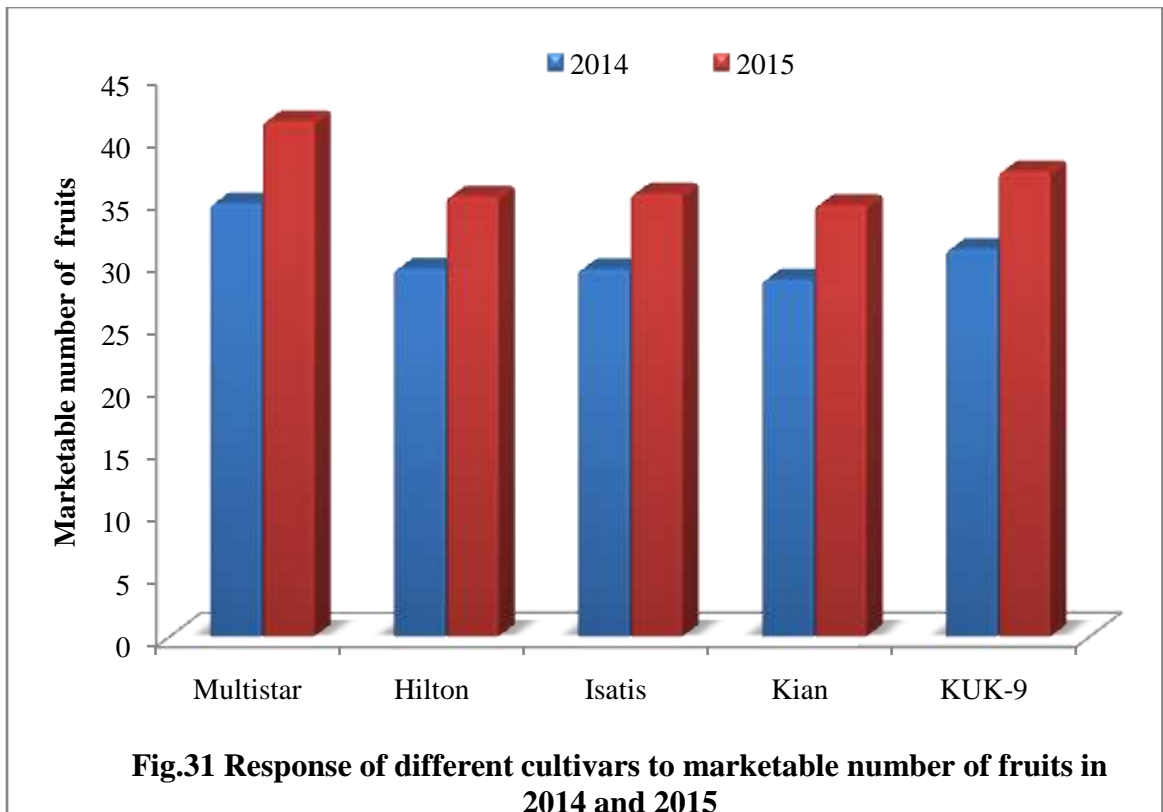
The interaction among cultivar, spacing and fertilizer treatments significantly influenced fruit diameter in all the treatment combinations (Table 18). The maximum value of fruit diameter was found in treatment combination of V₁S₁F₂ i.e. (6.00 cm and 5.88 cm) which was significantly higher than rest of the combination and minimum in V₁S₁F₁ (2.63 cm and 3.11 cm) during both the years.

4.3.6 Marketable number of fruits per vine

Data on marketable number of fruit per vine as affected by cultivar, plant spacing and fertilizer treatments is presented in Table 15.

A critical appraisal of data given in Table 15 revealed that the number of marketable fruits per vine was significantly affected by cultivars. The cultivar Multistar produced maximum number of marketable fruits per vine (34.50 and 41.25) as compared to rest of the cultivars during both the years of study. The cultivar KUK-9 also gave significantly maximum number of marketable fruits per vine (31.00 and 37.24) as compared to Hilton (29.44 and 35.22), Isatis (29.39 and 35.44) and Kian (28.56 and 34.53). The cultivars Hilton, Isatis and Kian with respect to marketable number of fruits per vine were statistically at par with each other during both the years of experiment. This might be due to the comparative better growth in terms of increased vine length, higher number of nodes per plant, lesser internodal distance which reflected in significantly higher number of fruits per vine in Multistar cultivar as compared to other cultivars. These results are conformity with Muhammad *et al* (1998); Santi *et al* (2013).

Plant spacing had significant variation in number of marketable fruits per vine. The higher number of marketable fruits per vine was recorded at wider plant spacing of 40 cm x 50 cm (32.13 and 38.29) as compared to rest of the plant spacing treatments during both the years of study. Treatments of spacing 40 cm x 40 cm (30.33 and 36.49) and 40 cm x 30 cm (29.26 and 35.43) gave the fruit number which were statistically at par with each other during both the years of study. This might be due to increased availability of inputs at 40cm x 50cm spacing. Similar findings earlier reported by Lacob *et al* (2009); Mamnoie *et al* (2014) and Jankauskiene and Brazaityte (2006).



Fertilizer treatments also significantly influenced the number of marketable fruits per vine. Treatment F2 (100:50:125Kg) of NPK per acre gave significantly higher number of marketable fruits per vine (31.72 and 38.01) as compared to treatment F1 (70:40:90Kg) of NPK per acre (29.46 and 35.46) during 2014 and 2015, respectively. Results obtained are in accordance with Watcharasak and Thammasak (2005) Umekwe *et al* (2014).

Interaction effect of cultivars, spacing and fertilizer treatments was found to be significant during both the years of study.

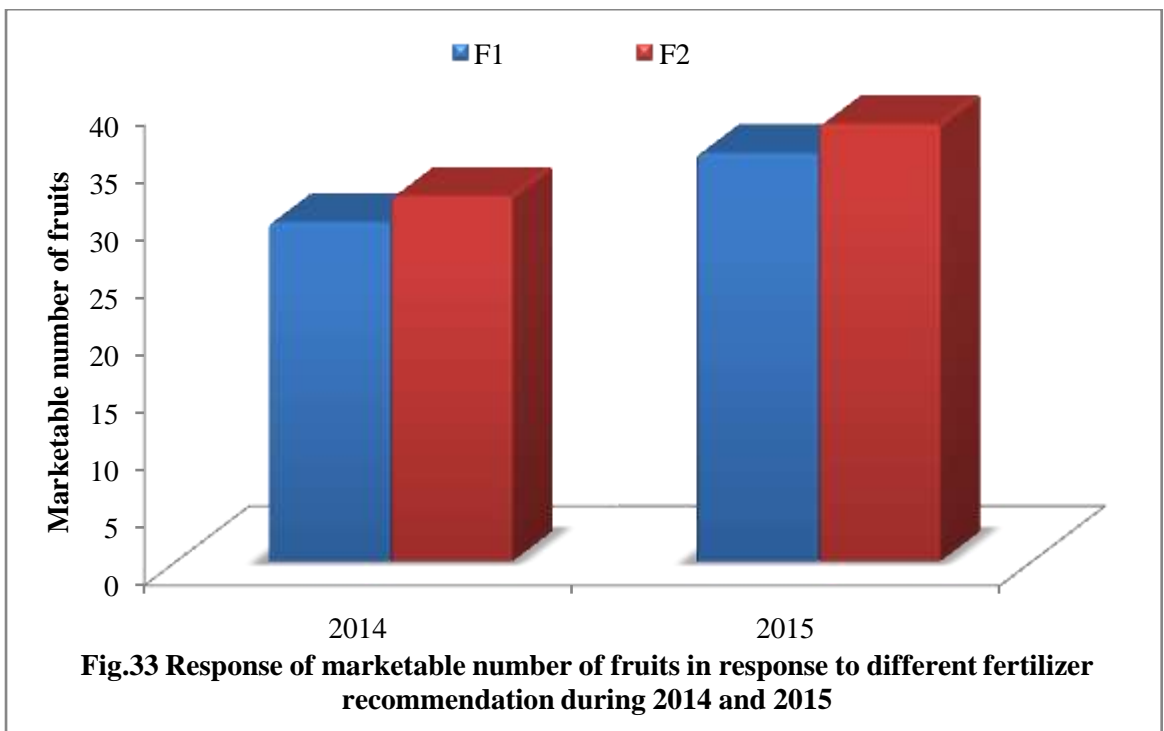
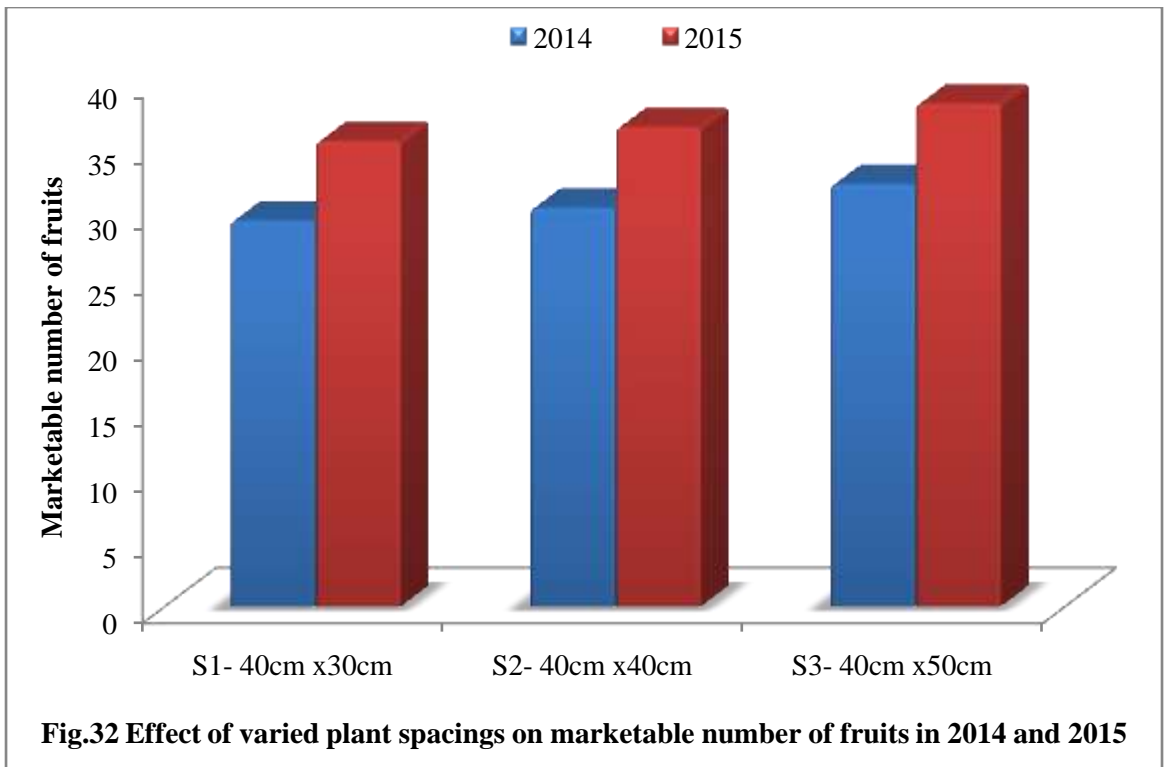


Table 19: Interaction effect for Marketable number of fruits per vine between cultivar and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	31.85	37.81	37.45	44.69	34.66	41.25
V ₂ - Hilton	28.83	34.61	30.06	35.84	29.44	35.22
V ₃ - Isatis	29.17	35.22	29.61	35.67	29.39	35.44
V ₄ - Kian	27.41	33.37	29.71	35.70	28.56	34.53
V ₅ - KUK-9	30.06	36.29	31.94	38.18	31.00	37.24
Mean for S					CD at 5% 1 st yr = 2.34 2 nd yr = 2.58	

Marketable number of fruits per vine were significantly influenced in cultivar and fertilizer treatment combination (Table 19). The maximum marketable fruits per vine was found in treatment combination of V₁F₂ i.e. (37.45 and 44.69) which was significantly higher as compared to rest of the combinations. The least value of Marketable number of fruits per vine was found in combination of V₄F₁ i.e. (27.41 and 33.37) during both the years of study. These results are in line with the findings of (Choudhari and More 2002; Veesar 2004; Surve *et al* 2002).

