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RESEARCH ARTICLE

RESPONSE OF PARTHENOCARPIC CUCUMBER TO FERTILIZERS AND TRAINING SYSTEMS UNDER NVPH IN SUBTROPICAL CONDITIONS

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ABSTRACT

An investigation was conducted during April, 2013 to study the response of fertilizers and training systems on parthenocarpic cucumber var. Dinamik under NVPH. The whole experiment was arranged over 12 treatments consisting of 4 levels of fertilizers [F_1-60:50:50 kg/ha (RDF through Conventional method), F_2-50% RDF (Fertigation), F_3-100% RDF (Fertigation), F_4-150% RDF (Fertigation)] with common dose of micro-nutrients and 3 training systems having system specific spacing [P_1-'Umbrella' (60 x 60 cm), P_2-'V' (60 x 60 cm), P_3-'Single Stem' (60 x 45 cm)]. The characters like days to first flowering, days to first picking, plant height, sensory characters, fruit diameter etc. were significantly influenced by individual effect either of fertilizer or training system. The significant differences for crude fibre were observed among various treatments and F_4P_1 recorded high value for this character which was at par with F_4P_2 and F_4P_3. The leaf area index (LAI) determined after 30 days of planting was significantly highest in F_4P_3 (2.15), whereas the interaction effect was not significant for LAI after 60 days of planting but F_4 and P_3 individually expressed significantly highest value of 5.59 and 4.85, respectively, thus signifying its importance *vis-a-vis* interception of light for photosynthetic activities. However, F_4P_2 registered significantly highest number of fruits per plant (41), but higher yield (10.76 t per 1000m^2) was registered by F_4P_3 having statistically similar results with that of F_4P_2. The benefit-cost ratio (BCR) of 1:1.30 was found to be highest for F_4P_3 with net realization of Rs. 121771, thus highlighting its significance in gaining maximum output from cucumber cultivation under NVPH during the growing season April to July, 2013.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an edible cucurbit popular throughout the world for its crisp texture and taste. Cucumber is a truly versatile vegetable because of wide range of uses from salads to pickles and digestive aids to beauty products. The caloric and nutritional value of cucumber is very low but it is a primary source of vitamins, minerals and fibre for human body (Keopraparl 1997). Protected cultivation being the most efficient means to overcome climatic diversity, has the potential of fulfilling the requirements of small growers as it can increase the yield manifolds and at the same time improve the quality of the produce significantly as per the demand of the market. In the recent times, the introduction of parthenocarpic varieties in cucumber has revolutionized its cultivation under protected culture in India. Simultaneously, implementation of protected cultivation through various financial aid schemes such as National Horticulture Mission (NHM), *Rashtriya Krishi Vikas Yojna* (RKVY) and many more at state level have bolstered the adoption of protected cultivation across the country. However, greenhouse growers often encounter various problems regarding agronomical aspects for successful cultivation of cucumber under such conditions. The appropriate dose of nutrients and systems of plant manipulation are the important factors deciding yield of cucumber. The nutrients are very essential for growth and development of a crop. So, the correct quantity of fertilizers application not only increases the yield but also improve the quality. Application of major nutrients in proper ratio and required quantity can help growers to get the maximum out of these inputs (Kavitha *et al*., 2007). Manipulation of plant architecture through training with appropriate spatial arrangements has also been revealed as a key management factor for getting maximum yield from greenhouse crops (Cebula, 1995; Guo *et al*., 1991; Lorenzo and Castilla 1995). Training system emphasizes on the plant ability to obtain sunlight for growth. It is also important to maintain sufficient air circulation around the plant to reduce the risk of pests. So, the investigation was aimed to determine the efficacy of fertilizers and training systems on growth and yield of cucumber under protected conditions.

