Indian Journal of Agricultural Sciences **88** (1): 63–9, January 2018/Article

Effect of planting time and fertilizer dose on growth, yield and quality of parthenocarpic cucumber (*Cucumis sativus*) grown under polyhouse and nethouse conditions

S Y MARAGAL[1], A K SINGH[2], T K BEHERA[3], A D MUNSHI[4] and SUKANTA DASH[5]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Received: 5 May 2017; Accepted: 11 September 2017

ABSTRACT

An experiment was conducted to study the effect of planting time and fertilizer dose on growth, yield and quality of cucumber (*Cucumber sativa* L.) var. Pusa Seedless Cucumber 6 under two different protected structures. Experiment was laid out in factorial randomized block design with 3 replications. The treatments were formulated with four fertilizer levels (15:7:16, 20:12:21, 25:17:26 and 30:22:31 kg NPK/ha) and three date of plantings (15 August, 1 September and 15 September) under two different protected structures (insect proof nethouse and naturally ventilated polyhouse). Among the combinations, 15 September planting with 30:22:31 kg NPK/ha showed highest interaction effect for number of fruits/plant (20.20), fruit weight (134.11 g), yield/plant (2709.1 g), yield/1000 m^2 (180.61 q), nitrogen (59 mg/100 g), phosphorus (27.33 mg/100 g), potassium (150.0 mg/100 g), calcium (11.29 mg/100 g), iron (0.23 mg/100 g) and zinc (0.22 mg/100 g) content of fruit under polyhouse. Based on these findings, it is recommended that the application of fertilizers at the rate of 30:22:31 kg NPK/ha on 15 September planting under naturally ventilated polyhouse is economical and found suitable for the successful growth, yield and quality of cucumber for higher productivity.

Key words: *Cucumis sativus*, Fertilizer dose, Flowering, Planting time, Quality, Yield

Cucumber (*Cucumis sativus* L.) is one of the most important vegetable crops of the family cucurbitaceace, cultivated as salad crop, which quenches thirst and add to the nutrient content of human diet, whereas non-desserts are used as vegetables (Chadha and Lal 1993). Fruits are good for people suffering from jaundice, constipation, and indigestion. The global production of cucumber is 71.36 million tonnes (FAOSTAT 2014) and in India it is grown in 43 thousand ha with an annual production of 678.00 thousand tonnes (NHB 2014). Nowadays cucumber production is gaining importance due to spread of awareness among consumers regarding its medicinal properties leading to elevated demand and higher yield and income in short period of time which is attracting more farmers to cultivate. However, frost injury during winter season is the limiting factor for successful cultivation during winter which adversely affects the overall morphological growth, fruit set and ultimately interrupts supply chain. Under such prevailing condition, protected cultivation under polyhouse and insect proof nethouse can be a viable option to provide specified climate for crop growth. Presently cucumber is gaining popularity for green house production due its indeterminate vine growth, response to training and pruning and development of gynoecious parthenocarpic hybrids which set fruits parthenocarically extended area of cucumber under green house production.

In crops like cucurbits, mere providing specified climate for crop is not sufficient because other factors like planting time and nutrient composition especially nitrogen are also known to have decisive role in successful production with enhanced productivity via affecting sex expression. Very few reports are available on cucumber production under protected condition in India. Hence present investigation was undertaken to find the proper planting time and fertilizer dose for the cucumber var. Pusa Seedless Cucumber 6 under polyhouse and nethouse conditions.

