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Influence of fertigation and pruning levels on soil status and mineral content of parthenocarpic cucumber under polyhouse conditions

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Abstract
An investigation was conducted at experimental field, Division of Vegetable Science, SKUAST-Kashmir in 2019 and 2020 to study "Influence of fertigation and pruning levels on soil status and mineral content of parthenocarpic cucumber under polyhouse conditions". The experiment was laid out in RCBD with three replications comprising of two factors with 2 levels of pruning (P) *viz*., P_0 (control or no pruning), P_1 (Single stem system) and 6 levels of fertigation (F) *viz*., F_0 (control or no fertigation), F_1 (100:75:125 NPK kg ha^{-1}), F_2 (150:112:188 NPK kg ha^{-1}), F_3 (200:150:250 NPK kg ha^{-1}), F_4 (250:188:312 NPK kg ha^{-1}) and F_5 (300:225:375 NPK 1.500 kg ha^{-1}). The observations were recorded on mineral content, availability of nutrients and soil properties. Significantly maximum value of N, P, K, Ca, Mn, Zn and Fe contents were observed in plants pruned with single system as compared to the plants with no pruning. In case of fertigation F_4 recorded maximum values while among treatment combination F_4P_1 has given maximum values of nutrient content. It was observed that neither pruning nor interaction between pruning and fertigation levels has not any significant effect on availability of nutrients. However, effect of different levels of fertigation on availability of N, P and K was found significant. Significantly higher values of available P (18.69 kg ha^{-1}) and K (177.8 kg ha-^{1}) in F_4, but available nitrogen was observed maximum in F_5.

Keywords: Cucumber, fertigation, NPK content and nutrients

Introduction
Cucumber (*Cucumis sativus* L., 2n=2x=14) popularly called as *Kheera*, in India is one of the most popular and profitable vegetable crops in the world (FAO, 2013) [9]. It belongs to family cucurbitaceae comprising of 117 genera and 825 species (Jeffrey, 1990) [17]. Among those genus *Cucumis* comprises about 30 species. It is thought to be one of the oldest vegetable crops and has been found in cultivation for over 3000 years in India (De Candolle, 1982) [6]. In terms of economic importance, it is ranked fourth among vegetable crops after tomato, cabbage and onion in Asia (Eifediyi and Remison, 2010) [8] and second after tomato in western Europe (Phu, 1997) [26]. Cucumber is thought to have originated in India (Harlan, 1975) [14] because of the fact that *Cucumis sativus* var. *hardwickii* progenitor of cultivated cucumber is found in the Himalayan foothills of the country. Fertigation is a new concept that is being recently adopted in several horticultural crops. Fertigation is the application of water soluble solid fertiliser through drip irrigation directly to the root zone plant. So, drip irrigation under greenhouse cultivation is concentrated to supply irrigation water and fertilizers to rhizosphere through various phases of nutrient demand of a crop (Mostafa *et al*., 2014) [21]. It also increases the fertilizer efficiency by saving fertilizer and is one of the most effective and convenient means of supplying nutrients and water according to specific requirement of the crop whenever required, resulting in higher productivity. The nature of growth is more of vertical in parthenocarpic cucumber due to its indeterminate growth habit. Hence, the plant density under protected condition is usually more. The density of plants managed through pruning of stems is an agronomic management variable associated with the productivity of vegetables under protected conditions. In order to boost up the production per unit area by utilizing the available space and nutrients applied. There is need to assess the optimum plant density for the cultivation of crop in polyhouse. Due to the high costs of the facilities and management it is necessary to develop and apply specific agricultural practices, such as optimizing the density of plants per unit area, for a maximum expression of the productive potential of the crop (Ortiz *et al*., 2009) [23].

The appropriate dose of nutrients and systems of plant manipulation are very important factors for cucumber production. So, it was found necessary to study "Influence of fertigation and pruning levels on soil status and mineral content of parthenocarpic cucumber under polyhouse conditions".

Materials and Methods

Experimental Site

The experiment was conducted under naturally ventilated polyhouse at Vegetable Experimental Farm, Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J&K, India during 2019 and 2020. The experimental site is located at an attitude of 1585 m, 34.50 °N latitude and 74.40 ºE longitude.