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MATERIALS AND METHODS

A parthenocarpic variety Dinamik (Yuksel Tohumculuk Ltd., Turkey) popular among the greenhouse growers in South Gujarat was taken for the investigation during April, 2013. The experiment was conducted under naturally ventilated polyhouse (NVPH) of 2000m^2 at Regional Horticulture Research Station, Navsari Agricultural University, Navsari (Gujarat) situated at latitude 20^{o}57'N and longitude 72^{o}54'E with an altitude of 12 m above the mean sea level. The location is characterized by high humid climate with high annual rainfall of 1600 to 2400 mm mostly concentrated during monsoon.

The whole experiment was arranged over 12 treatments consisting of 4 levels of fertilizers [F_1-60:50:50 kg/ha (RDF through conventional method), F_2-50% RDF (Fertigation), F_3-100% RDF (Fertigation), F_4-150% RDF (Fertigation)] with common dose micro-nutrients (50 kg/ha as soil application) and 3 training systems having system specific spacing as illustrated by Premalatha *et al*., 2006 [P_1-'Umbrella' (60 x 60 cm), P_2-'V' (60 x 60 cm), P_3-'Single Stem' (60 x 45 cm)]. In case of conventional method of fertilizer application, full dose of phosphorous and potassium and half dose of nitrogen were applied before sowing and remaining half of N in two splits at 30 and 60 days after sowing. Whereas fertigation (N: P: K) was scheduled after 10 days of sowing at the ratio of 2:3:1, 1:2:3 and 1:2:3 in first, second and third month of growing period of the crop. The variety was exposed to three training systems (Figure 1); the apical buds of plants were removed at the height of approximately 180cm near to the overhead wire in Umbrella system. After attaining a height of 45-60cm, the growing point was removed and the two emerging laterals were trained into V system. While in case of single stem system, only main stem was allowed to grow vertically along the supporting string. In all the three systems, all other laterals arising from the axials of leaves were commonly removed from the plants.

The experiment was laid out in a Randomized Complete Block Design (Factorial concept) with three replicates on raised beds having dimensions of 100 x 40 x 50 cm (width, height & distance between two beds) and plot size of 7.2 x 4.5m. The data on various parameters *viz.,* days to first flowering, days to first picking, plant height, leaf area index (LAI), fruit length, fruit diameter, number of fruits per plant, fruit weight, yield, fruit colour, fruit texture, fruit flavour, shelf life and crude fibre were recorded on ten randomly taken plants and the mean values were subjected to stastical analysis as per Panse and Sukhatme (1985). The drip irrigation was made operational daily at the rate of 0.3, 0.45 and 0.4 l day-1 plant-1 applied during initial stages, flowering and fruit harvesting stage, respectively (PFDC, 2000-2001). The data on sensory characters like fruit colour, texture and flavour were recorded on the basis of nine-point Hedonic scale and accordingly, the overall acceptability was worked out.

RESULTS AND DISCUSSION

The mean weekly meteorological data recorded during the crop growth period has been illustrated in Figure 2. The mean temperature inside NVPH was 30.7^{o}C during the growing period of cucumber, while maximum and minimum temperature were 40.2 and 28.7 ^{o}C respectively with average relative humidly of 84 per cent. Although, temperature and relative humidity fall out of optimum range of slicing cucumber (24-27 ^{o}C and 60-65%) as specified by Johnson and Hickman (1984) but parthenocarpic cucumber performed well under such micro-climatic conditions. As temperature is a major regulator of development processes, so it was regulated only through timely opening and closing of top shade net, side curtains and fogging for better growth of plants. Relative humidity during the growing season was on higher side, which might have played important role in initial survival of plants and availability of net energy for crop growth. Relative humidity reduces evaporation loss from plants which lead to