MATERIALS AND METHODS

The experiment was conducted at Centre for Protected Cultivation Technology (CPCT), Indian Agricultural Research Institute (IARI), New Delhi, India during August 2015 to January 2016. Experiment was laid out in

[1]Ph D Scholar (e mail: siddu271@gmail.com), [2]Senior Scientist (e mail: singhawani5@gmail.com), [3]Professor and Principal Scientist (e mail: tusar@rediffmail.com), [4]Principal Scientist (e mail: anilbhm@yahoo.co.in), Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi 110 012. [5]Scientist (e mail: sukanta.dash@icar.gov.in), ICAR-Indian Agricultural Statistics Research Institute, New Delhi 110 012.

factorial randomized block design with three replications. The treatments were formulated with four different dose of NPK fertilizers applied at rate of 15:7:16 kg/ha (D_1), 20:12:21 kg/ha (D_2), 25:17:26 kg/ha (D_3) and 30:22:31 kg/ha (D_4) at three date of plantings, *viz.* 15 August (P_1), 1 September (P_2) and 15 September (P_3) under two different protected structures, viz. insect proof nethouse (S_1) and naturally ventilated polyhouse (S_2) each of size 500 m^2. Planting of gynoecious, parthenocarpic cucumber variety Pusa Seedless Cucumber- 6 was done at spacing of 50 × 30 cm and all the recommended cultural practices were carried throughout the growing season. To meet the requirement of recommended doses of plant nutrients, urea (46:0:0), urea phosphate (17:44:0) and potassium sulphate (0:0:50) were taken as source of nitrogen, phosphorus and potassium respectively. Fruits were oven dried at 70°C and crushed into powder form to determine the fruit mineral content. For nitrogen content, samples were digested according to the method of Chapaman and Pratt (1961) and total nitrogen content was determined using Kjeldhal method. Phosphorus content was determined using the calorimetric method developed by Jackson (1962). According to the method of Knudsen *et al*. (1982), potassium content was determined by Flame photometer. For trace elements analysis, the method developed by Edward (1999) was applied using atomic absorption spectrophotometer (AAS). Data were analyzed using the SAS package (9.3 SAS Institute, Inc, USA). The F values and P values ≤ 0.05 were calculated and considered as significant.

RESULTS AND DISCUSSION

Effect on flowering traits

The effect of different treatment combinations on flowering characters are presented in Table 1. Among the protected structures, first female flower noticed on early node of 1.75 after 22.24 days of sowing under polyhouse. Data on fertigation levels showed that lesser number of days required for the initiation of first female flower at higher dose of fertilizers application. The result revealed that first female flower produced on early node of 1.64 after 22 days of sowing by application of 30:22:31 kg NPK/ha under polyhouse. The results obtained were in agreement with report of Choudhari and More (2002). The date of planting exhibited marked influence on flowering related characters of cucumber that, first female flower produced 20.75 days of after sowing on early node of 1.55 at 15 September planting under nethouse. The flowering coincided with low temperature in last planting which revealed that low temperature had correlation with earliness in parthenocarpic cucumber (Narayanankutty *et al*. 2013). Among the combinations, 15 September planting with

Table 1 Effect of planting time and fertilizer dose on days to opening and node of first female flower appearance of cucumber var. Pusa Seedless Cucumber 6 under polyhouse and nethouse conditions

Treatment	Days to opening of first female flower								Node at first female flower appearance							
	Date of plantings								Date of plantings							
	Nethouse (S1)				Polyhouse (S2)				Nethouse (S1)				Polyhouse (S2)			
(N:P:K)	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
D_1	23.80	23.27	21.07	22.71	23.47	23.40	20.07	22.31	2.20	1.80	1.47	1.82	1.53	1.80	1.67	1.67
D_2	24.27	23.33	20.53	22.71	23.47	23.13	20.93	22.51	2.20	1.53	1.67	1.80	1.67	1.80	1.63	1.70
D_3	24.40	22.93	20.87	22.73	23.20	22.87	20.40	22.16	2.13	1.73	1.53	1.80	2.53	1.67	1.73	1.98
D_4	24.07	23.00	20.53	22.53	23.67	21.33	21.00	22.00	2.40	1.87	1.53	1.93	1.60	1.73	1.60	1.64
Mean	24.13	23.13	20.75	22.67	23.45	22.68	20.60	22.24	2.23	1.73	1.55	1.84	1.83	1.75	1.66	1.75