Experimental designs and treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications to evaluate effect of different fertigation and pruning treatments. Each block consisted of three sub blocks which in turn were divided into seven equal plots of size 2 × 1 m^2 totaling 21 plots per block. A border of 1m width separated the two blocks. The soil was analyzed for nutrient availability and chemical properties before and after of planting. Treatment combinations were 12 and their detail are described below: P_0F_0: No fertigation + no pruning, $P_0F_{1:}$ 100:75:125 NPK kg/ha + no pruning, $P_1F_{0:}$ No fertigation + Single stem system, $P_1F_{1:}$ 100:75:125 NPK kg/ha + Single stem system, $P_0F_{2:}$ 150:112:188 NPK kg/ha + no pruning, $P_1F_{2:}$ 150:112:188 NPK kg/ha + Single stem system, $P_0F_{3:}$ 200:150:250 NPK kg/ha + no pruning, $P_1F_{3:}$ 200:150:250 NPK kg/ha + Single stem system, $P_0F_{4:}$ 250:188:312 NPK kg/ha + no pruning, $P_1F_{4:}$ 250:188:312 NPK kg/ha + Single stem system, $P_0F_{5:}$ 300:225:375 NPK kg/ha + no pruning and $P_1F_{5:}$ 300:225:375 NPK kg/ha + Single stem system.

Collection and preparation of soil samples

Before laying out of each experiment, initial soil samples were taken at random spots from different soil depths (0-20, upto 45 cm and upto 65 cm) from the experimental field. The soil was mixed thoroughly and about half a kilogram (Kg) soil sample was obtained by quartering method and was stored in neatly labelled polythene bags for soil analysis. Also after conducting each of the experiment, soil samples were again collected and analyzed for final nutrient element estimation.

Physical and chemical properties of soil

The initial soil samples were analyzed for its physical and chemical properties by adopting standard procedures described below;

pH and Electrical conductivity (ds m^{-1}): The pH of the soil sample was determined by digital pH meter in 1:2.5 ratio of soil water suspension (Jackson 1973) [16] and Electrical conductivity was estimated by solubridge conductivity meter-Jackson (1973) [16].

Available nitrogen (Kg ha^{-1}): Available nitrogen was estimated by alkaline $KMnO_4$ method where the organic matter in soil was oxidised with hot alkaline $KMnO_4$ solution. The ammonia (NH_3) evolved during oxidation was distilled and trapped in boric acid mixed indicator solution. The amount of NH_3 trapped was estimated by titrating with standard acid (Subbiah and Asija, 1956) [31].

Available phosphorus (Kg ha^{-1}): Available phosphorus content of the soil was extracted by 0.5 N sodium bicarbonate at pH 8.5 (Olsen *et al.*, 1954) [22] and was estimated by ammonium molybdate method as outlined by Jackson (1973) [16].

Available potassium (Kg ha^{-1}): Available potassium was extracted with neutral normal ammonium acetate at 1:5 soil to extract ratio and the content of potassium was estimated by flame photometer (Jackson, 1973) [16].

Mineral content (N, P, K %)

The fruit samples were collected from five randomly selected plants from each treatment of every replication for analysis. After collecting fresh fruit samples, they were washed thoroughly with tap water then dipped in dilute HCl and further washed with single and double distilled water. The moisture was whipped with filter paper and muslin cloth. Treatment wise fruit samples from each replication were then analyzed for estimation of nutrient elements.

Nitrogen (%): Nitrogen content was determined by Kjeldhal's method as outlined by Tandon (1993) [32].

Phosphorus (%): Phosphorus content was estimated from digested samples by the Vanado molybdate colour reaction method with the help of the spectrophotometer (Jackson, 1973) [16].

Potassium (%): Potassium content was determined by flame photometer (Jackson, 1973) [16].

Micronutrient cations (mg 100g^{-1}): The micronutrient cations like Zn, Fe, Ca and Mn were estimated by Atomic absorption spectrophotometric method (Isaac and Kerber, 1971) [15].