Table 20: Interaction effect for Marketable number of fruits per vine between spacing and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
S ₁ (40 cm x 30 cm)	27.37	32.93	31.33	37.93	29.36	35.43
S ₂ (40 cm x 40 cm)	29.57	35.65	31.10	37.32	30.33	36.49
S ₃ (40 cm x 50 cm)	31.57	37.73	32.70	38.86	32.13	38.29
Mean for F					CD at 5% 1 st yr= 1.81 2 nd yr = 2.00	

Spacing and fertilizer treatment combination significantly influenced marketable fruits per vine in all the treatment combinations. The maximum value of marketable fruits per vine was found in treatment combination of S₃F₂ i.e. (32.70 and 38.86) which was significantly higher than rest of the combination and minimum in S₁F₁ (27.37 and 32.93) during both the years.

Table 21: Interaction effect for Marketable number of fruits per vine among cultivar, spacing and fertilizer treatments

Factors	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)	
	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ S ₁	27.83	32.58	39.50	48.25
V ₁ S ₂	33.83	40.58	34.60	41.25
V ₁ S ₃	33.50	40.25	37.83	44.58
V ₂ S ₁	26.17	31.95	28.50	34.28
V ₂ S ₂	28.83	34.61	30.60	36.28
V ₂ S ₃	31.50	37.28	31.37	36.95
V ₃ S ₁	25.83	31.88	30.60	36.55
V ₃ S ₂	29.50	35.55	28.60	34.88
V ₃ S ₃	32.27	38.23	29.83	35.88
V ₄ S ₁	26.50	32.48	27.67	33.81
V ₄ S ₂	26.50	32.48	30.17	36.15
V ₄ S ₃	29.50	35.15	31.27	37.15
V ₅ S ₁	29.50	35.74	30.50	36.74
V ₅ S ₂	29.17	35.41	31.83	38.07
V ₅ S ₃	31.50	37.74	33.50	39.74
Mean of F	29.46	35.46	31.75	38.01
CD at 5% = 4.06 (1 st yr) and 4.47 (2 nd yr)				

The interaction among cultivar, spacing and fertilizer treatments significantly influenced marketable fruits per vine in all the treatment combinations (Table 21). The maximum number of Marketable fruits per vine was found in treatment combination of V₁S₁F₂ i.e. (39.50 and 48.25) which was significantly higher than rest of the combination and the less number of Marketable fruits per vine was found in

treatment combination of $V_3S_1F_1$ (25.83 and 31.88) during both the years of experimentation.

4.3.7 Total fruit yield per vine (Kg)

The data pertaining to total fruit yield per vine as influenced by cultivars, spacing and fertilizer treatments is presented in Table 22.

A perusal data in Table 22 showed that total fruit yield per vine was significantly influenced by cultivars. The total fruit yield per vine obtained from cultivar Multistar was significantly higher (4.41 Kg and 5.30 Kg) which was statistically at par with cultivars KUK-9 (4.29 Kg and 5.21 Kg), Hilton (4.29 Kg and 5.07 Kg) and Isatis (4.23 Kg and 5.06 Kg). The cultivars Multistar, Hilton, Isatis and KUK-9 were significantly higher than Kian (3.91 Kg and 4.66 Kg) during both the years of study. The cultivar Multistar recorded (11.33 and 12.07 per cent) higher total fruit yield per vine over Kian in 2014 and 2015, respectively. This might be due to the fact that higher fruit yield per vine and comparative better performance of Multistar in yield contributing characters such as number of fruits per vine, fruit length, fruit diameter and fruit weight. These results are in close conformity with Golabadi *et al* (2012); Kushwaha *et al* (2012); Kumar and Verma (2012); Monisha *et al* (2014) and Khan *et al* (2015) who reported higher total yield in cucumber hybrids.

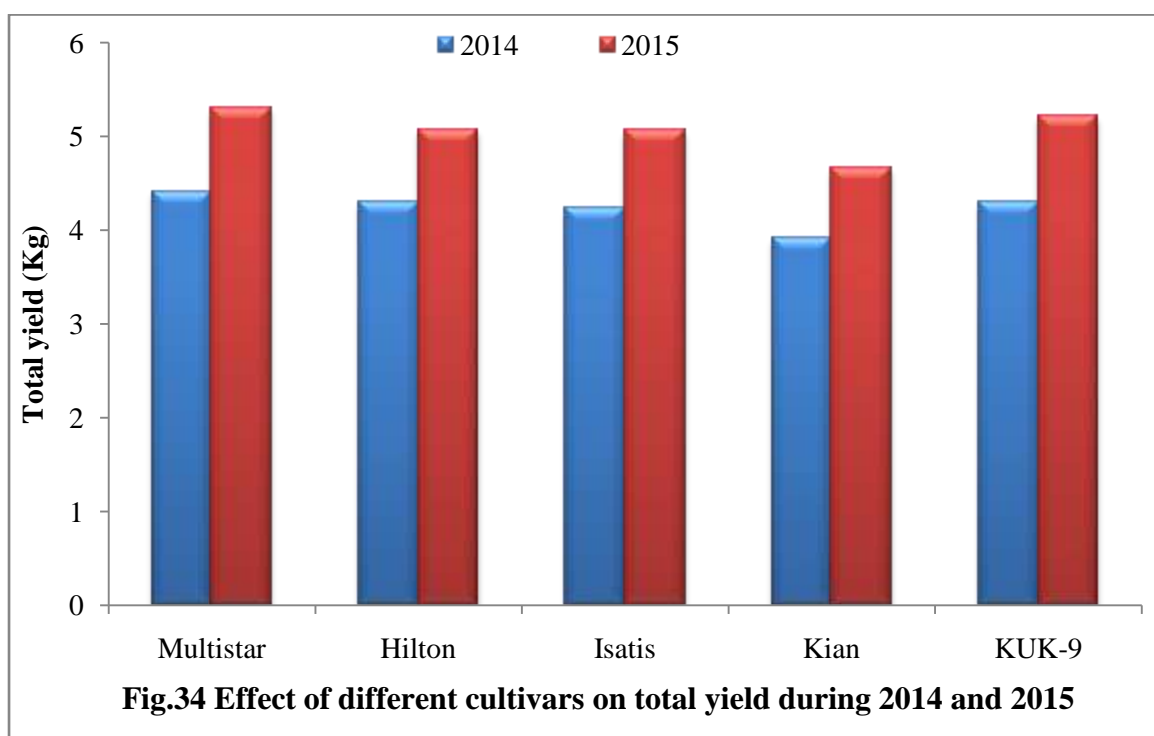
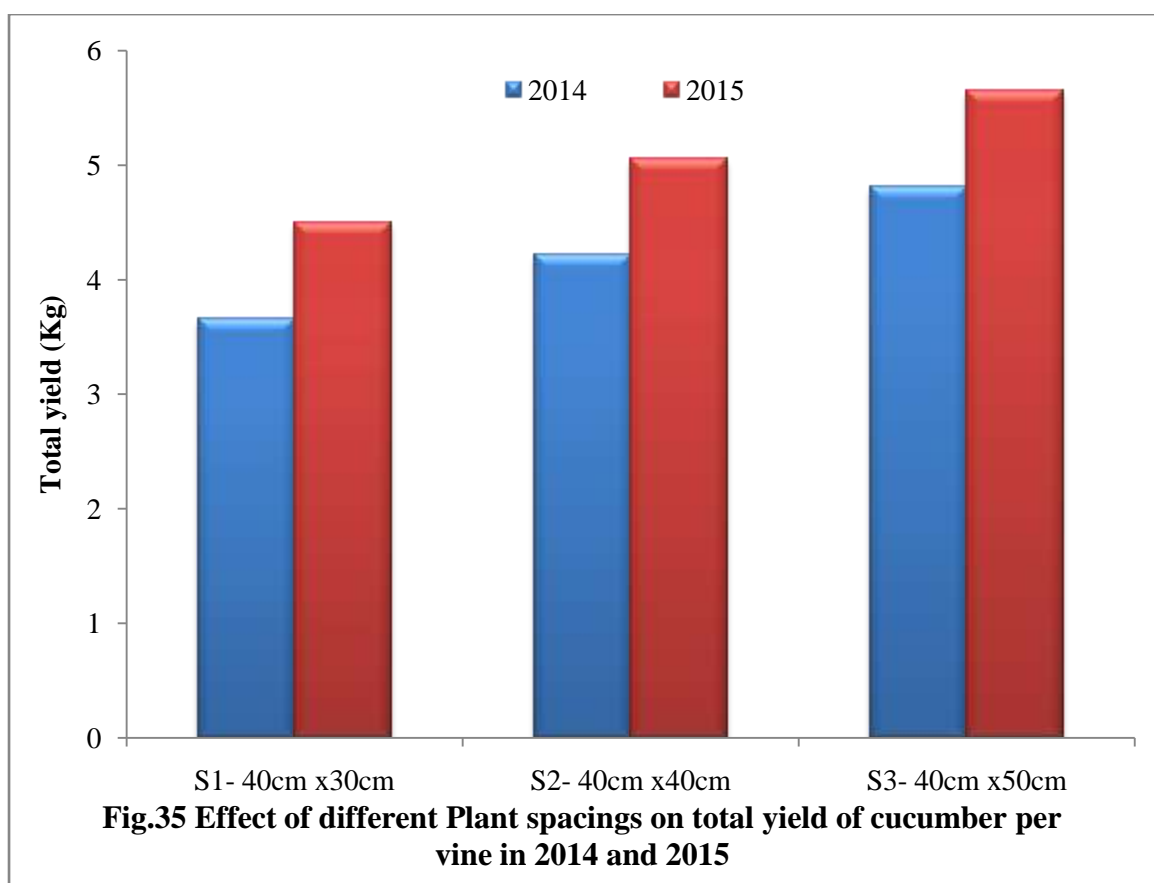


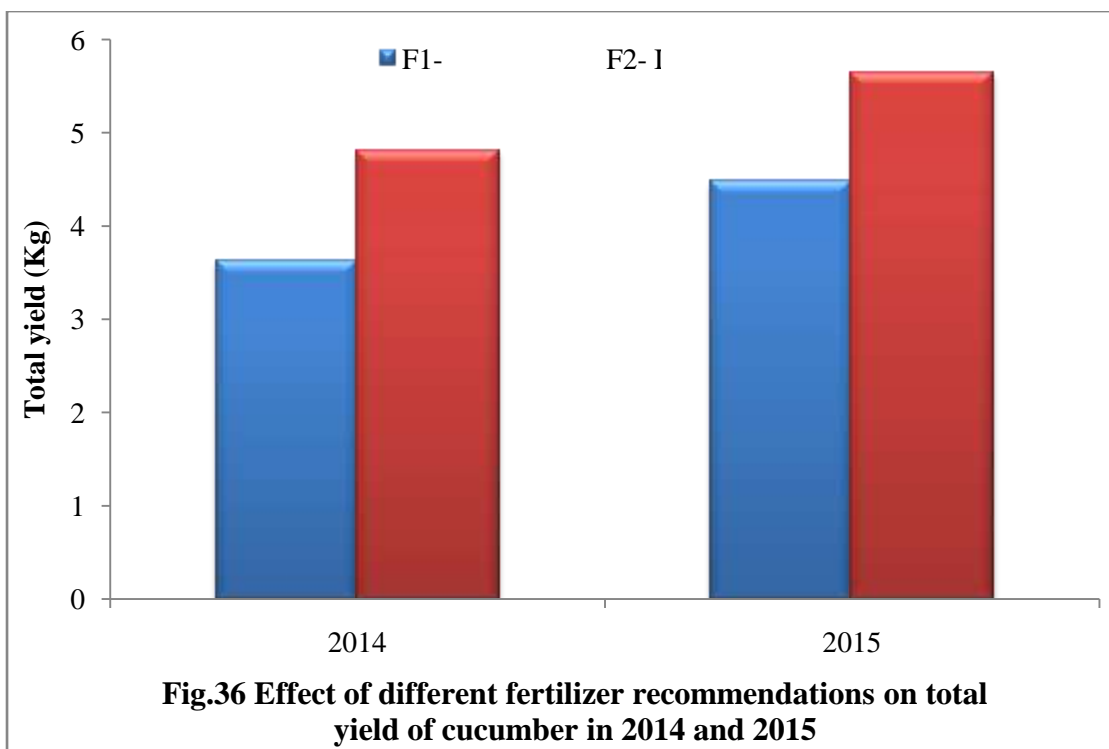
Table 22: Fruit yield per vine and Fruit drop (%) as influenced by different treatments.