D_1: 15:7:16 kg/ha, D_2: 20:12:21 kg/ha, D_3: 25:17:26 kg/ha, D_4: 30:22:31 kg/ha; P_1: 15 August, P_2: 1 September, P_3: 15 September

Table 2 Effect of planting time and fertilizer dose on fruit length (cm) and fruit diameter (cm) of cucumber var. Pusa Seedless Cucumber 6 under polyhouse and nethouse conditions

Treatment	Fruit length (cm)								Fruit diameter (cm)							
	Date of plantings								Date of plantings							
	Nethouse (S1)				Polyhouse (S2)				Nethouse (S1)				Polyhouse (S2)			
(N:P:K)	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
D_1	12.05	12.29	12.79	12.37	12.18	12.31	12.27	12.26	3.15	3.2	2.91	3.08	3.03	2.97	3.20	3.07
D_2	12.55	12.44	13.21	12.73	12.83	12.65	13.11	12.86	3.18	3.19	3.21	3.20	3.12	3.10	3.19	3.14
D_3	13.24	13.49	13.55	13.42	13.41	13.65	13.46	13.51	3.32	3.37	3.37	3.34	3.35	3.26	3.37	3.33
D_4	13.28	13.51	13.75	13.51	13.33	13.57	13.49	13.46	3.24	3.26	3.26	3.25	3.30	3.17	3.26	3.24
Mean	12.78	12.79	13.32	13.01	12.94	13.05	13.08	13.02	3.22	3.25	3.25	3.36	3.20	3.13	3.26	3.19

D_1: 15:7:16 kg/ha, D_2: 20:12:21 kg/ha, D_3: 25:17:26 kg/ha, D_4: 30:22:31 kg/ha; P_1: 15 August, P_2: 1 September, P_3: 15 September

30:22:31 kg NPK/ha shown early female flowering (20.53 DAS) under nethouse. On other hand, 15 September planting with 15:7:16 kg NPK/ha produced first female flower on early node of 1.47 in the nethouse.

Effect of growth, yield and yield attributing traits

Improvement in fruit set and development is considered to be pre-requisite to increased yield of cucumber. The effect of different treatment combinations on yield and yield attributing characters is presented in Table 2, 3 and 4. Among the two protected structures, highest number of fruits per plant (15.67), fruit length (13.02 cm), fruit weight (121.99 g), yield/plant (1927.2 g) and yield/1000 m^2 (128.49 q) were noticed in polyhouse. This may be due to decreased stomatal resistance in green house which facilitated higher CO_2 uptake and thereby more photosynthetic rate which resulted in more number of fruits and increased fruit weight. The results corroborated with findings of Gayathri *et al*. (2015). However, fruit related traits like fruit diameter (3.36 cm) and flesh thickness (1.11 cm) noticed highest under nethouse. It is obvious that increased yield potential is achieved at the expense of number of fruits per plants in polyhouse rather than fruit weight in nethouse. Yield response of cucumber grown at different levels of fertigation differed significantly and highest fruit length (13.51 cm), fruit diameter (3.25 cm) and fruit weight (129.38 g) were obtained at the application of 30:22:31 kg NPK/ha under nethouse. However, highest number of fruits (17.27), yield/plant (2237.4 g) and yield per 1000 m^2 (149.16 q) reported by application of higher level of fertigation 30:22:31 kg NPK/ha under polyhouse. The lowest yield and yield attributing characters noticed by lower dose 15:7:16 kg NPK/ha (86.64 q/1000 m^2) under nethouse. The systematic increase in NPK fertilizer rate enhanced the release of essential nutrients, which invariably increased cucumber growth and productivity. The findings were in consonance with studies of Adekiya and Ojeniyi (2002) and John *et al*. (2004). The date of planting also exhibited significant influence on yield and yield components of cucumber. The highest number of fruits (17.97), fruit weight (124.96 g), fruit diameter (3.26 cm), yield/plant (2264.3 g) and yield/1000 m^2 (150.96 q) was noticed in 15 September planting under polyhouse condition. On other hand, lowest yield was noticed in 1 September planting under nethouse (99.14 q/1000 m^2). This might be due to the fact that 15 September coincides with lower temperature at growing period leads to reduced physiological processes like transpiration and respiration that resulted in reduced water loss from the fruits and increased net accumulation of photosynthates under polyhouse. The results showed that low temperature was preferable for the formation of more female flowers which leads to increased fruit set and development (Hikosaka *et al*. 2008). Among the combinations, 15 September sowing with 30:22:31 kg NPK/ha showed highest interaction effect for number of fruits/plant (20.20), fruit weight (134.11 g), yield/plant (2709.1 g) and yield/1000 m^2 (180.61 q) under polyhouse.