Statistical analysis

To test the significance of treatments and calculating critical difference (CD), the replicated data obtained from each treatment was subjected to statistical analysis as per the standard statistical procedures given by Gomez and Gomez (1984). The experimental data was analyzed in R-Software and levels of significance used for 'F' and 't' tests were p=0.05 as given by Fisher (1970) [10].

Results and Discussion

Perusal of Table-1 of data revealed that different levels fertigation had imparted significant effect on the pH of soil. The data showed that minimum pH 6.70 was recorded from pooled data with F_5 (250:188:312 NPK kg ha^{-1}) while maximum pH values 7.68 was registered with $F_{0.}$ Soil Ph decreased with increasing level of fertigation might be due to increase in organic carbon content and nitrification. Reduction in pH might be due to formation of nitrates from the urea in the soil by nitrification. Similar findings were reported by Singh *et al.*, (2018) [30], Goha and Malkout (1992) [11] and Parchomchuk *et al.*, (1993) [24]. Initially urea can increase Soil pH in the zone of application due to release of NH_3 but with passage of time it is converted into nitrate (Sigurdarson, 2018) [28]. Pruning did not cause any significant effect on soil pH.

However, the combination F_5P_1 registered lowest soil pH *viz.*, 6.69 but over all effect was non-significant. Results are in conformity with results of Bhat *et al.*, (2016) [3]. Analysed pooled data of Electrical conductivity depicts that maximum Ec of 0.353 dSm^{-1} was observed with F_5. This might be due to fact that some amounts of basic material might have accumulated in the soil layer with increasing fertigation levels and slow fertizer application via., fertigation. The increase in EC might also be due to increasing amount of K^+ ions in soil solution. Similar findings were reported by Singh *et al.*, (2018) [30], Parchomchuk *et al.*, (1993) [24] and Goha and Malkout (1992) [11]. Pruning treatments did not show any significant effect on Electrical conductivity (dSm^{-1}) also interaction effect was found non significant on soil EC. Similar findings were founded by Bhat *et al.*, (2016) [3].

Table 1: Effect of fertigation and pruning on soil pH and EC (dSm^{-1}) of cucumber (*Cucumis sativus* L.) var. Pusa parthenocarpic cucumber-6

	pH							EC						
FP	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**
P_0	7.71	7.53	7.32	7.23	7.09	6.72	7.27	0.254	0.279	0.299	0.311	0.328	0.337	0.318
P_1	7.64	7.45	7.28	7.19	7.04	6.69	7.22	0.252	0.284	0.301	0.308	0.322	0.335	0.317
Mean	7.68	7.48	7.30	7.21	7.07	6.70		0.253	0.282	0.300	0.310	0.325	0.336	
C.D. ($p \leq 0.05$)														
P	N/A							N/A						
F	0.23							0.007						
PXF	N/A							N/A						
Initial status:	7.65							0.28						

The pooled data on the effect of different treatments of fertigation on available nitrogen, phosphorus and potassium in soil after crop harvest are presented in Table 2. Perusal of final soil status indicated that among treatments the total N, P, K (Kg ha^{-1}) was found higher in fertigation treatments F_2-F_5 as compared to F_1 i.e. soil application of RDF indicating that there was higher losses when applied directly to soil as in conventional method mainly due to leaching and other losses. Nutrient application directly to soil leads to maximum losses resulting in negative/low gain of nutrients **(**Harisha *et al.*, 2017) [13]. Application of fertigation at the rate of 300:225:375 NPK kg ha^{-1} (F_5) registered maximum values of 429.33, 22.9 and 189.0 kg ha^{-1} for available nitrogen, phosphorus and potassium of pooled data, which were significantly superior reported with other levels. F_0 recorded lower values 296.50 kg ha^{-1}, 11.6 and 128.9 for available nitrogen phosphorus and potassium of pooled data over years. Increased availability of nitrogen, phosphorus and potassium might be due to direct contribution towards the availability of these nutrients. This might also be due to that in fertigation levels especially in F_5 more than 50-65% NPK was given as compared to control. This helps in enriching soil fertility after satisfying nutrient needs of the parthenocarpic cucumber. Similar results were obtained by Kumar *et al.*, (2021) [20], Hadole *et al.*, (2020) [12], Brewer *et al.*, (2018) [4], Tank and Patel (2013) [33] and Bhat Sujhata (2009) [2] and Shedeed *et al.*, (2009) [27]. Shedeed *et al.*, (2009) [27] reported after conducting an experiment found that fertigation maintains higher NO_3- N in soil. Pruning treatment P_1 (plants with one shoot) recorded an available nitrogen, phosphorus and potassium content of 362.33, 18.4 and 159.6 kg ha^{-1} in data pooled over years. However, overall effect of pruning was found to be non significant. Interaction effect of different fertigation and pruning levels also on available nitrogen were found non significant in data pooled over years. Similarly interaction effects between fertigation levels and pruning patterns were observed Non significant effects on available nutrients. Data were showed on Table-2. Results are in line with the findings of Bhat *et al.*, (2016) [3].