Treatments	Total fruit yield per vine (Kg)		Fruit drop (%)	
	I st Year	II nd Year	I st Year	II nd Year
Cultivars				
V ₁ -Multistar	4.41	5.30	10.08	9.70
V ₂ -Hilton	4.29	5.07	13.30	13.98
V ₃ -Isatis	4.23	5.06	13.86	14.18
V ₄ -Kian	3.91	4.66	14.45	15.41
V ₅ -KUK-9	4.29	5.21	11.68	11.33
C.D at 5 %	0.30	0.24	0.71	0.78
Spacing				
S ₁ - 40cm x 30cm	3.65	4.49	13.23	13.45
S ₂ - 40cm x 40cm	4.22	5.05	12.69	12.98
S ₃ - 40cm x 50cm	4.80	5.64	12.11	12.33
C.D at 5%	0.23	0.18	0.55	0.60
Fertilizer				
F1-70:40:90 Kg of NPK per acre	3.63	4.48	13.09	13.36
F2-100:50:125 Kg of NPK per acre	4.81	5.64	12.26	12.48
C.D at 5%	0.19	0.15	0.45	0.49
Interaction (C.D at 5%)				
Vx _F	0.42	0.34	NS	NS
Sx _F	0.33	0.26	NS	NS
VxSx _F	0.73	0.58	NS	NS

Plant spacing also had significant effect on total fruit yield per vine. The crop planted at plant spacing of 40 cm x 50 cm recorded significantly higher total fruit yield per vine (4.80 Kg and 5.64 Kg) as compared to 40 cm x 40 cm (4.22 Kg and 5.05 Kg) and 40 cm x 30 cm (3.65 Kg and 4.49 Kg), respectively, during both the years. Similarly, total fruit yield at plant spacing of 40 cm x 40 cm was also significantly higher as compared to 40 cm x 30 cm during both the years of study. Plant spacing of 40 cm x

50 cm recorded 23.95 and 20.39 per cent higher fruit yield over 40 cm x 30 cm and 12.08 and 10.46 per cent over 40 cm x 40 cm plant spacing, during 2014 and 2015, respectively. This higher total fruit yield per vine might be due to the less competition for light, nutrients, water and space in wide row spacing compared to closer one. Similar results were also reported More *et al* (1990); Cook *et al* (1991); Kanthaswamy *et al* (2000); Premalatha *et al* (2006); Bhatia *et al* (2012) and Oga and Umekwe (2015).





The effect of fertilizer treatments also showed significant effect on total fruit yield per vine during the study. Treatment F2 (100:50:125Kg) of NPK per acre recorded significantly higher total fruit yield per vine (4.81 Kg and 5.64 Kg) which was 21.73 and 18.31 per cent higher over treatment F1 (70:40:90Kg) of NPK per acre (3.63 Kg and 4.48 Kg) during both the years of study. Sharma *et al* (1997) and Jaksungnaro and Seema (2001); Watcharasak and Thammasak (2005); Fang *et al* (2015) and Nwofia *et al* (2015) also observed similar results.

The interaction effect of cultivars, spacing and fertilizer treatments was found to be significant in both the years of study.

Table 23: Interaction effect for Total fruit yield per vine between cultivars and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	3.49	4.44	5.34	6.16	4.41	5.30
V ₂ - Hilton	3.81	4.59	4.76	5.54	4.29	5.07
V ₃ - Isatis	3.80	4.59	4.65	5.52	4.23	5.06
V ₄ - Kian	3.29	4.04	4.53	5.28	3.91	4.66
V ₅ - KUK-9	3.86	4.73	4.72	5.68	4.29	5.21
Mean for S	3.63	4.48	4.81	5.64	CD at 5% 1 st yr = 0.42 2 nd yr = 0.34	

Average total fruit yield per vine was significantly influenced in different cultivars and fertilizer treatments combination. The maximum total fruit yield was found in treatment combination of V₁F₂ i.e. (5.34 kg vine⁻¹ and 6.16 kg vine⁻¹) which was significantly higher as compared to rest of the combinations. The least value of total fruit yield was found in combination of V₄F₁ i.e. (3.29 kg vine⁻¹ and 4.04 kg vine⁻¹) during both the years of study. In general, all the cultivars respond significantly to the application of fertilizers. These results were also reported by Choudhari and More (2002); Veesar (2004); Surve *et al* (2002).

Table 24: Interaction effect for Total fruit yield per vine between spacing and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
S ₁ (40 cm x 30 cm)	2.88	3.73	4.42	5.24	3.65	4.49
S ₂ (40 cm x 40 cm)	3.74	4.55	4.70	5.56	4.22	5.05
S ₃ (40 cm x 50 cm)	4.31	5.16	5.28	6.11	4.80	5.64
Mean for F					CD at 5% 1 st yr = 0.33 2 nd yr = 0.26	

It is concluded that cultivars planted at different spacing had responded to the different fertilizers doses. The maximum total fruit yield was recorded in S₃F₂ i.e. (5.28 kg vine⁻¹ and 6.11 kg vine⁻¹) which was significantly higher than rest of the combination and the least value of total yield (Kg) was found in treatment combination of S₁F₁ (2.88 kg vine⁻¹ and 3.73 kg vine⁻¹) during both the years.

Table 25: Interaction effect for Total fruit yield per vine among cultivar, spacing and fertilizer treatments

Factors	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)	
	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ S ₁	2.16	3.25	5.60	6.29
V ₁ S ₂	3.84	4.73	4.89	5.79
V ₁ S ₃	4.46	5.35	5.52	6.41
V ₂ S ₁	3.24	4.02	4.19	4.97
V ₂ S ₂	3.81	4.59	4.78	5.56
V ₂ S ₃	4.37	5.15	5.32	6.10
V ₃ S ₁	3.22	4.05	4.22	5.17
V ₃ S ₂	3.73	4.56	4.57	5.40
V ₃ S ₃	4.34	5.17	5.16	5.99
V ₄ S ₁	2.31	3.06	3.96	4.71
V ₄ S ₂	3.51	4.32	4.69	5.44
V ₄ S ₃	4.00	4.76	4.93	5.68
V ₅ S ₁	3.35	4.27	4.13	5.05
V ₅ S ₂	3.62	4.54	4.59	5.61
V ₅ S ₃	4.47	5.39	5.45	6.37
Mean of F	3.63	4.48	4.81	5.64
CD at 5% = 0.73 (1 st yr) and 0.58 (2 nd yr)				

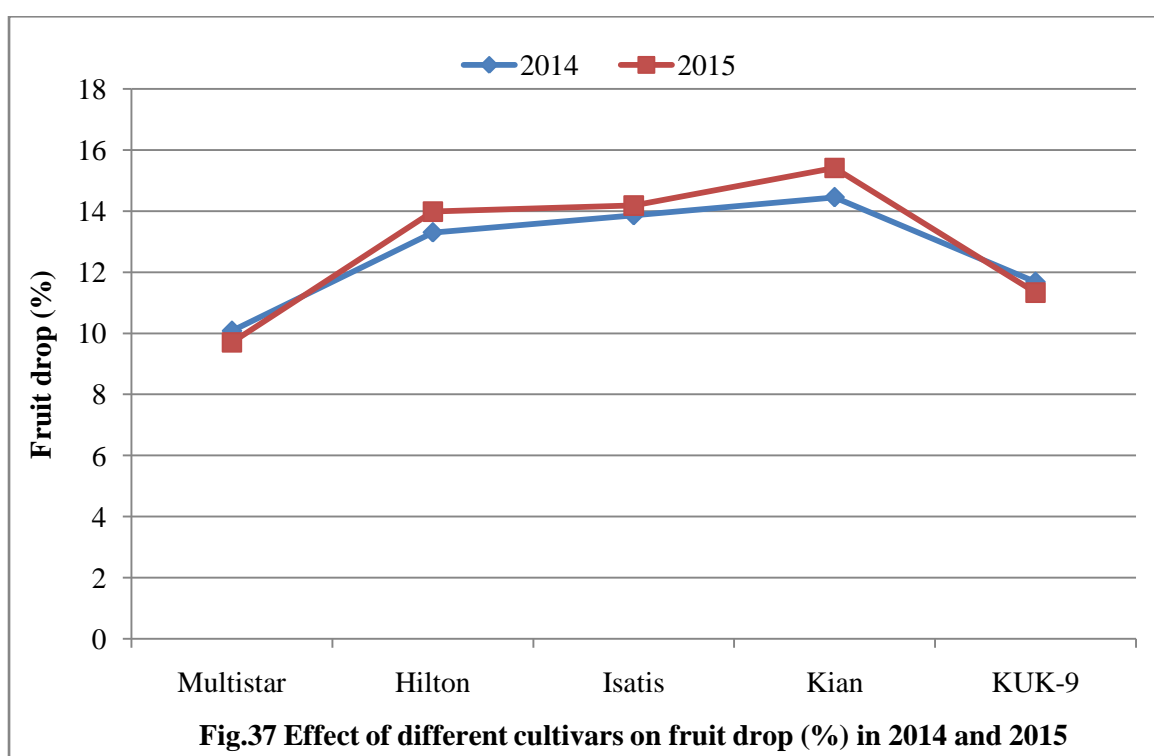
The interaction among cultivar, spacing and fertilizer treatments significantly influenced total fruit yield in all the treatment combinations. Total fruit yield was found the highest in V₁S₁F₂ (5.60kg vine⁻¹) in the Ist year and V₁S₃F₂ in IInd year (6.41kg vine⁻¹) which was significantly higher than rest of the combination and the lowest total fruit yield was observed in V₁S₁F₁ (2.16 kg vine⁻¹) in 2014 and V₄S₁F₁ (3.06 kg vine⁻¹) in 2015. In general, total fruit yield was increased significantly at higher doses of fertilizers in all the cucumber cultivars and it was more where planting distance between plant to plant was wider.

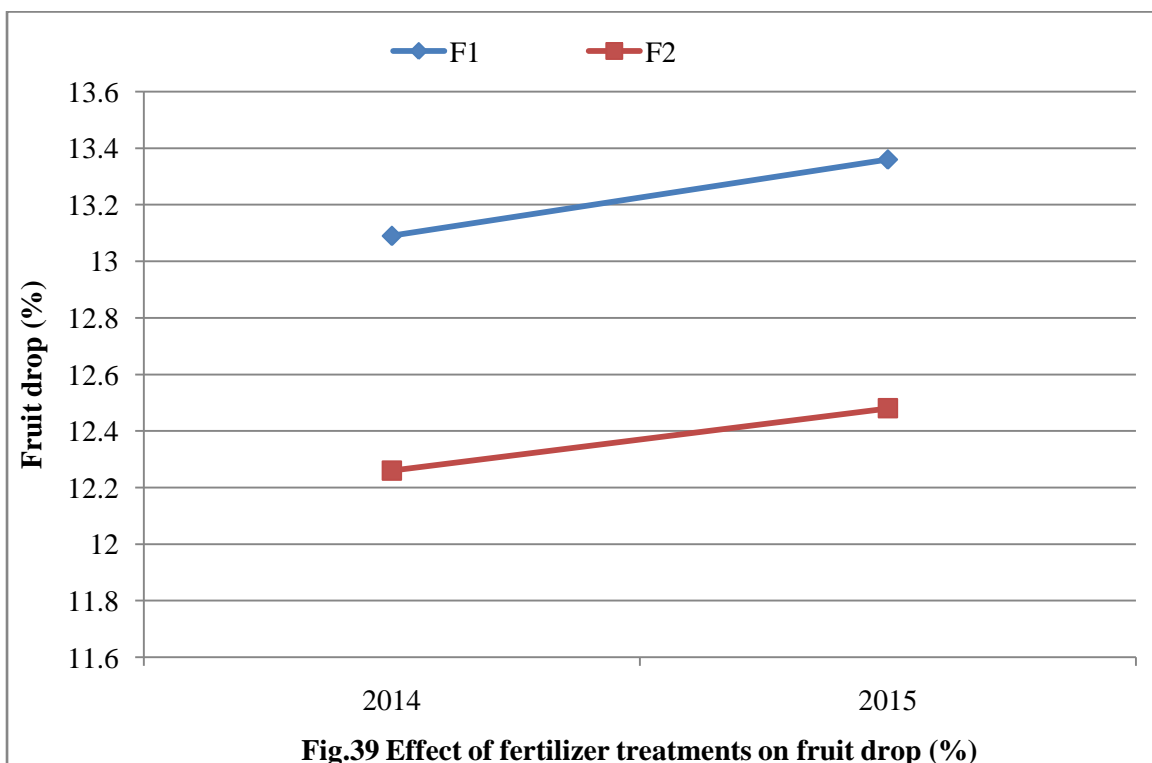
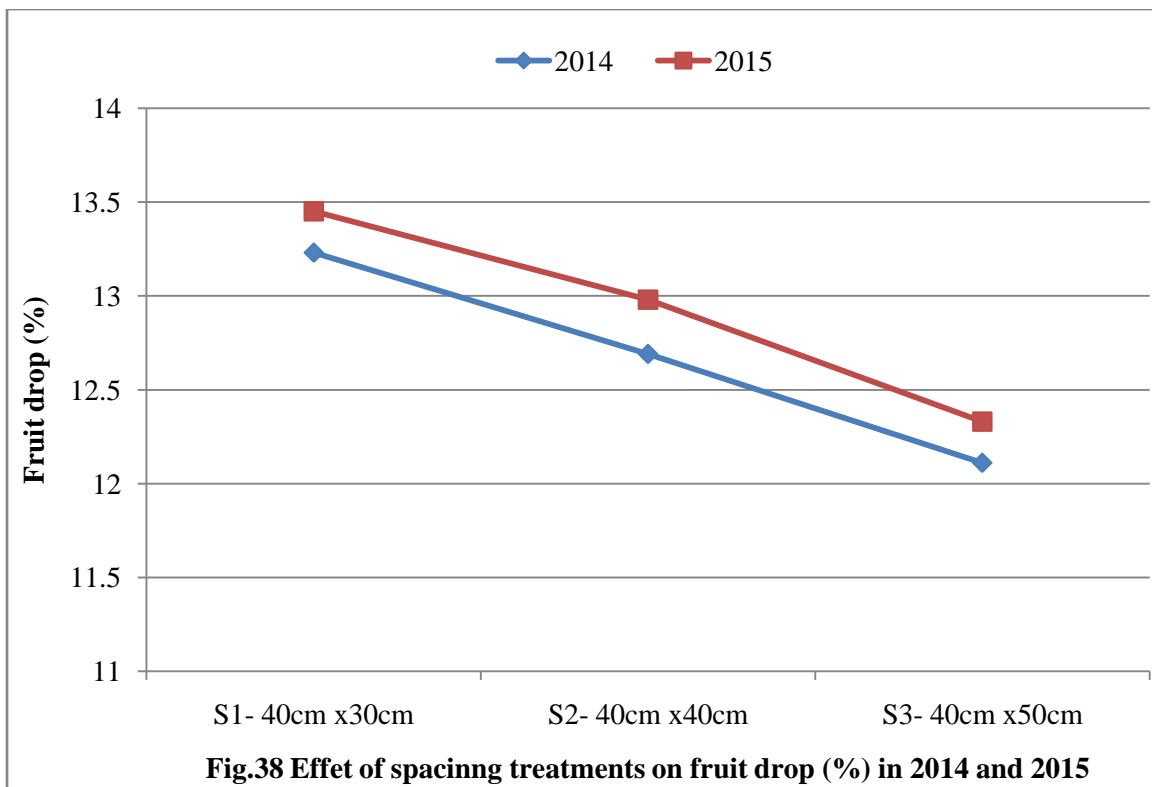
4.3.8 Fruit drop (%)