Table 3 Effect of planting time and fertilizer dose on number of fruits and fruit weight (g) of cucumber var. Pusa Seedless Cucumber-6 grown under polyhouse and nethouse conditions

Treatment	Number of fruits								Fruit weight (g)							
	Date of plantings								Date of plantings							
	Nethouse (S1)				Polyhouse (S2)				Nethouse (S1)				Polyhouse (S2)			
(N:P:K)	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
D_1	11.47	11.80	13.60	12.29	12.60	12.87	15.40	13.62	107.16	102.09	107.85	105.70	112.32	104.51	109.12	108.65
D_2	13.27	12.47	14.87	13.53	14.00	13.67	16.80	14.82	114.62	111.74	122.08	116.15	123.23	119.19	122.67	121.70
D_3	14.53	13.73	15.87	14.71	15.80	15.60	19.47	16.96	124.10	119.68	133.13	125.64	128.87	122.69	133.96	128.51
D_4	15.60	13.67	16.13	15.13	16.20	15.40	20.20	17.27	129.03	124.77	134.05	129.28	128.27	124.95	134.11	129.11
Mean	13.72	12.92	15.12	13.92	14.65	14.38	17.97	15.67	118.73	114.57	124.28	119.19	123.18	117.84	124.96	121.99

D_1: 15:7:16 kg/ha, D_2: 20:12:21 kg/ha, D_3: 25:17:26 kg/ha, D_4: 30:22:31 kg/ha; P_1: 15 August, P_2: 1 September, P_3:15 September

Table 4 Effect of planting time and fertilizer dose on fruit yield/plant (g) and yield/1000m^2 (q) of cucumber var. Pusa Seedless Cucumber-6 grown under polyhouse and nethouse conditions

Treatment	Fruit yield/plant (g)								Yield/1000m^2 (q)							
	Date of plantings								Date of pantings							
	Nethouse (S1)				Polyhouse (S2)				Nethouse (S1)				Polyhouse (S2)			
(N:P:K)	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
D_1	1228.5	1205.6	1464.7	1299.6	1415.3	1345.0	1680.2	1480.2	81.90	80.38	97.65	86.64	94.36	89.67	112.02	98.68
D_2	1520.5	1394.2	1814.9	1576.5	1728.2	1629.0	2059.8	1805.7	101.37	92.95	120.99	105.11	115.22	108.60	137.33	120.38
D_3	1803.6	1643.5	2111.6	1852.9	2034.8	1914.1	2608.2	2185.7	120.24	109.57	140.78	123.53	135.65	127.61	173.88	145.72
D_4	2012.8	1704.7	2164.2	1960.6	2077.7	1925.4	2709.1	2237.4	134.19	113.65	144.28	130.71	138.52	128.36	180.61	149.16
Mean	1641.3	1487.0	1888.8	1672.4	1814.0	1703.4	2264.3	1927.2	109.43	99.14	125.93	111.50	120.94	113.56	150.96	128.49