Table 2: Effect of fertigation and pruning on soil available nutrients (kg/ha) of cucumber (*Cucumis sativus* L.) var. Pusa parthenocarpic cucumber-6

	N							P							K						
FP	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**
P_0	292.00	315.33	339.33	377.33	405.00	426.66	358.61	11.1	15.5	17.4	19.7	21.3	22.7	18.0	128.5	139.8	149.0	162.7	175.9	187.4	157.3
P_1	301.00	315.00	339.66	378.66	407.66	432.00	362.33	12.0	15.9	17.5	19.8	21.7	23.2	18.4	129.4	139.2	151.7	163.3	179.5	191.2	159.6
Mean	296.50	315.16	339.50	378.00	406.33	429.33		11.6	15.7	17.4	19.7	21.5	22.9		128.9	139.5	150.4	163.0	177.8	189.0	
C.D. ($p \leq 0.05$)																					
P	N/A							N/A							N.S						
F	5.57							5.63							6.43						
PXF	N/A							N/A							N.S						
Initial status	290.1							11.06							122.70						

Perusal of data depicted on Table-3-4 revealed that different levels of fertigation showed significant variation on mineral content. Data on Table -3 depicts that significantly highest values of N, P, K and Ca of 1.41%, 0.55%, 0.95% and 17.57 mg/100 g were obtained with F_4 treatment (250:188:312 NPK kg ha^{-1}) in data pooled over years and was found superior to all other treatments except in case of F_5 treatment with which it was found significantly at par in pooled over years in N %. Control recorded lower values of 1.05%, 0.40%, 0.73% and 14.00 mg/100g for N, P, K and Ca content. Results are in conformity with Khader (2021) [19]. It was also observed various levels of fertigation showed significant difference on Fe, Mn and Zn content of Pusa Parthenocarpic Cucumber-6 fruit (Table- 4). Among fertigation levels highest values of Fe (0.19 mg/100 g), Mn (0.65 mg/100 g) and Zn (0.47 mg/100 g) contents were obtained observed with F_4 fertigation level (250:188:312 NPK kg ha^{-1}) in pooled data over years which was found significantly superior to all other fertigation levels including control. Highest available micro nutrients content might also due to indirect of crop growth and root activity. The high root activity helped in producing organic acids and thus chelated the micronutrients in available form. The

Results are in conformity with the studies of Kumar *et al*., (2021) [20] and Khader (2021) [19]. A comparison of data among different fertigation levels revealed that concentration of nutrients was mainly due to higher availability of nutrients under uniform, frequent and on-spot direct fertilization contributed to improved utilization recovery in the root zone by reducing leaching losses. This improved availability under fertigation resulted in increased photosynthesis, larger and greener leaves and better absorption as well as translocation of nutrients that ultimately led to higher nutrient content. Higher application of nutrients at regular intervals in root zone of fertigated treatments also improved availability of bound nutrients leading to better translocation from roots to different parts. Further application of water soluble micronutrients helped the dissolved nutrients for better absorption and uptake which resulted in higher nutrient content. Similar results were also reported by Bhat and Sujhata (2009) [2] and Karuthamani *et al.* (2018) [18].