Fruit drop is another important character which affects the fruit yield and the data on fruit drop is presented in Table 22. Cucumber cultivars behaved significantly with respect to fruit drop per cent. Fruit drop (%) was recorded significantly lower in cucumber cultivar Multistar and the values were 10.08 % in 2014 and 9.70 % in 2015 as compared to other cultivars during both the years. The highest fruit drop percentage

was observed in Kian (14.45% and 15.41%) which was statistically maximum in comparison to Isatis (13.86% and 14.18%) and Hilton cultivar (13.30% and 13.98%) but Hilton and Isatis were statistically at par with each other.

The effect of different spacing on fruit drop is mentioned in Table 22 and it was maximum (13.23% in 2014 and 13.45% in 2015) at closer plant spacing of 40 cm x 30 cm which was statistically at par with plant spacing of 40 cm x 40 cm and the value were 12.69% in 2014 and 12.98% in 2015 and the minimum fruit drop percentage was recorded at wider plant spacing of 40 cm x 50 cm viz., (12.11% in 2014 and 12.33% in 2015).





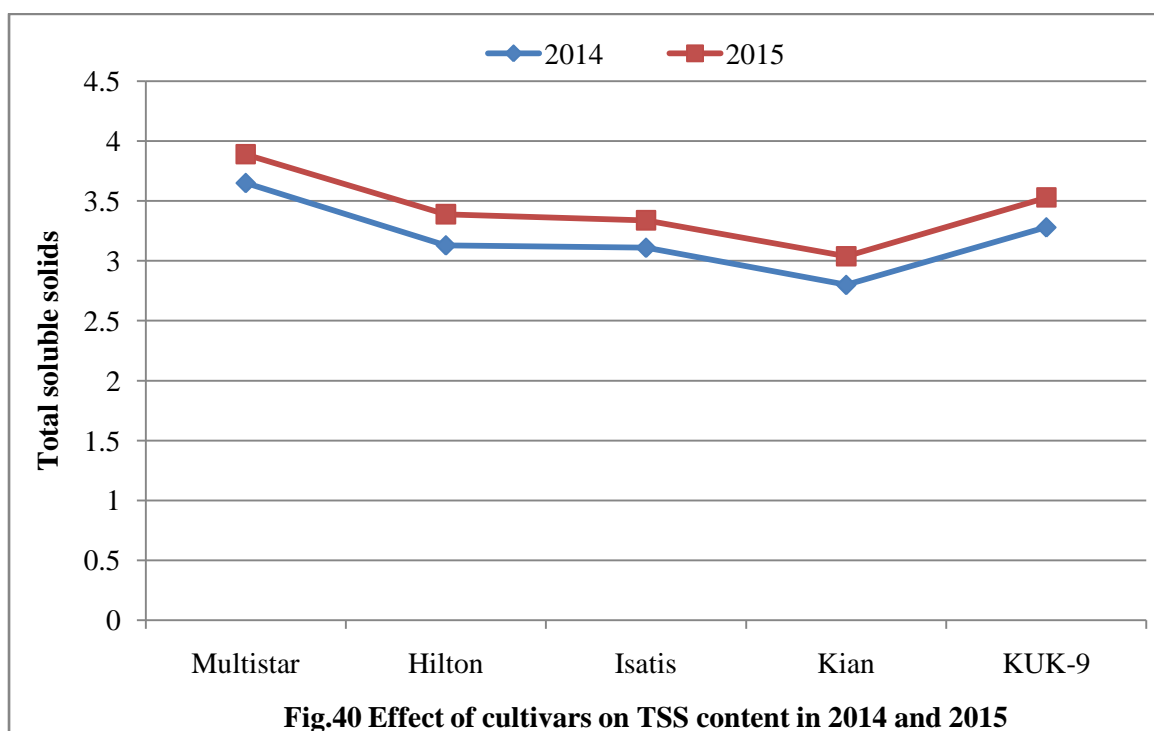
The effect of different fertilizer doses on fruit drop is illustrated in Table 22 and maximum fruit drop was observed in treatment F1 (70:40:90Kg) of NPK per acre and

values were 13.09% and 13.36% in 2014 and 2015 respectively over treatment F2 (100:50:125Kg) of NPK per acre (12.26% and 12.48%). The interaction effect between cultivars, spacing and fertilizer treatments was statistically non-significant.

4.4 Quality Parameters:

4.4.1 Total Soluble Solids (TSS)

The data recorded for juice total soluble solids as influenced by different treatments is shown in Table 26. Higher TSS (%) is desirable for processing purpose. Total soluble solids were significantly varied in different cucumber cultivars under study. The cultivar Multistar possessed the highest total soluble solids (3.65 % and 3.89 %) which was significantly higher than KUK-9 (3.28 % and 3.53 %) during both the years. The least value of TSS was recorded in Kian (2.80 % and 3.04 %). The reason for higher TSS recorded by Multistar may be due to more production and translocation of synthesized carbohydrates into fruits which is the resultant of better growth of the plants of Multistar. Similar observations were reported by Kanwar *et al* (2003); Patel *et al* (2013) Shah *et al* (2016).



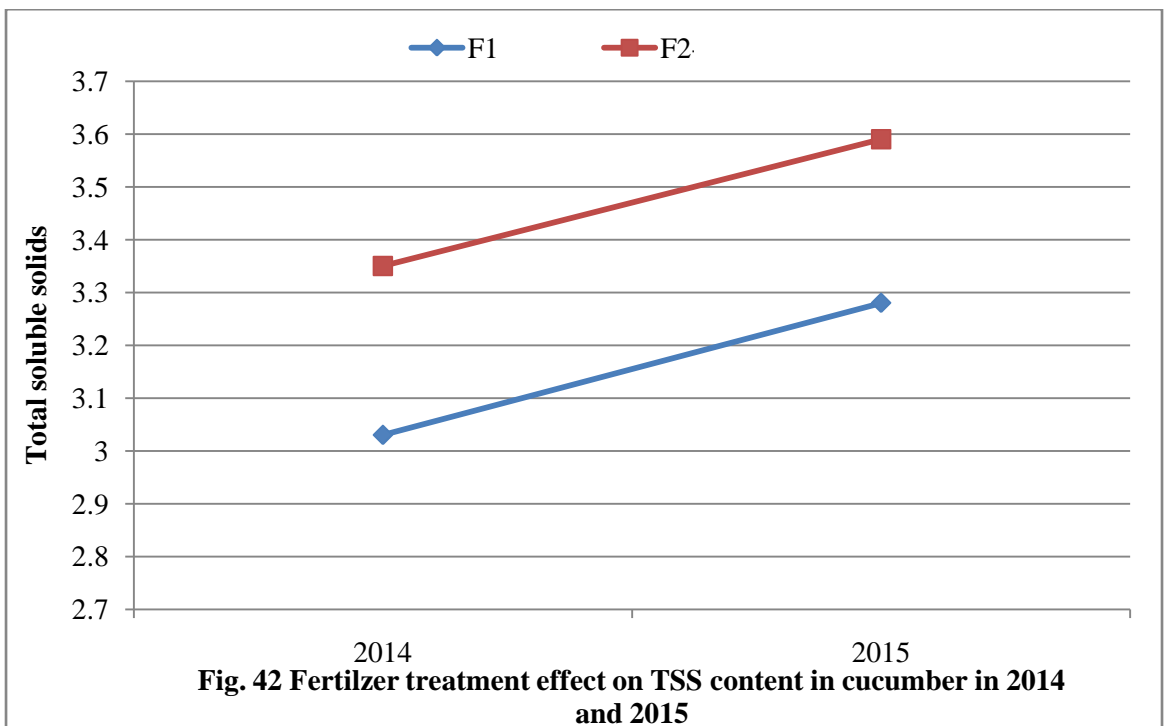
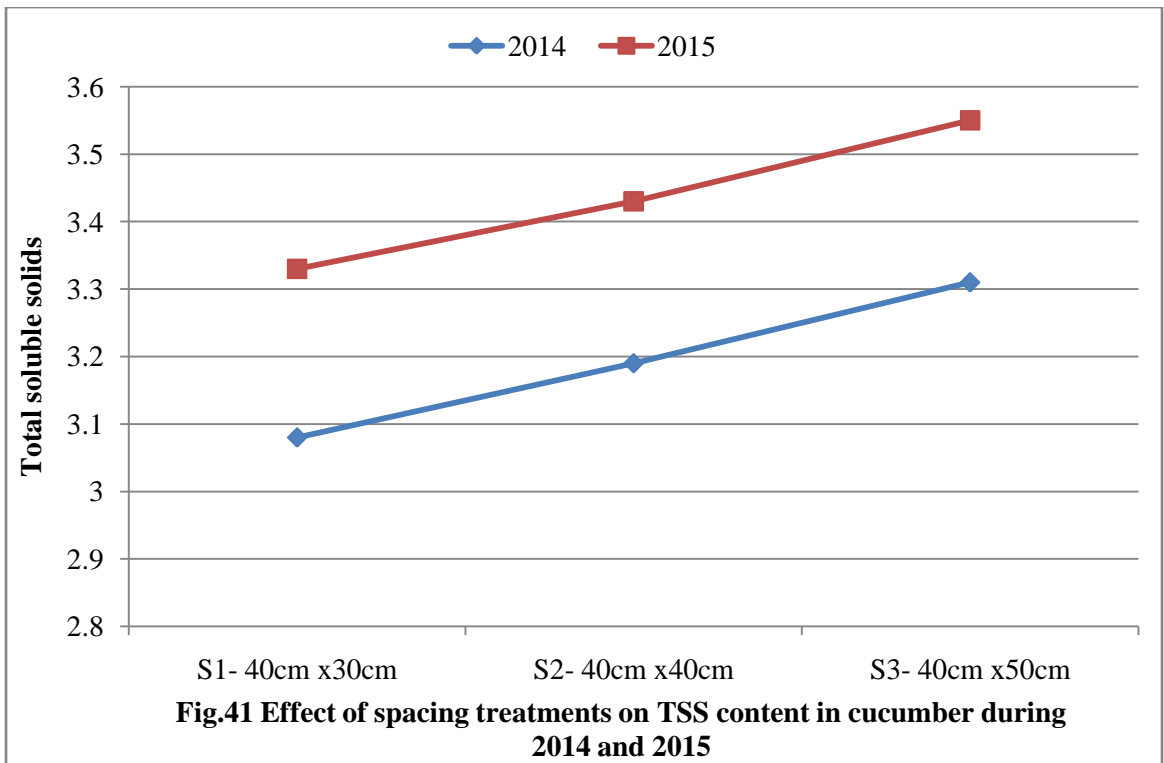


Table 26: Total Soluble Solids (TSS) and Acidity as influenced by different treatments.