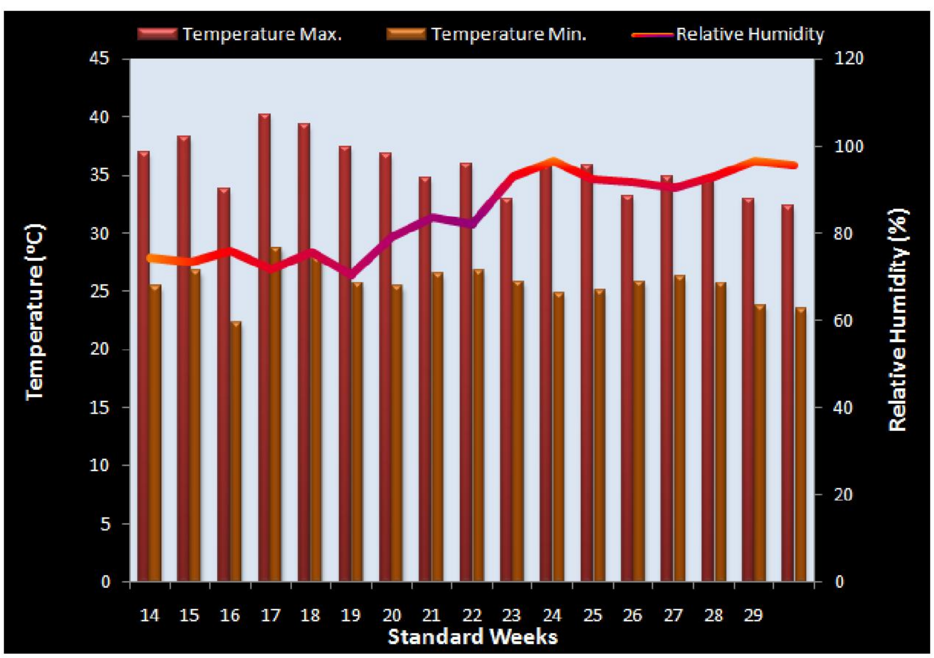

Figure 2. Mean Meteorological data during the experimentation period inside the NVPH (April-July, 2013)