D_1: 15:7:16 kg/ha, D_2: 20:12:21 kg/ha, D_3: 25:17:26 kg/ha, D_4: 30:22:31 kg/ha; P_1: 15 August, P_2: 1 September, P_3: 15 September

Table 5 Effect of planting time and fertilizer dose on nitrogen (N) and phosphorus (P) content in fruit of cucumber var. Pusa Seedless Cucumber- 6 grown under polyhouse and nethouse conditions

Treatment	Nitrogen (mg/100 g)								Phosphorus (mg/100 g)							
	Date of plantings								Date of plantings							
	Nethouse (S1)				Polyhouse (S2)				Nethouse (S1)				Polyhouse (S2)			
(N:P:K)	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
D_1	41.67	42.33	43.67	42.56	45.33	46.33	45.00	45.56	15.67	17.67	18.33	17.22	17.67	19.00	20.00	18.89
D_2	47.67	48.00	48.33	48.00	50.33	48.67	49.00	49.33	18.67	19.67	21.33	19.89	20.33	21.33	22.33	21.33
D_3	49.67	51.67	52.00	51.11	54.00	54.33	55.00	54.44	21.00	22.67	24.00	22.56	22.67	24.00	26.00	24.22
D_4	53.00	54.67	56.33	54.67	55.00	57.67	59.00	57.22	23.33	25.00	26.33	24.89	25.00	26.00	27.33	26.11
Mean	48.00	49.17	50.08	49.08	51.17	51.75	52.00	51.64	19.67	21.25	22.50	21.14	21.42	22.58	23.92	22.64

D_1: 15:7:16 kg/ha, D_2: 20:12:21 kg/ha, D_3: 25:17:26 kg/ha, D_4: 30:22:31 kg/ha; P_1: 15 August, P_2: 1 September, P_3: 15 September

Table 6 Effect of planting time and fertilizer dose on potassium (K) and calcium (Ca) content in fruit of cucumber var. Pusa Seedless Cucumber-6 grown under polyhouse and net house conditions

Treatment	Potassium (mg/100 g)								Calcium (mg/100 g)							
	Date of plantings								Date of plantings							
	Nethouse (S1)				Polyhouse (S2)				Nethouse (S1)				Polyhouse (S2)			
(N:P:K)	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
D_1	126.00	128.33	129.00	127.78	129.67	131.33	132.67	131.22	6.28	6.35	6.47	6.37	6.53	6.57	6.80	6.63
D_2	134.33	136.33	136.67	135.78	138.00	139.67	139.67	139.11	7.51	7.82	7.83	7.72	7.89	8.02	7.91	7.94
D_3	138.33	141.67	142.33	140.78	141.67	145.00	145.67	144.11	8.37	8.54	8.92	8.61	8.59	8.72	9.28	8.86
D_4	142.67	145.00	147.00	144.89	146.33	148.33	150.00	148.22	10.30	10.55	10.89	10.58	10.72	10.74	11.29	10.92
Mean	135.33	137.83	138.75	137.31	138.92	141.08	142.00	140.67	8.12	8.31	8.53	8.32	8.43	8.52	8.82	8.59

D_1: 15:7:16 kg/ha, D_2: 20:12:21 kg/ha, D_3: 25:17:26 kg/ha, D_4: 30:22:31 kg/ha; P_1: 15 August, P_2: 1 September, P_3: 15 September

Table 7 Effect of planting time and fertilizer dose on iron (Fe) and zinc (Zn) content in fruit of cucumber var. Pusa Seedless Cucumber-6 grown under polyhouse and nethouse conditions