Treatments	TSS (%)		Acidity (%)	
	I st Year	II nd Year	I st Year	II nd Year
Cultivars				
V ₁ -Multistar	3.65	3.89	0.128	0.148
V ₂ -Hilton	3.13	3.39	0.121	0.141
V ₃ -Isatis	3.11	3.34	0.119	0.139
V ₄ -Kian	2.80	3.04	0.117	0.137
V ₅ -KUK-9	3.28	3.53	0.125	0.146
C.D at 5 %	0.10	0.15	NS	NS
Spacing				
S ₁ - 40cm x 30cm	3.08	3.33	0.121	0.141
S ₂ - 40cm x 40cm	3.19	3.43	0.122	0.142
S ₃ - 40cm x 50cm	3.31	3.55	0.123	0.142
C.D at 5%	0.30	0.12	NS	NS
Fertilizer				
F1-70:40:90 Kg of NPK per acre	3.03	3.28	0.119	0.139
F2-100:50:125 Kg of NPK per acre	3.35	3.59	0.125	0.146
C.D at 5%	0.25	0.35	NS	NS
Interaction (C.D at 5%)				
V x S	0.19	0.26	NS	NS
V x F	0.15	0.21	NS	NS
S x F	0.12	NS	NS	NS
V x S x F	NS	NS	NS	NS

The study also indicated that TSS content was significantly influenced by plant spacing and it was improved at wider spacing in both the years of the study. Plants spaced at 40 cm x 50 cm recorded significantly higher (3.31 % and 3.55%) TSS as compared to other spacing of 40 cm x 30 cm and 40 cm x 40 cm. This might be due to the effective utilization of sunlight which in turn improved the rate of photosynthesis and translocation of carbohydrates to developing fruits. These results are supported by

the work of Nerson (1998) who reported higher TSS content in cucumber at wider plant spacing.

The plants applied with the fertilizers treatment F2 (100: 50:125) of NPK had recorded significantly the highest TSS to the tune of 3.35 % and 3.59 % in first and second year respectively as compared to treatment F1 (70:40:90) of NPK and values were 3.03 % and 3.28 % in 2014 and 2015, respectively, (Table 26). Al-Moshileh (2017) also reported increased TSS content with higher dose of potassium.

Table 27: Interaction effect for TSS between cultivar and spacing treatments

Factors/Year	S1 (40cm x 30cm)		S2 (40cm x 40cm)		S3 (40cm x 50cm)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	3.36	3.61	3.55	3.80	4.03	4.28	3.65	3.89
V ₂ - Hilton	3.12	3.39	3.09	3.37	3.17	3.44	3.13	3.39
V ₃ - Isatis	3.05	3.28	3.14	3.38	3.13	3.36	3.11	3.34
V ₄ - Kian	2.73	2.97	2.84	3.08	2.84	3.08	2.80	3.04
V ₅ - KUK-9	3.19	3.44	3.30	3.55	3.36	3.61	3.28	3.53
Mean for S	3.08	3.33	3.19	3.43	3.31	3.55	CD at 5% V x S = 0.19 and 0.26	

The effect of cultivar planted at the different plant spacing had significant influenced juice TSS content (Table 27). Maximum TSS content was found in cultivar Multistar planted at the spacing of 40 cm x 50 cm (V₁S₃) and the values were 4.03 % in first year and 4.28 % in second year as compared to other combination. The minimum TSS was observed in V₄S₁ (2.73 % and 2.97 %) during both the years of study. In general, it is concluded that juice TSS was increased with the increased in plant to plant spacings in different cultivars. These results are in conformity with the results of Ejaz *et al* (2011).

Table 28: Interaction effect for TSS between cultivar and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	3.32	3.57	3.98	4.23	3.65	3.89
V ₂ - Hilton	3.01	3.29	3.24	3.51	3.13	3.39
V ₃ - Isatis	2.99	3.22	3.23	3.46	3.11	3.34
V ₄ - Kian	2.69	2.94	2.91	3.15	2.80	3.04
V ₅ - KUK-9	3.16	3.41	3.40	3.65	3.28	3.53
Mean for S	3.03	3.28	3.35	3.59	CD at 5% V x F = 0.15 and 0.21	

Cultivar x fertilizer treatments also influenced the TSS content in all the combination (Table 28) but the maximum was observed in cultivar Multistar applied with fertilizer doses of 100:50:125 Kg of NPK per acre and values were 3.98 % in first year and 4.23 % in second year and the minimum TSS values was observed in V₄F₁ and the values were 2.69 % in first year and 2.94 % in second year. The response of fertilizers was significantly more at higher doses in all the cucumber cultivars.

Table 29: Interaction effect for TSS between spacing and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
S ₁ (40 cm x 30 cm)	2.87	3.12	3.30	3.56	3.08	3.33
S ₂ (40 cm x 40 cm)	3.06	3.30	3.31	3.56	3.19	3.43
S ₃ (40 cm x 50 cm)	3.18	3.43	3.43	3.68	3.31	3.55
Mean for F	3.03	3.28	3.35	3.59	CD at 5% S x F = 0.12 and NS	

It is noted from Table 29 that maximum TSS content (3.43 % in 2014 and 3.68 % in 2015) was found at wider plant spacing i.e. 40 cm x 50 cm and higher doses of fertilizers i.e. F2 (100:50:125) Kg of NPK per acre and the minimum percentage of TSS was observed in S₁F₁ at 40cm x 30cm spacing i.e. (2.87 % in 2014 and 3.12 % in 2015).

4.4.2 Juice acid content

The data presented in Table 26 revealed the effect of different cultivars, spacing and fertilizers on fruit juice acid content. The cultivar Multistar recorded the highest acidity (0.128 % and 0.148 %) during both the years while lowest was observed in cultivar Kian (0.117 % and 0.137%). The cultivars Hilton and Isatis had shown non significant effect with each other in first and second year of study. The cultivars planted at closest plant spacing had produced fruits of low juice acid content in comparison to wider spacing in both the years and the values ranged from 0.121% to 0.141 %. The influence of different cultivars, plant spacing and fertilizer doses did not show significant effect on juice acid content during both the years.

4.4.3 Firmness

Fruit firmness is one of the criteria of fruit quality and is one of the texture which is a complex sensory attribute that also included crispiness and juiciness and important character for storage life and keeping quality. Significantly maximum fruit firmness was observed in cultivar Multistar (14.02 lbf in 2014 and 14.42 lbf in 2015) as compared to KUK-9 (12.58 Kgcm⁻¹ in 2014 and 12.98 in 2015) and the least firmness was observed in cultivar Kian (11.03 lbf in 2014 and 11.43 lbf in 2015). This might be due to the genetic constituent of cultivars. Cultivars viz. Hilton, Isatis and Kian were statistically non significant in both the years.

Table 30: Fruit firmness and Vitamin C as influenced by different treatments

Treatments	Fruit Firmness		Vitamin C	
	I st Year	II nd Year	I st Year	II nd Year
Cultivars				
V ₁ -Multistar	14.02	14.42	6.27	6.52
V ₂ -Hilton	11.59	11.98	4.39	4.63
V ₃ -Isatis	11.18	11.58	3.50	3.73
V ₄ -Kian	11.03	11.43	3.28	3.50
V ₅ -KUK-9	12.58	12.98	5.11	5.35
C.D at 5 %	0.78	0.74	0.19	0.23
Spacing				
S ₁ - 40cm x 30cm	11.14	11.54	3.46	3.69
S ₂ - 40cm x 40cm	12.13	12.53	4.50	4.73
S ₃ - 40cm x 50cm	12.97	13.37	5.58	5.82
C.D at 5%	0.61	0.58	0.15	0.18

Fertilizer				
F1-70:40:90 Kg of NPK per acre	11.60	12.00	3.93	4.17
F2-100:50:125 Kg of NPK per acre	12.56	12.96	5.09	5.33
C.D at 5%	0.49	0.47	0.12	0.14
Interaction (C.D at 5%)				
V x S	NS	NS	NS	NS
V x F	1.10	1.05	0.27	0.32
S x F	0.85	0.81	0.21	NS
V x S x F	1.91	1.82	0.46	0.56

Cucumber cultivars planted under different plant spacings also showed significant effect on fruit firmness. Wider plant spacing had higher values and depict that fruit were firm in texture (Table 30). Plant spacing of 40 cm x 50 cm recorded fruit firmness of 12.97 lbf and 13.37 lbf and the least fruit firmness was recorded at 40 cm x 30 cm (11.14 lbf and 11.54 lbf) during both the years of investigation. Whereas fruit firmness was 12.13 lbf and 12.53 lbf at plant spacing of 40 cm x 40 cm during both the years of study. The applied fertilizer at different doses also had significant effect on fruit firmness. Maximum fruit firmness (12.56 lbf and 12.96 lbf) was recorded in the plants where fertilizers were applied with treatment F₂ (100:50:125kg) of NPK per acre as compared to treatment F₁ (70:40:90kg) of NPK per acre and values were 11.6 lbf in first year and 12.0 lbf in second year of study. Interaction effect between cultivars X plant spacing was found to be non-significant.

Table 31: Interaction effect for firmness between cultivars, spacing and fertilizer treatments

Factors/Year	S1		S2		S3		Mean for V	
	(40cm x 30cm)		(40cm x 40cm)		(40cm x 50cm)			
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
V ₁ - Multistar	12.25	12.62	14.41	14.77	15.42	15.76	14.02	14.42
V ₂ - Hilton	11.33	11.68	11.00	11.35	12.43	12.78	11.59	11.98
V ₃ - Isatis	10.46	10.82	11.41	11.77	11.67	12.01	11.18	11.58
V ₄ - Kian	9.75	10.10	11.08	11.43	12.25	12.60	11.03	11.43
V ₅ - KUK-9	11.92	12.26	12.75	13.10	13.08	13.43	12.58	12.98
Mean for S	11.14	11.54	12.13	12.53	12.97	13.37	CD at 5% = NS	

The interaction between the combination of variety x spacing treatments was non-significant during both the years of study. However, maximum fruit firmness was observed in cultivar Multistar planted at different plant spacings Viz., 40 cm x 30 cm,

40 cm x 40 cm and 40cm x 50 cm in both the years. Fruit firmness in different cultivars ranged from 10.10 lbf to 12.62 lbf under spacing of 40 cm x 30 cm, 11.35 lbf to 15.42 lbf at plant spacing of 40 cm x 40 cm and 11.03 lbf to 14.42 lbf at plant spacing of 40 cm x 50 cm.