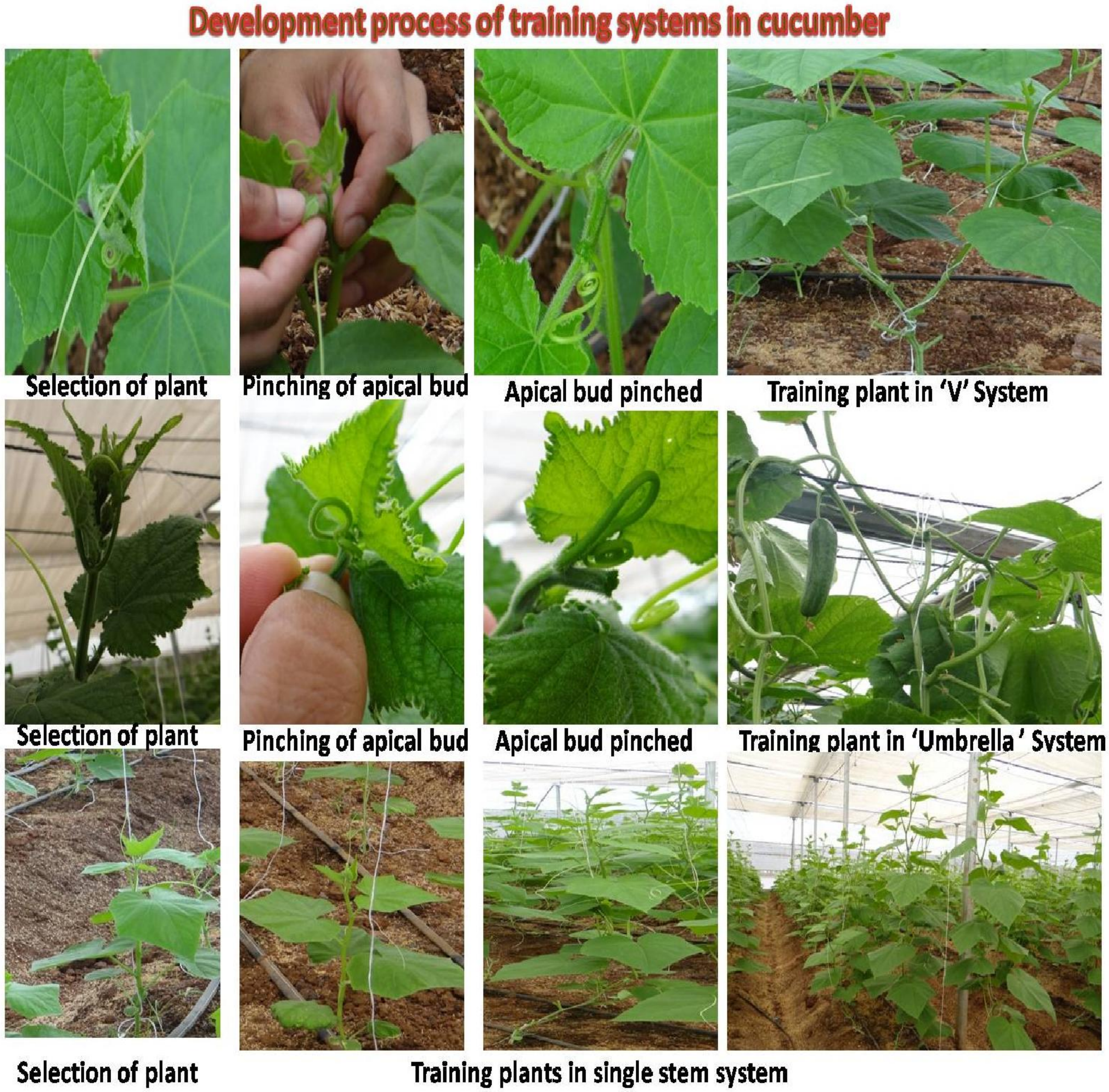

Figure 1. Training systems in cucumber

optimum utilization of nutrients. It also maintains turgidity of cells which is useful in enzymatic activities leading to higher yield (Rajasekar *et al*., 2013). However, this also necessitates further to investigate precisely the micro-climate requirement for cultivation of slicing cucumber under NVPH in high humid sub-tropical climate. The analysis of variance (Table 1) revealed that mean sum squares due to interaction effect of fertilizers and training systems were significant for leaf area index (LAI) after 30 days, number of fruits per plant, fruit yield and crude fibre only. However, remaining traits under investigation were highly influenced by main effects of treatments, which is clearly depicted by the significant values of mean sum squares for the concerned trait.

The data on vegetative, flowering, fruiting and sensory traits are presented in Table 2. Among various treatments of fertilizers, F_4 took significantly lowest number of days to first flowering (27.22) and picking (38.00) which was at par with treatment F_3 for days to first flowering only. The plant height at all the intervals of growth period of crop were significantly higher in F_4.Whereas in case of training systems, the flowering and picking were the earliest in P_1 and P_3 having non-significant differences between these systems but differed significantly in V-system of training. Likewise P_1 and P_3 systems showed statistically similar results for plant height after 30 and 60 days of planting except for the observation after 90 days of planting, where P_3 expressed significantly highest plant height over rest of the systems of training. This could be attributed to the fact that plants in 'Umbrella' system (P_1) and 'V'-system (P_2) were forced to train into two laterals subject to the timing of operation, so plants with single stem system (P_3) had highest plant height without partitioning of the nutrients as is the case in other two systems of training. The optimum supply of nutrients aided early flowering due to vigorous vine growth in cucumber (Bishop *et al*., 1969) and fruit maturity is mainly dependent on application of fertilizer, which is

Table 1. Analysis of variance for various traits in parthenocarpic cucumber under NVPH