Table 3: Effect of fertigation and pruning on fruit mineral content s (N, P and K % and Ca mg/100g) of cucumber (*Cucumis sativus* L.) var. Pusa parthenocarpic cucumber-6

	N %							**P%**							**K%**							**Ca mg/100g**						
FP	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**
P_0	0.99	1.13	1.14	1.25	1.35	1.19	1.18	0.37	0.39	0.42	0.46	0.5	0.44	0.43	0.72	0.77	0.82	0.88	0.95	0.84	0.83	13.29	13.9	14.51	15.36	16.06	15.73	14.81
P_1	1.11	1.18	1.24	1.34	1.46	1.28	1.27	0.42	0.45	0.49	0.55	0.6	0.51	0.5	0.73	0.8	0.85	0.91	0.97	0.87	0.85	14.71	15.29	16.08	17.01	19.08	16.51	16.45
Mean	1.05	1.16	1.19	1.3	1.41	1.23		0.4	0.42	0.46	0.49	0.55	0.48		0.73	0.79	0.83	0.9	0.96	0.86		14	14.59	15.3	16.19	17.57	16.12	
C.D. ($p \le 0.05$)																												
P	0.02							0.048							0.02							0.301						
F	0.04							0.083							0.03							0.521						
PXF	0.06							0.011							0.04							0.739						

Table -3 showed that highest N, P, K and Ca % in Pusa Parthenocarpic Cucumber-6 were recorded from P_1 (plants with one stem) *viz*., 1.27%, 0.95%, 0.50% and 16.45 mg/100g in data pooled over years which was significantly superior to P_0 (plants with no pruning). It might be due to destabilization of root –shoot ratio which resulted in more nutrient content in plants pruned with single stem. It might be also due to more dry matter accumulation in plants pruned to single stem. Pruning of plants to single stem increased nutrient uptake and translocation which ultimately leads to more nutrient content. Pruning also promotes growth ultimately increased sink availability for the deposition of minerals. The results are in line with the results of Tockchom *et al*., (2021) [34], Divyabhrathi *et al*., (2020) [7], Singh and Singh (2010) [10] and Badar *et al*., (2018) [1]. The results on interaction effect of fertigation and pruning patterns on mineral content are presented on Table 3 and 4. Data shows the treatment combination F_4P_1 (250:188:312 NPK kg ha^{-1} + Single stem system) recorded highest N, P, K and Ca content of 1.46%, 0.60%, 0.85% and 16.45 mg/100g content in pooled data over years in Pusa Parthenocarpic Cucumber-6 which was significantly superior to all other treatment combination including control. Same combination also recorded highest values for Fe (0.30 mg/100g), Mn (0.69 mg/100g) and Zn (0.53 mg/100g) contents, The lowest Fruit P content (%) was estimated in P_0F_0 (No fertigation + no pruning). The more mineral contents in treatment combination than individual's treatments might be due to synergism between the treatments. The results are in agreement with Badar *et al*., (2018) [1].

Table 4: Effect of fertigation and pruning on fruit mineral content s (Zn, Mn and Fe mg/100g) of cucumber (*Cucumis sativus* L.) var. Pusa parthenocarpic cucumber-6

	Zn							**Mn**							**Fe**						
FP	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_0**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**
P_0	0.09	0.16	0.24	0.32	0.44	0.38	0.27	0.18	0.27	0.33	0.39	0.60	0.47	0.39	0.06	0.09	0.15	0.20	0.28	0.22	0.17
P_1	0.14	0.21	0.27	0.36	0.53	0.43	0.33	0.22	0.31	0.36	0.43	0.69	0.53	0.43	0.08	0.12	0.17	0.26	0.30	0.25	0.19
Mean	0.12	0.20	0.25	0.34	0.47	0.41		0.20	0.29	0.35	0.41	0.65	0.50		0.07	0.11	0.16	0.23	0.29	0.24	
C.D. ($p \le 0.05$)																					
P	0.01							0.01							.011						
F	0.01							0.02							.019						
PXF	0.02							0.04							.028						

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