Table 32: Interaction effect for firmness between cultivar and fertilizer treatments

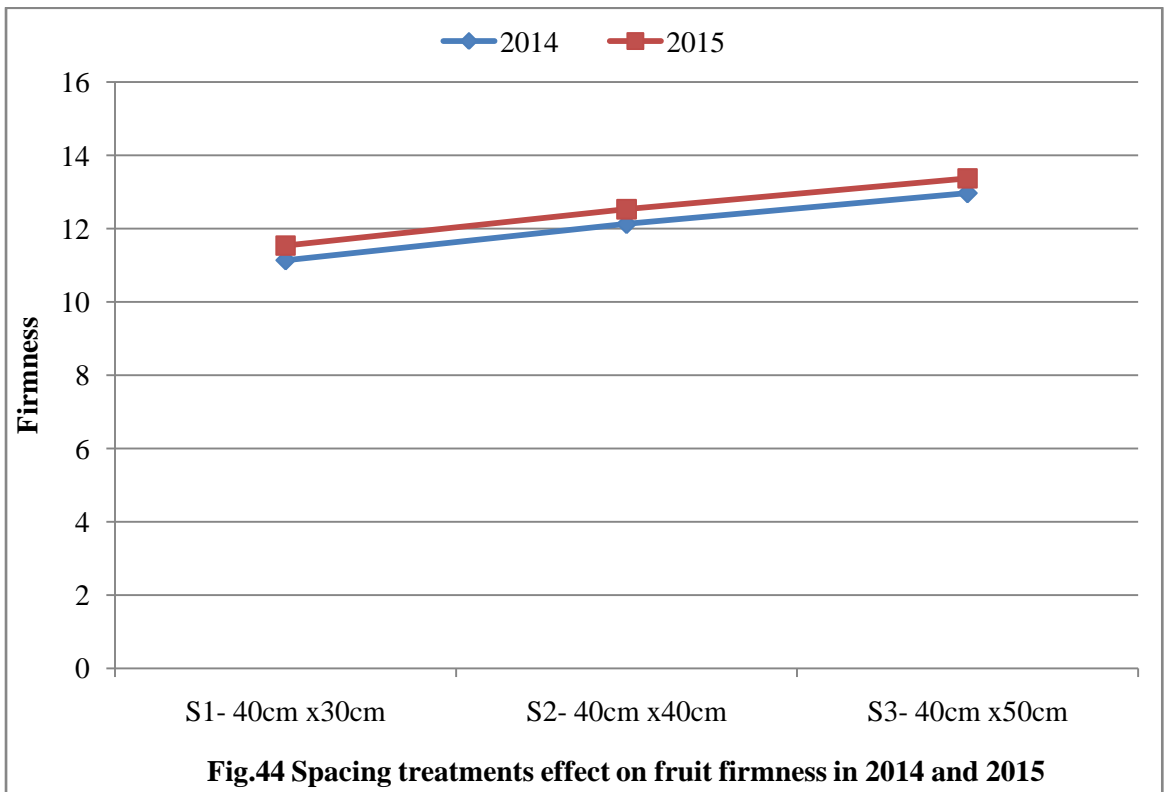
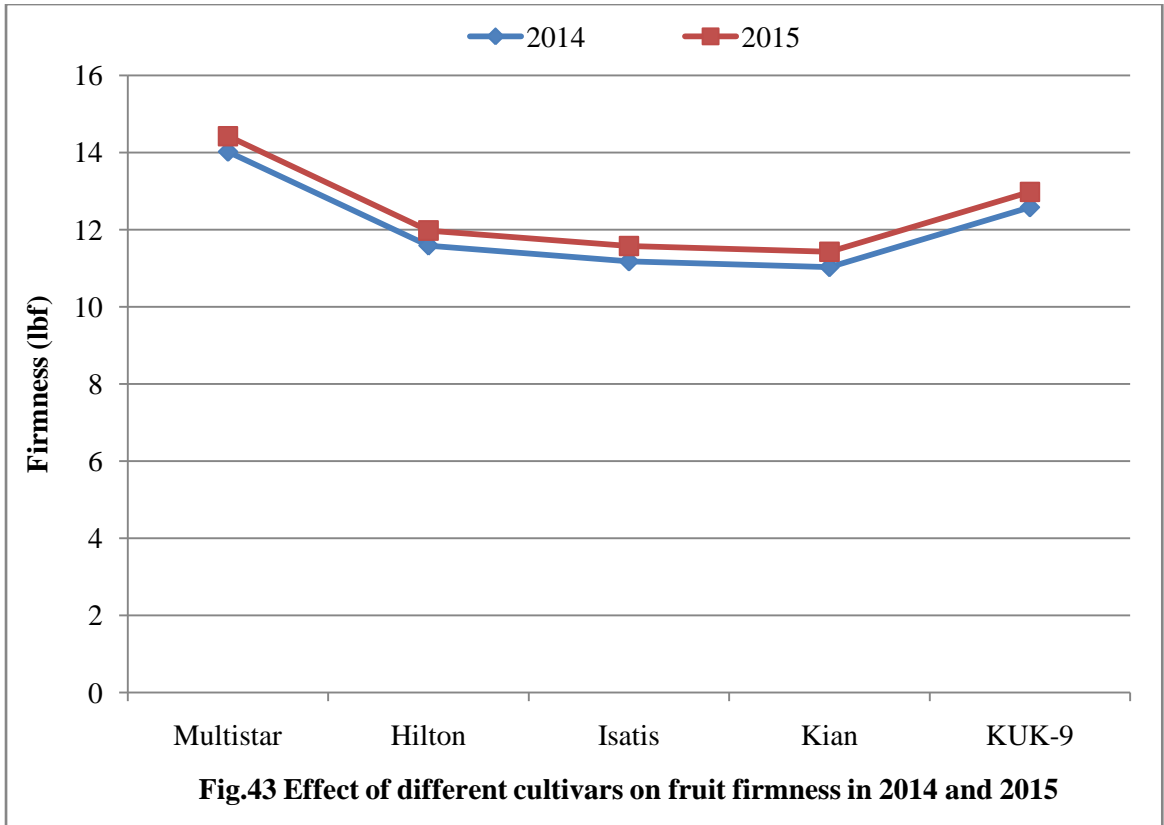
Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	11.40	11.75	16.65	17.02	14.02	14.42
V ₂ - Hilton	11.73	12.08	11.44	11.79	11.59	11.98
V ₃ - Isatis	11.14	11.49	11.22	11.57	11.18	11.58
V ₄ - Kian	11.33	11.68	10.72	11.07	11.03	11.43
V ₅ - KUK-9	12.39	12.74	12.78	13.13	12.58	12.98
Mean for S	11.60	12.00	12.56	12.96	CD at 5% 1 st yr = 1.10 2 nd yr = 1.05	

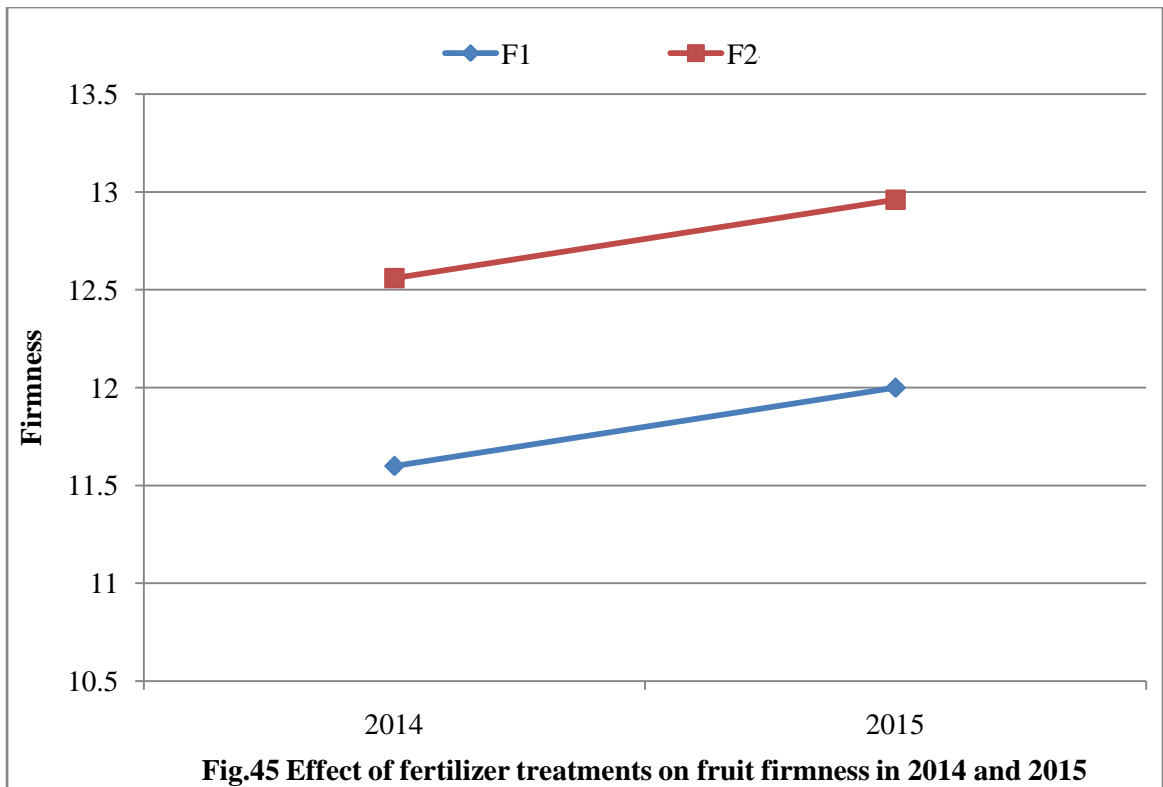
It is cleared from Table 32 that all the cucumber cultivars responded significantly to the different doses of fertilizers in term of fruit firmness being maximum in cultivar ‘Multistar’ where fertilizer doses were applied in the ratio of 100:50:125 Kg of NPK per acre (V₁F₂) and values were 16.65 lbf and 17.02 lbf in 2014 and 2015, respectively, and the minimum fruit firmness (11.14 lbf in 2014 and 11.49 lbf in 2015) was recorded in cultivar ‘Isatis’ under the combined fertilizer doses of 70:40:90 Kg of NPK per acre. Overall, all the cucumber cultivars under study respond positively and had higher fruit firmness when fertilizers were applied at higher doses i.e. N:P:K per acre (100:50:125Kg). In first and second year of study, fruit firmness was varied from 11.14 lbf in Isatis to 12.74 lbf in KUK-9 when fertilizers were applied in the combination of 70:40:90 Kg of NPK per acre and 10.72 lbf in cultivar Kian.

Table 33: Interaction effect for firmness between spacing and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
S ₁ (40 cm x 30 cm)	10.23	10.58	12.06	12.42	11.14	11.54
S ₂ (40 cm x 40 cm)	11.80	12.15	12.47	12.82	12.13	12.53
S ₃ (40 cm x 50 cm)	12.77	13.12	13.16	13.52	12.97	13.37
Mean for F	11.60	12.00	12.56	12.96	CD at 5% 1 st yr= 0.85 2 nd yr = 0.81	

The interaction studies between different spacing and fertilizer treatments is mentioned in Table 33 revealed that fruit firmness was affected significantly in all the combinations. Maximum fruit firmness was observed when plants were spaced at 40 cm x 50 cm and fertilizer doses of 100:50:125 Kg of NPK per acre was applied and values were 13.16 lbf in 2014 and 13.52 lbf in 2015 which was statistically at par with S₂F₂ combination (12.47 lbf and 12.82 lbf), S₃F₁ (12.77 lbf and 13.12 lbf) during both the years of study. The least value of firmness was found in S₁F₁ combination i.e. (10.23 lbf and 10.58 lbf). In general, cucumber plants planted at wider spacing responded significantly to higher doses of fertilizers. At treatment F1 (70:40:90Kg) of NPK per acre fruit firmness values ranged from 10.23 lbf under spacing of 40 cm x 30 cm to 13.12 lbf under 40 cm x 50 cm.





4.4.4 Vitamin C

The data in Table 30 depicted that vitamin C was influenced by different treatments. Different cultivars had significant influence on quality of cucumber. Vitamin-C is another parameter of quality of cucumber. The maximum content of vitamin-C was recorded in cultivar Multistar (6.27 mg/100 g and 6.52 mg/100g) which was significantly higher than rest of the cultivars followed by KUK-9 (5.11 mg/100 g and 5.35 mg/100 g) and the least vitamin-C content was recorded in cultivar Kian (3.28 mg/100 g and 3.50 mg/100 g) when plants were planted at 40 cm x 30 cm, 40 cm x 40 cm and 40 cm x 50 cm. This is due to the varietal genetical characteristics and more efficient metabolism process in the cultivar. These results are in line with the findings Rahayu *et al* (2011); Patel *et al* (2013) and Shah *et al* (2016).

The plants applied with the fertilizers treatment F2 (100: 50:125) of NPK had recorded significantly the highest Vitamin C to the tune of 5.09 mg/100 g and 5.33 mg/100 g in first and second year respectively as compared to treatment F1 (70:40:90) of NPK and values were 3.93 mg/100 g and 4.17 mg/100 g in first and second year of the study. The results obtained are in line with findings of Narayanamma *et al* (2010).