Source of variation	df	Mean sum of squares														
		Days to first flowering	Days to first picking	Plant height after 30 days	Plant height after 60 days	Plant height after 90 days	LAI after 30 days	LAI after 60 days	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Number of fruits per plant	Fruit yield (t/1000m^2)	Overall acceptability	Self life	Crude fibre
Replication	2	1.58	9.00	1.86	518.46	53.17	0.00	0.06	2.37	0.01	11.93	1.19	1.14	1.14	0.03	0.00
Fertilizer levels (F)	3	23.78*	46.77*	2840.27*	4004.49*	8190.30*	0.87*	9.12*	2.19*	0.17*	47.49	606.74*	52.87*	9.31*	17.41*	0.82*
Training systems (P)	2	25.08*	36.08*	717.42*	910.56*	3532.42*	0.97*	2.76*	0.02	0.02	5.95	114.53*	4.72*	0.11	0.19	0.02*
F x P	6	2.08	1.82	21.22	54.69	120.72	0.03*	0.12	0.24	0.03	5.93	16.05*	1.11*	0.14	0.16	0.02*
Error	22	4.22	8.61	64.98	162.70	554.39	0.01	0.33	0.71	0.05	60.53	4.07	0.43	0.34	0.79	0.00
Total	35	6.57	12.31	329.03	536.54	1276.08	0.14	1.17	0.82	0.05	44.16	63.93	5.33	1.11	2.03	0.08

*P=0.05

Table 2. Effect of fertilizers and training systems on vegetative, flowering, fruiting and sensory traits parthenocarpic cucumber under NVPH

Treatment	Days to first flowering	Days to first picking	Plant height after 30 days	Plant height after 60 days	Plant height after 90 days	Fruit length (cm)	Fruit dia. (cm)	Fruit weight (g)	Overall Acceptability	Self life
F_1	30.56	41.89	126.33	210.11	294.89	14.70	3.82	120.98	6.65	6.11
F_2	30.67	43.33	111.87	197.00	277.44	14.87	3.68	120.66	5.91	5.33
F_3	28.89	41.78	138.00	217.42	315.67	14.93	3.82	123.16	7.41	6.22
F_4	27.22	38.00	153.78	246.83	347.61	15.80	4.01	125.62	8.28	8.56
CD (P=0.05)	2.01	2.87	7.88	12.47	23.02	0.72	0.20	NS	0.49	0.75
P_1	28.58	40.17	139.42	217.25	297.83	15.03	3.86	122.37	7.07	6.42
P_2	31.00	43.25	124.15	209.44	300.21	15.10	3.79	122.05	6.96	6.58
P_3	28.42	40.33	133.92	226.83	328.67	15.10	3.85	123.40	7.15	6.67
CD (P=0.05)	1.74	2.48	6.82	10.80	19.93	NS	NS	NS	NS	NS
F X P										
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

F_1-RDF through conventional method, F_2-50% RDF (Fertigation), F_3-100% RDF (Fertigation), F_4-150% RDF (Fertigation), P_1-'Umbrella system', P_2-'V' system, P_3-'Single Stem system'

Table 3. Interaction effect of fertilizer and training system on LAI, fruits per plant, yield per m^2 and crude fibre in parthenocarpic cucumber under NVPH

Treatments	LAI after 30 days	LAI after 60 days	Fruits per plant	Fruit yield (t/1000m^2)	Crude fibre
$F_1 P_1$	1.07	3.11	19.33	4.90	1.02
F_1P_2	1.33	3.80	20.33	5.17	1.04
F_1P_3	1.49	4.64	16.00	5.65	1.01
F_2P_1	0.78	2.71	15.67	3.84	1.04
F_2P_2	0.96	2.86	17.00	4.28	1.02
F_2P_3	1.19	3.41	13.33	4.57	1.28
F_3P_1	1.13	4.02	24.67	6.32	1.30
F_3P_2	1.35	4.31	26.00	6.71	1.33
F_3P_3	1.77	4.75	20.00	6.94	1.35
F_4P_1	1.36	4.96	31.00	8.05	1.72
F_4P_2	1.68	5.42	41.00	10.58	1.69
F_4P_3	2.15	5.82	30.33	10.76	1.70
		CD (P=0.05)			
F	0.08	0.56	1.97	0.64	0.07
P	0.07	0.49	1.71	0.56	0.06
F x P	0.14	NS	3.42	1.12	0.11