Treatment	Iron (mg/100 g)								Zinc (mg/100 g)							
	Date of Plantings								Date of Plantings							
	Nethouse (S1)				Polyhouse (S2)				Nethouse (S1)				Polyhouse (S2)			
(N:P:K)	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
D_1	0.12	0.13	0.13	0.13	0.12	0.13	0.13	0.13	0.15	0.16	0.16	0.15	0.15	0.16	0.17	0.16
D_2	0.14	0.16	0.18	0.16	0.15	0.17	0.18	0.17	0.17	0.18	0.18	0.17	0.16	0.18	0.18	0.18
D_3	0.17	0.18	0.21	0.19	0.17	0.19	0.21	0.19	0.18	0.19	0.20	0.19	0.16	0.19	0.20	0.19
D_4	0.20	0.21	0.23	0.21	0.19	0.21	0.23	0.21	0.19	0.20	0.22	0.20	0.20	0.21	0.22	0.21
Mean	0.16	0.17	0.19	0.17	0.16	0.18	0.19	0.17	0.17	0.18	0.19	0.18	0.17	0.18	0.19	0.18

D_1: 15:7:16 kg/ha, D_2: 20:12:21 kg/ha, D_3: 25:17:26 kg/ha, D_4: 30:22:31 kg/ha; P_1: 15 August, P_2: 1 September, P_3: 15 September

Table 8 Critical difference (CD) at 5% for growth, yield and nutritional characters of cucumber var. Pusa Seedless Cucumber-6 grown under polyhouse and net house conditions

Source	(P = 0.05)														
	Days to first female flower	Node of 1st female flower	Fruit length	Fruit diameter	Number of fruits	Fruit weight	Yield/ plant	Yield /1000 m^2	N	P	K	Ca	Fe	Zn	Mn
S	0.42	NS	0.14	0.33	0.24	0.82	31.12	2.07	0.72	0.33	0.41	0.08	NS	0.09	0.00
P	0.52	0.17	0.17	NS	0.29	1.01	38.11	2.54	0.88	0.40	0.50	0.09	0.01	NS	0.01
D	NS	NS	0.19	NS	0.34	1.16	44.01	2.93	1.02	0.47	0.58	0.11	0.01	0.13	0.01
S × P	NS	0.25	0.24	NS	0.41	1.42	53.90	3.59	NS	NS	NS	NS	NS	0.16	NS
S × D	NS	NS	NS	NS	0.58	2.01	76.23	5.08	NS	NS	NS	NS	NS	0.22	NS
P × D	NS	NS	NS	NS	0.47	1.64	62.24	4.15	NS	NS	0.82	0.15	0.01	0.18	0.00
S × P × D	NS	NS	NS	NS	0.82	NS	107.80	7.19	NS	NS	NS	NS	NS	0.31	NS

S: Protected structures; P: date of plantings; D: fertilizer doses; NS: Non-significant

Effect on nutrient content of the fruit

The effect of different treatment combinations on nutrient content of cucumber fruits presented in Table 5, 6 and 7.The protected structures had significant effect on nutrient content of the cucumber fruit. Among the protected structure, fruits with the highest amount nitrogen (51.64 mg/100 g), phosphorus (22.64 mg/100 g), potassium (140.67 mg/100 g), calcium (8.59 mg/100 g), iron (0.17 mg/100 g), zinc (0.18 mg/100 g) and manganese (0.12 mg/100 g) were produced under polyhouse. By increasing fertigation level from 15:7:16 kg NPK/ha to 30:22:31 kg NPK/ha, the amount of fruit nutrients also increased. The higher amount of nitrogen (57.22 mg/100 g), phosphorus (26.11 mg/100 g), potassium (148.22 mg/100 g), calcium (10.92 mg/100 g), iron (0.21 mg/100 g), zinc (0.21 mg/100 g) and manganese (0.14 mg/100 g) were reported by application of 30:22:31 kg NPK/ha under polyhouse. The results obtained corroborated with the findings of Mostafa *et al*. (2012) who reported that increasing nitrogen fertigation from 75 to 225 kg/ha increased N (53.265%), P (77.61%), K (25.85%), Ca (14.28%), Zn (16.58%) and Mn (24.75%) in the bitter gourd. Results were also in consonance with reports of Choudhari and More (2002). There was no significant effect of date of planting for nutrients content of the fruit. Among the combinations, the highest interaction effect was noticed at 15^{th} Sept planting with 30:22:31 kg NPK/ha for nitrogen (59 mg/100 g), phosphorus (27.33 mg/100 g), potassium (150.0 mg/100 g), calcium (11.29 mg/100 g), iron (0.23 mg/100 g) and zinc (0.22 mg/100 g) under polyhouse.