Table 34: Interaction effect between cultivar and spacing treatments for Vitamin-C

Factors/Year	S1 (40cm x 30cm)		S2 (40cm x 40cm)		S3 (40cm x 50cm)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	5.25	5.50	6.12	6.38	7.44	7.69	6.27	6.52
V ₂ - Hilton	3.24	3.48	4.39	4.62	5.57	5.81	4.39	4.63
V ₃ - Isatis	2.46	2.68	3.52	3.75	4.52	4.75	3.50	3.73
V ₄ - Kian	2.24	2.46	3.35	3.57	4.27	4.49	3.28	3.50
V ₅ - KUK-9	4.12	4.36	5.11	5.35	6.11	6.35	5.11	5.35
Mean for S	3.46	3.69	4.50	4.73	5.58	5.82	CD at 5% = NS	

Interaction was found to be non-significant between cultivars and spacing.

Table 35: Interaction effect between cultivar and fertilizer treatments for Vitamin-C

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
V ₁ - Multistar	5.45	5.69	7.10	7.35	6.27	6.52
V ₂ - Hilton	3.85	4.09	4.94	5.18	4.39	4.63
V ₃ - Isatis	2.99	3.22	4.00	4.23	3.50	3.73
V ₄ - Kian	2.76	2.99	3.81	4.03	3.28	3.50
V ₅ - KUK-9	4.61	4.84	5.61	5.85	5.11	5.35
Mean for F	3.93	4.17	5.09	5.33	CD at 5% 1 st yr = 0.27 2 nd yr = 0.32	

The effect of different cultivars to different fertilizer doses is shown in Table 35. All cultivars behaved differently to the applied fertilizer doses and maximum vitamin C content was recorded in cultivar Multistar, followed by KUK-9, Hilton, Isatis and Kian in the both the years under investigation. Treatment F2 (100:50:125kg) of NPK

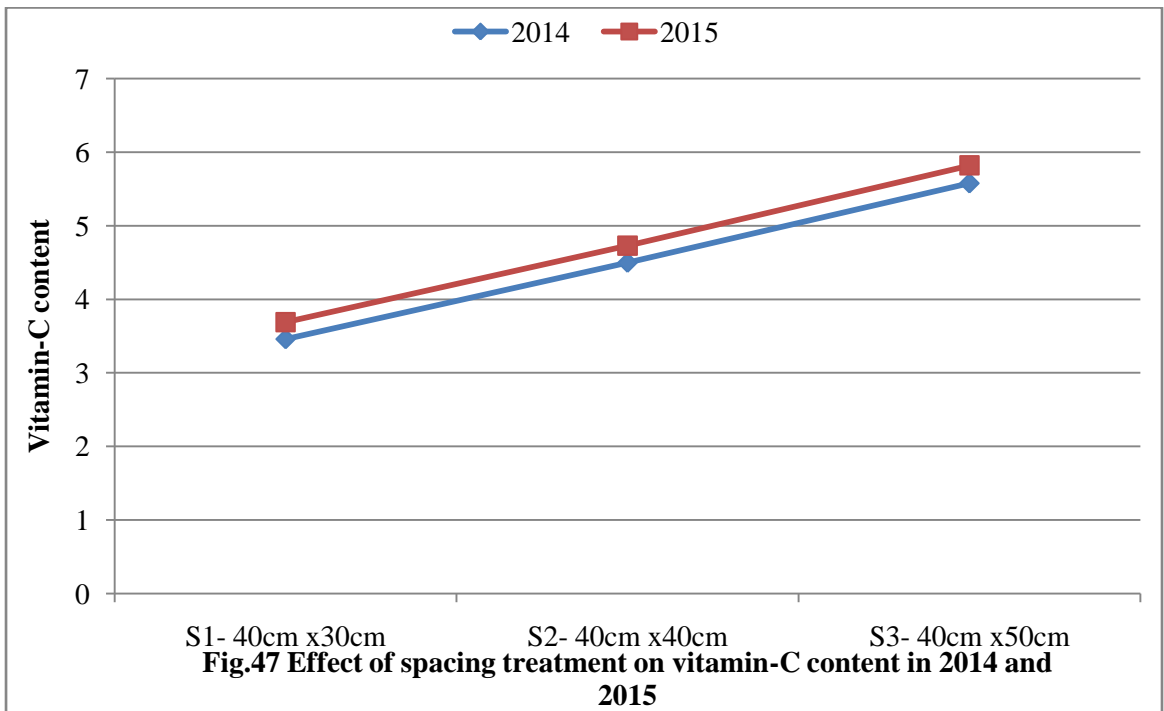
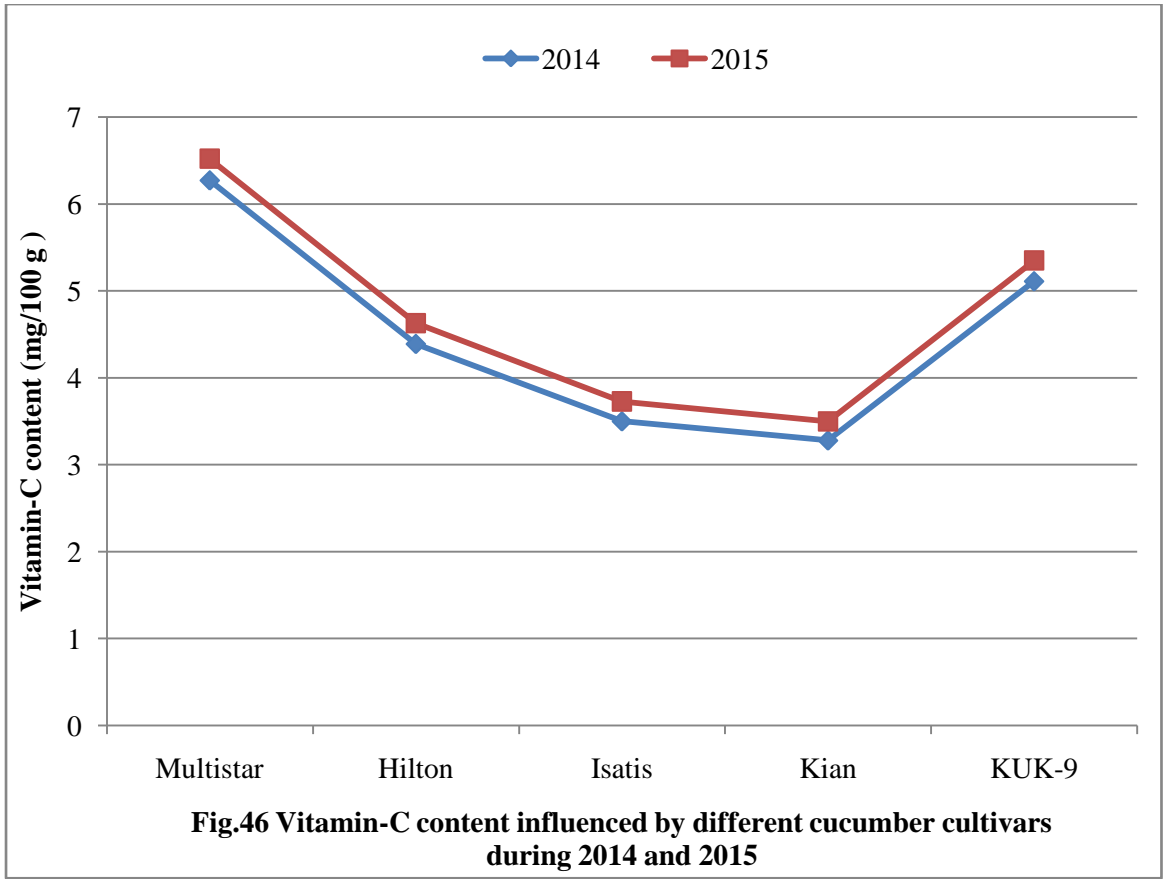
per acre recorded maximum content of vitamin-C (5.09 mg/100 g and 5.33 mg/100 g) as compared to treatment F1 (70:40:90kg) of NPK per acre (3.93 mg/100 g and 4.17 mg/100 g) during both the years of study.

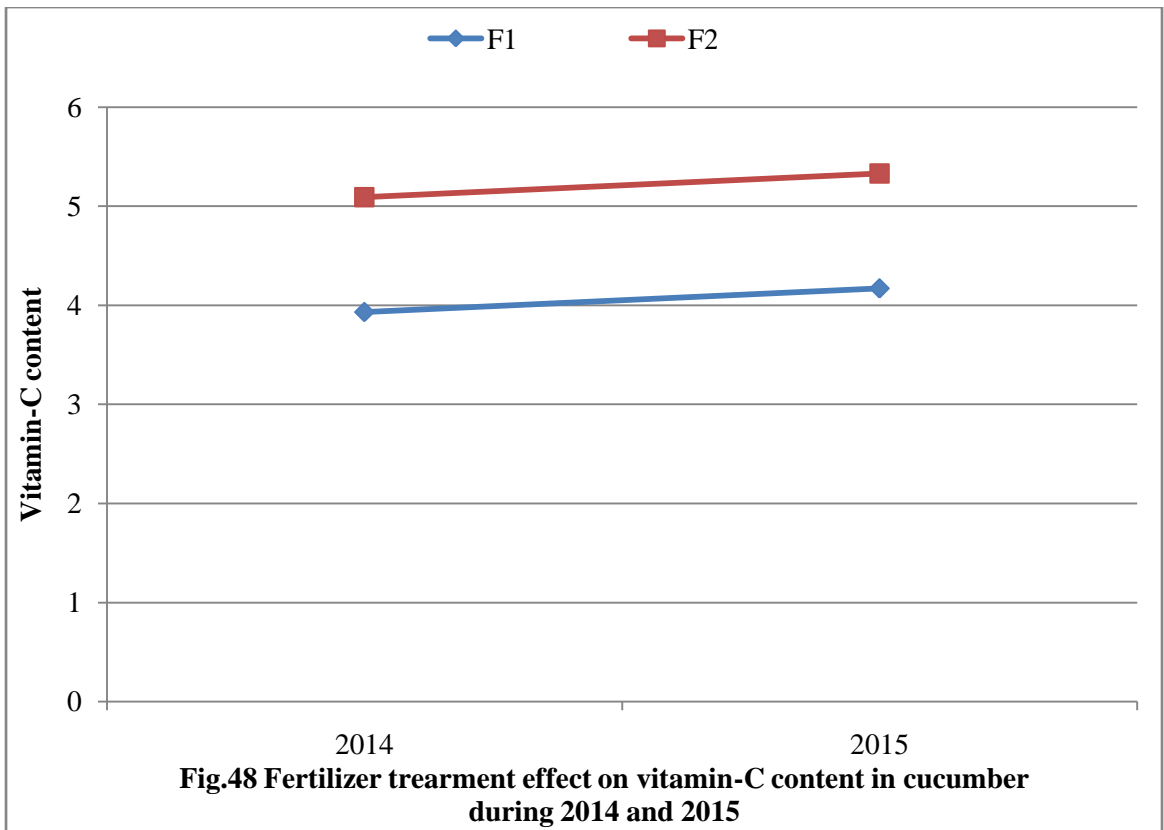
In Table 35, vitamin C content was significantly influenced between different cultivars and fertilizer combinations is mentioned. The maximum vitamin-C content was found in treatment combination of V₁F₂ i.e. (7.10 mg/100 g and 7.35 mg/100 g) which was significantly higher as compared to rest of the combinations. The least value of vitamin-C content was found in combination of V₄F₁ i.e. (2.76 mg/100 g and 2.99 mg/100 g) during both the years.

Table 36: Interaction effect for Vitamin-C, between spacing and fertilizer treatments

Factors/Year	F1 (70:40:90 Kg of NPK)		F2 (100:50:125 Kg of NPK)		Mean for V	
	1 st yr	2 nd yr	1 st yr	2 nd yr	1 st yr	2 nd yr
S ₁ (40 cm x 30 cm)	2.76	2.99	4.16	4.40	3.46	3.69
S ₂ (40 cm x 40 cm)	3.98	4.22	5.02	5.25	4.50	4.73
S ₃ (40 cm x 50 cm)	5.06	5.30	6.11	6.34	5.58	5.82
Mean for F	3.93	4.17	5.09	5.33	CD at 5% 1 st yr= 0.21 2 nd yr = NS	

Spacing and fertilizer treatment combinations significantly influenced vitamin-C content in all the treatment combinations (Table 36). The maximum value of vitamin-C was found in treatment combination of S₃F₂ i.e. (6.11 and 6.34) which was significantly higher than rest of the combination and the least value of vitamin-C was found in treatment combination of S₁F₁ (2.76 and 2.99) during both the years of experimentation.