F_1-RDF through conventional method, F_2-50% RDF (Fertigation), F_3-100% RDF (Fertigation),
F_4-150% RDF (Fertigation), P_1-'Umbrella system' P_2-'V' system (60 x 60 cm), P_3-'Single Stem system'

Table 4. Economic analysis of various treatments for parthenocarpic cucumber cultivation under naturally ventilated polyhouse (1000 m^2)

S. No.	Components	Treatments											
		F_1P_1	F_1P_2	F_1P_3	F_2P_1	F_2P_2	F_2P_3	F_3P_1	F_3P_2	F_3P_3	F_4P_1	F_4P_2	F_4P_3
A. Amortized Fixed cost for the period of 120days													
1.	Polyhouse	31167	31167	31167	31167	31167	31167	31167	31167	31167	31167	31167	31167
2.	Red Soil	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
3.	Rice Husk	444	444	444	444	444	444	444	444	444	444	444	444
4.	Plant support system	667	667	667	667	667	667	667	667	667	667	667	667
Total (A)		34678	34678	34678	34678	34678	34678	34678	34678	34678	34678	34678	34678
B. Variable cost													
1.	Labour	32400	36000	28800	32400	36000	28800	32400	36000	28800	32400	36000	28800
2.	Pesticides	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
3.	Fertilizer	1786	1786	1786	1432	1432	1432	2863	2863	2863	4295	4295	4295
4.	Packing	980	1034	1130	768	856	914	1264	1342	1388	1610	2116	2152
5.	Seed cost	9585	9585	13050	9585	9585	13050	9585	9585	13050	9585	9585	13050
6.	Requirement of Formaldehyde	3375	3375	3375	3375	3375	3375	3375	3375	3375	3375	3375	3375
7.	Application of formaldehye	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
8.	*Trichoderma viridi*	40	40	40	40	40	40	40	40	40	40	40	40
9.	*Pseudomonas inflorescens*	40	40	40	40	40	40	40	40	40	40	40	40
10.	Micro-nutrients	900	900	900	900	900	900	900	900	900	900	900	900
11.	Bed preparation	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
12.	Miscellaneous	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Total (B)		55206	58860	55221	54640	58328	54651	56567	60245	56556	58345	62451	58752
Total cost (A+B)		89884	93538	89899	89318	93006	89329	91245	94923	91234	93023	97129	93430
Yield (kg)		4900	5170	5650	3840	4280	4570	6320	6710	6940	8050	10580	10760
Gross Realization (Rs.)		98000	103400	113000	76800	85600	91400	126400	134200	138800	161000	211600	215200
Net Realization (Rs.)		8116	9862	23101	-12518	-7406	2071	35155	39277	47566	67977	114471	121770
Benefit-cost-ratio		0.09	0.11	0.26	-0.14	-0.08	0.02	0.39	0.41	0.52	0.73	1.18	1.30
Sale rate (Rs./kg)		20.00											

F_1-RDF through conventional method, F_2-50% RDF (Fertigation), F_3-100% RDF (Fertigation), F_4-150% RDF (Fertigation), P_1-'Umbrella system', P_2-'V' system, P_3-'Single Stem system' substantially supported by the earlier worker (Janapriya *et al*., 2010) that 100% fertigation can induce early harvest in polyhouse conditions. Also supported by Hong (2000) who reported that earliness depends on training system and spacing.

In case of fertilizer, the significant variation for fruit length and diameter were recorded by F_4 treatment, which showed non-significant differences for fruit diameter with F_1 and F_3 level of fertilizer application. However fruit weight remained unaffected by main as well interaction effects of treatments. There were no significant differences for fruit length and diameter among training systems. As these traits were influenced by dry matter partitioning, the changes in plant architecture in 'V' and 'Umbrella' system appeared to be unfavorable for dry matter partitioning to fruit sink. Similarly, high leaf area index might have affected the process under close spacing in single stem system, which is reflected its higher value for these traits. This is also confirmed by the results of earlier experiments where reduction of size of plant frames or overlapping of vines and high plant densities have negative influence on fruit size (Lower and Edwards, 1986).