On the basis of present investigation, it can be concluded that cucumber variety Pusa Seedless Cucumber-6 responded well to different date of planting and level of fertilizers under protected structure for growth, yield and nutrients content fruit. Based on these findings, it is recommended that the application of fertilizers at the rate of 30:22:31 kg NPK/ha on 15 September planting under naturally ventilated polyhouse is economical and suitable for the successful growth, yield and quality of cucumber for higher productivity.

REFERENCES

Adekiya A O and Ojeniyi S O. 2002. Evaluation of tomato growth and soil properties under methods of seedling bed preparation in an Alfisol in the rainforest zone of southwest Nigeria. *Bioresource Technology* **96**: 509–16.

Chadha K L and Lal T. 1993. Improvement of cucurbits. *Advances in Horticulture*, pp 137-144. Chandha K L and Kalloo G. (Eds). Malhotra Publishing House, New Delhi.

Chapman H D and Pratt P F. 1961. *Methods of Analysis for Soils, Plants, and Waters*, pp 309. Division of Agriculture Sciences, Berkeley, University of California, CA.

Choudhari S M and More T A. 2002. Fertigation, fertilizer and spacing requirement of tropical gynoecious cucumber hybrids. Proc. *2nd International Symposium on cucumbers*. *Acta Horticulturae*: 233–40.

Edward A H. 1999. Elemental determination by atomic absorption spectrophotometry. *Handbook of Reference Method for Plant Analysis,* pp 157-64. Yash P Kalra (Eds). Soil and Plant Analysis Council, Inc.

FAOSTAT. 2014. Major crops – by countries/regions, rankings; choose cucumber and gherkins, world. Food and Agricultural Organization. www.fao.org.

Gayathri Rajasekharan and Nandini K. 2015. Photosynthetic characters in relation to yield of cucumber grown in naturally ventilated polyhouse**.** *Journal of Tropical Agriculture* **53**(2): 200–5.

Hikosaka S, Boonkorkaew P and Sugiyama N. 2008. Effects of air temperature at the seedling stage and pollination on the development of pistillate flowers and fruit set in cucumbers. *Environ. Control Biology* **46**: 249–56.

Jackson M L. 1962. *Soil Chemical Analysis*, 521 p. Prentice Hall of India, New Delhi.

John L W, James D B, Samuel L T and Warner L W. 2004. *Soil Fertility and Fertilizers: An Introduction to Nutrient Management*, pp 528. Pearson Education, India.

Knudsen D G A, Peterson G A and Pratt P F. 1982. Lithium, sodium, and potassium. *Methods of Soil Analysis (Part 2), Chemical and Microbiological Prosperities*, pp 225-46. Page A L, Miller R H and keeney D R (Eds). ASA-SSSA, Madison, WI, USA.

Mostafa H and Mohammad M M. 2012. Effect of rate and time of nitrogen application on fruit yield and accumulation of nutrient elements in *Momordica charantia*. *Journal of the Saudi Society of Agricultural Sciences* **11**: 29–133.

Narayanankutty C, Sreelatha U, Jyothi M L and Gopalakrishnan T R. 2015. Advances in protected cultivation of vegetables in Kerala. *Journal of Tropical Agriculture* **53**(2): 200–5.

NHB. 2014. Cucumber. Indian Horticulture Database 2013, National Horticultural Board. http://nhb.gov.in/annual_report.aspx.