SUMMARY AND CONCLUSION

The experiment entitled. “Effect of Crop Geometry and Fertigation on Quality and Yield of Parthenocarpic Cucumber Cultivars Under Protected Conditions” was conducted during September to December 2014 and 2015 at Centre of Excellence for Vegetables, Kartarpur, Jalandhar with the following objectives in view:

- To find out suitable cultivar for protected cultivation under Punjab conditions.
- To assess the response of cucumber cultivars to variable crop geometry under polyhouse conditions.
- To assess the response of cucumber cultivars to fertigation under polyhouse.
- To identify the best spacing and fertigation schedule for obtaining high yield in cucumber under protected conditions.

The experiment was laid out in a factorial randomized block design with three replications, consisting of 30 treatments having combinations of five cultivars viz., Multistar, Hilton, Isatis, Kian and KUK-9, three spacings viz., 40 cm x 30 cm, 40 cm x 40 cm and 40 cm x 50 cm and two fertilizer treatments viz., F1 (70:40:90 Kg of NPK per acre) and F2 (100:50:125 Kg of NPK per acre)

The observation on growth development, yield attributes, yield and quality of fruit were recorded to explain the effect of treatments. The important findings are summarized as under.

Significantly more number of branches were produced in Multistar cultivar and the least number of branches were produced in Kian cultivar during both the years of investigation. Multistar, KUK 9 and Hilton cultivars were statistically at par with each other, similarly cultivars Isatis and Kian were also statistically at par with each other. Among different spacing treatments, significantly highest numbers of branches were produced in spacing of 40 cm x 50 cm. The number of branches in spacing S2 and S3 were significantly higher as compared to spacing of 40 cm x 30 cm. Among fertilizer treatments, there was more numbers of branches produced in treatment (F2) 100:50:125 Kg of NPK per acre which was significantly higher than treatment (F1) 70:40:90 Kg of NPK per acre.

Internode distance determines the height and number of nodes per plant. Internode distance was recorded significantly less in Multistar cultivar (8.76 cm and 8.81 cm) which was statistically at par with cultivar KUK9 (8.92 cm and 8.94 cm) followed by Hilton (9.32 cm and 9.34 cm), Isatis (9.38 cm and 9.43 cm) and Kian (9.46 cm and 9.50 cm) during both the years of study. Cultivars Hilton, Isatis and KUK9 were statistically at par with each other during the study. Plant spacing had significant effect on internode distance. Wider spacing (40 cm x 50 cm) resulted in smaller internode distance as compared to the spacings of 40 cm x 40 cm and spacing of 40 cm x 30 cm. Fertilizer treatment also had effect on internode distance. The treatment F2 gave significantly smaller internode distance (8.66 cm and 8.69 cm) as compared to F1 treatment i.e. 9.67 cm and 9.71 cm.

Vine girth was significantly influenced by cultivars. Significantly maximum vine girth was recorded in Multistar cultivar which was statistically at par with cultivar Hilton, Isatis and KUK9 during the experiment. Cultivars Multistar, Hilton, Isatis and KUK9 recorded significantly maximum vine girth as compared to Kian cultivar. The vine girth also increased significantly due to different spacings, out of which the spacing of 40 cm x 50 cm produced significantly thicker plants which was statistically at par with the spacing of 40 cm x 40 cm and 40 cm x 30 cm. Similarly, spacing of 40 cm x 40 cm and 40 cm x 30 cm were also statistically at par with each other. Fertilizer treatments showed significant effect on vine girth during the study. Treatment F2 recorded significantly maximum vine girth which was statistically at par with the treatment F1.

It is revealed from the results that the vine length at maturity was significantly influenced by cultivars. Significantly maximum vine length was recorded in Multistar cultivar (3.63 m and 3.69 m) as compared to other cultivars such as Hilton (3.41 and 3.45 m), Isatis (3.14 m and 3.19 m), Kian (2.81 m and 2.85 m) and KUK9 (3.31 m and 4.11 m). Plant spacing also had significant effect on vine length during the study. Significantly maximum vine length was recorded in at a spacing of 40cm x 50cm as compared to rest of the spacing treatments but was statistically at par with the spacing of 40 cm x 40 cm. Similarly, spacing of 40 cm x 40 cm was statistically at par with the spacing of 40 cm x 30 cm during both the years of study. Fertilizer treatments had significant effect on vine length at maturity stage. Among different fertilizer

recommendation, the treatment F2 recorded significantly maximum vine length which was significantly higher as compared to F1 treatment.

The data regarding days to first female flower appearance showed that the response of different cultivars was non-significant during the study. Similarly, the effect of different spacing treatments on number of days to first female flower appearance was also found to be non-significant. The effect of two fertilizer treatments on the days to first female flower appearance of cucumber was also found to be non-significant.

With respect to the node number at which first female flower appears, the cultivar Kian recorded better position of node at which first female flower appears (3.44 and 3.50) which was significantly differed than other cultivars KUK9 (4.00 and 4.12), Hilton (3.94 and 4.03), Isatis (3.89 and 3.90) and Multistar (4.0 and 4.07) during both the years of study. Plant spacing also had significant effect on the position of node at which first female flower appears. The close spacing i.e. 40 cm x 30 cm gave significantly better node position (3.63 and 3.70) for the appearance of first female flower than other two spacing of 40 cm x 40 cm (3.83 and 3.90) and 40 cm x 50 cm (4.10 and 4.17). Fertilizer treatments also had significant effect on the node number at which the first female flower appears. Plant which are fertilized with treatment F1 (3.69 and 3.76) gave significantly better result for female flower appearance on node as compared to treatment F2 (4.02 and 4.09).

With respect to varietal response to first fruiting/picking, it was significantly early in Multistar cultivar followed by KUK-9 cultivar followed by Hilton and Isatis cultivars. Among different spacings, spacing of 40 cm x 50 cm showed significantly lesser number of days to first fruiting as compared to spacing of 40 cm x 30 cm but spacing of 40 cm x 40 cm and 40 cm x 30 cm were statistically at par with each other. Among fertilizer treatments, in treatment F2, the number of days to first fruiting was significantly less as compared to F1 treatment which took more number of days to first fruiting.

Fruit length is another important factor in cucumber crop which is considered a crucial component that markedly affects the yield. Fruit length was affected by different treatments. The fruit length of five different cultivars responded differently. Significantly maximum fruit length was recorded in Multistar cultivar (15.51 cm and

16.27 cm) as compared to rest of the cultivars under study. Hilton, Isatis, Kian and was statistically at par with KUK-9 cultivar. Multistar and KUK-9 were statistically at par with each other. Spacing treatments also had significant effect on fruit length. Spacing of 40 cm x 50 cm gave significantly maximum fruit length (15.20 cm and 15.66 cm) followed by 40 cm x 40 cm spacing (14.77 cm and 15.23 cm) followed by 40 cm x 30 cm spacing (14.17 cm and 14.63 cm) during both the years of study. Fertilizer treatments also influenced the fruit length where F2 led to maximum fruit length (15.58 cm and 16.04 cm) as compared to treatment F1 (13.84 cm and 14.30 cm) during both the years of experimentation.

The number of fruits per vine was different in different cultivars. Significantly maximum fruit number per vine was recorded in Multistar cultivar i.e. 43.00 and 44.50 which was statistically at par with KUK-9 cultivar (41.61 and 42.74) and Hilton cultivar (40.67 and 41.45) and cultivars Isatis and Kian were statistically at par with each other. Treatments of plant spacing also showed that the spacing of 40 cm x 50 cm recorded significantly maximum fruit per vine (41.33 and 42.33) which was statistically at par with a spacing of 40 cm x 40 cm (39.77 and 40.76) and spacing of 40 cm x 30 cm treatment (38.40 and 39.36). Treatment F2 (42.10 and 42.60) gave significantly more number of fruits per vine as compared to F1 treatment (37.56 and 39.03) during both the years of experiment.

Among different cultivars, the fruit weight was significantly maximum in Multistar cultivar (117.08 g and 118.65 g) and the least one was in cultivar Kian i.e. 100.97 g and 102.99 g during both the years of experiment. With respect to different spacing treatments, spacing of 40 cm x 50 cm recorded significantly more fruit weight (110.95 g and 112.41 g) as compared to spacing of 40 cm x 30 cm (105.72 g and 107.18 g) and was statistically at par with the spacing of 40 cm x 40 cm (108.52 g and 109.98 g). The significantly maximum fruit weight was recorded in treatment F2 (111.95 g and 113.41 g) give through F2 treatment as compared to treatment of F1 (104.84 g and 106.30 g) during both the years of experiment.

Fruits obtained from the cultivar Multistar had significant maximum fruit diameter (4.63 cm and 4.81 cm) as compared to other cultivars. Cultivar Kian had less fruit diameter (4.04 cm and 4.27 cm) than all other cultivars. Cucumber planted under different spacing treatments influenced the fruit diameter. The fruits produced at

spacing 40 cm x 50 cm gave significantly higher fruit diameter (4.48 cm and 4.67 cm) than other spacing treatments. The lowest fruit diameter was recorded at spacing of 40 cm x 30 cm (4.02 cm and 4.21 cm). Fruit diameter was also influenced by different fertilizer treatments significantly. The maximum fruit diameter was recorded in F2 treatment (4.54 cm and 4.70 cm) as compared to F1 treatment (3.97 cm and 4.17 cm) during both the years of study.

Total fruit yield per vine was significantly influenced by cultivars. The total fruit yield per vine obtained from cultivar Multistar was significantly higher (4.41 Kg and 5.30 Kg) which was statistically at par with cultivars KUK-9 (4.29 Kg and 5.21 Kg), Hilton (4.29 Kg and 5.07 Kg) and Isatis (4.23 Kg and 5.06 Kg). Cultivar Multistar recorded (11.33 and 12.07 per cent) higher total fruit yield per vine over the Kian cultivar. Plant spacing also had significant effect on total fruit yield per vine. The crop which was planted at a spacing of 40 cm x 50 cm recorded significantly higher total fruit yield per vine (4.80 Kg and 5.64 Kg) as compared to 40 cm x 40 cm (4.22 Kg and 5.05 Kg) and 40 cm x 30 cm (3.65 Kg and 4.49 Kg), respectively. Similarly, total fruit yield at spacing of 40 cm x 40 cm was also significantly higher as compared to 40cm x 30cm during the study. Spacing of 40 cm x 50 cm recorded 23.95 and 20.39 per cent higher fruit yield over 40 cm x 30 cm and 12.08 and 10.46 per cent over 40 cm x 40 cm during 2014 and 2015, respectively. The effect of fertilizer treatments also showed significant effect on total fruit yield per vine (Kg) during the study. Treatment F2 recorded significantly higher total fruit yield per vine (4.81 Kg and 5.64 Kg which was 21.73 and 18.31 per cent higher as compared to treatment F1 which recorded 3.63 Kg and 4.48 Kg fruit.

Fruit drop is another important factor which responds to five cucumber cultivars and was significantly different with respect to each other. Significantly lesser fruit drop (%) was recorded in Multistar cultivar as compared to other cultivars during both the years of study. The maximum fruit drop percentage was recorded in cultivar Kian which was statistically at par with Isatis cultivar and which was also statistically at par with Hilton cultivar. Spacing effect also showed significant effect on fruit drop (%) during the experiment. The maximum fruit drop (%) was recorded at a spacing of (40 cm x 30 cm) i.e. 13.23 and 13.45 which was statistically at par with the spacing of 40 cm x 40 cm i.e. 12.69 and 12.98 and the lowest fruit drop percentage was recorded at a spacing of 40 cm x 50 cm. The treatments of fertilizer recorded maximum fruit

drop percentage in treatment F1 (13.09 and 13.36) as compared to F2 treatment (12.26 and 12.48) during both the years of experiment.

Total soluble Solids (TSS) recorded highest in hybrid Multistar (3.65 and 3.89) in both the years of investigation at plant spacing of 40 cm X 50 cm under F2 treatment. The data pertaining to acidity was found non-significant among different treatments. Maximum fruit firmness was recorded in hybrid Multistar at plant spacing of 40 cm X 50 cm under F2 treatment. Likewise, Vitamin C content was also found maximum in Multistar at wider plant spacing and F2 treatment.

Conclusion

- The cultivar Multistar responded better than rest of the cultivars of cucumber under study.
- The cultivar Multistar gave significantly higher values of all parameters in comparison to other cultivars.
- The plants planted at wider spacing of 40 cm x 50 cm gave maximum yield and all yield contributing attributes than other spacings.
- The cultivar Multistar of cucumber produced significantly higher fruit yield as compared to other cultivars.

It is thus concluded from the investigation that the cultivar Multistar is the best which should be planted at distance of 40 cm X 50 cm and fertilized with 100:50:125 Kg of NPK per acre to get maximum yield of cucumber.

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