Nine-point Hedonic scaling was done for fruit colour, texture and flavour and overall acceptability of the produce was worked based on these observations. So, it is clearly indicated from the investigation that it is only the fertilizer application which affected these sensory traits. F_4 had significant effect on overall acceptability of cucumber produce from NVPH which is attributable to the optimum dose of fertilizer through fertigation and favourable microclimate inside the polyhouse. Similarly, shelf-life of cucumber was highly and significantly influenced by the main effect of fertigation (F_4). Sufficient supply of nutrients might have increased the production Indole Acetic Acid which consequently would have shown stimulatory action in terms of cell elongation and thus, resulting in increase plant growth. Nitrogen being the chief constituent of chlorophyll, protein and amino acids, is accumulated in the shoot through increased supply of nitrogen to the plants at appropriate time. Thus, fertigation deserves to be an important aspect that contributes to increased plant growth. Fruits from well grown plants through proper nutrient supplement give the higher shelf life (Balasubramanian, 2008, Arumugam and Vadivel, 2013).

Leaf area index determined after 30 days of sowing was significantly different in all the treatments (Table 3). The interaction effect of 150% RDF (F_4) and single stem system (P_3) registered highest LAI, whereas periodical determination for this trait after 60 days of sowing was significantly influenced by the main effect of treatments. Medrano *et al*. (2005) studied the evolution of solar radiation transmitted to crop canopy in relation to increase in the value of LAI and strongly demonstrated the dependence of the intercepted radiation on LAI. They further substantiated that the sensitivity of radiation interception to LAI decreases with the increase in values for this trait. Production and productivity of a crop is largely and directly influenced by number of fruits per plant. The treatment combination F_4P_2 recorded significantly highest number of fruits per plant which could be reflected by the positive effect of fertilizer application (El Sanafawi *et al*., 2006 and Sharma *et al*., 2009) and decapitation of apical bud at early stage of growth on yield of cucumber (Premalatha *et al*., 2006). However, maximum fruit yield of 10.76 tonnes per 1000m^2 was recorded by the treatment combination F_4P_3 having statistically similar results with F_4P_2 (Table 3). The similar observations have been recorded by Hochmith *et al*. (1996), where higher yields were obtained from training cucumber vine without removing of growing point. 150% of RDF through fertigation produced maximum yield in the present investigation, which is highly in line with the findings of Sharma (1995) and Janapriya (2010).

The optimal presence of fibre content in slicing cucumber reflects the digestibility of a produce. The significantly highest crude fibre was obtained through 150% of RDF in combination with any of the training systems. The fibre content around 2% or more than 1.5% is highly desirable. Table 4 presents the economic analysis of cultivation of parthenocarpic cucumber under NVPH. The net realization in NVPH was found to be highest (Rs. 121771) for F_4P_3 (150% RDF through fertigation + Single stem system) followed by F_4P_2 (Rs. 114472) with highest benefit-cost-ratio of 1.30 and 1.18, respectively.

Conclusion

Most of the traits under investigation were influenced by main effect of either of fertilizer application or training systems. The combined effects of treatments were observed only for few traits like LAI after 30 days of sowing, number of fruits per plant, yield and crude fibre. The combination of fertigation (150% RDF) and single stem system (F_4P_3) resulted in maximum gain in yield under naturally ventilated polyhouse, which was statistically comparable with F_4P_2. But, benefit-cost-ratio has been observed to be highest for F_4P_3. The excellent performance of parthenocarpic cucumber is a result of congenial microclimate inside the polyhouse, high yield potential of parthenocarpic cucumber supplemented with optimal fertigation dose in properly trained plants. Therefore, it can be concluded that cultivation of parthenocarpic cucumber under NVPH is highly profitable through fertigation (150% RDF i.e. 90kg N, 75kg P_2O_5 & 75 K_2O) of plants trained in single stem system.

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