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Response of cucumber (*Cucumis sativus* L.) to differential pruning under greenhouse

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Sustainable cucumber production requires optimized agronomic practices that are adaptive to changing climates as well as enhanced crop yield and fruit quality. Commercial Greenhouse experiment was conducted to determine the effect of differential pruning on the growth and yield of cucumber in the Sudan Savanna of Nigeria. The treatments consisted of two hybrid cucumber varieties (Sirana F1 and Marketer) and four pruning regimes (No pruning, pruning at 4, 5 and 6 weeks after sowing (WAS). These were laid out in Randomized Completely Block Design with three replications. Analysis of variance shows that pruning regime significantly ($P<0.05$) influenced plant height (cm), number of leaves per plant, days to physiological maturity, unit fruit weight (kg) and total yield. Further, pruning at 4 WAS resulted in better growth in terms of plant height and the number of leaves per plant which ultimately enhances yield. Delayed pruning at 5 WAS resulted in the highest yield (14 tons ha^{-1}) which coincides with the period when leaves, side branches, and profuse flowers can be efficiently pruned for better yield and fruit quality. In conclusion, for better growth and yield in hybrid cucumber varieties under greenhouse conditions, pruning should be delayed until 4th to 6th weeks after sowing.

Key words: Pruning regime, cucumber, yield, variety.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the most important versatile vegetables grown throughout the year in Nigeria because of its wide range of uses. Recently, the demand for cucumber in Nigeria is on the increase due to the continued awareness of its overwhelming health benefits along with skincare among others (Umeh and Ojiako, 2018). Despite the increasing realization of the importance of cucumber and its relevance as one of the major vegetables in Nigeria, attainable yields and overall productivity in farmer's fields are seriously constrained by inappropriate agronomic practices, pests, and diseases, high fruit perishability as compounded by climate change.

Generally, shifting weather patterns resulting in changing climate, has threatened agricultural productivity through increased rainfall variability and temperature fluctuations (Somarribaa et al., 2013; Malhotra and Srivastva, 2014). To cope with these changes, adaptive strategies that will ensure crops are protected or become resilient to these changes in weather conditions become

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relevant. One approach to this is the protected cultivation which is an agrotechnology that involves covering the crop to allows regulation of macro- and micro-environments, facilitating optimal plant growth and development, the extension of growth duration, induction of earliness, and improved yield and quality (Gruda and Tanny, 2014, 2015). Greenhouses which are a form of protected cultivation, present good opportunities in vegetable productions in Nigeria where issues of seasonality and produce perishability persisted. It presents a major advantage over open field production and a powerful tool in coping with climate change impacts.

Cucumber, being a high-value low volume crop, its exploitation on a commercial scale in the greenhouse becomes more apparent and can serve as an avenue to improve productivity growers' income. The protected cultivation represents the best option to increase the production of cucumber, by promoting a less restrictive environment for the growth and development of the plants than the one that occurs under open field conditions (Smitha and Sunil, 2016). Due to the high costs of these facilities and management, it is necessary to develop and apply specialized agronomic practices, such as the appropriate period of pruning, optimizing stand density, staking, fertilization and irrigation towards achieving high yield and fruit quality.

Under the protected environment, cucumber is predominantly grown with a single main stem and axillary buds are eliminated on a regular basis (Maboko et al., 2011; Max et al., 2016; Mendoza-Pérez et al., 2018). The plants are often trained into a better arrangement of leaves to take advantage of light energy and greater ventilation, which promotes a lower incidence of pests and diseases, facilitates the harvest and allows the use of higher densities of population to obtain high yields of fruits with higher quality (Olalde et al., 2014).

Also, the crop being a profusely and fast-growing, it requires manipulation of its plant architecture through pruning and training for optimizing maximum yields and fruit quality. Pruning has shown to reduced competition and increased efficiency of plant photosynthesis and performance through better use of growth-factors (Premalatha et al., 2006; Shivaraj et al., 2018; Ayala-Tafoya et al., 2019). It has also been demonstrated to increase the flow of air around the plant that helps to reduce incidences of pests and diseases. In another study, Eifediyi and Remison (2009) stated that pruning enhances marketable yield in terms of the size and weight of the fruit. Despite the reported importance of pruning in cucumber, there is still a dearth of literature on the appropriate time of the pruning that will result in increased yield and fruit quality. Most of the previous studies focused on the type of pruning and stand density (Premalatha et al., 2006; Shivaraj et al, 2018; Ayala-Tafoya et al, 2019). This study was therefore undertaken to determine the appropriate pruning regime that will result in increased growth and yield of cucumber under greenhouse condition.

MATERIALS AND METHODS

Description of the study site, and experimental procedures

This experiment was set up in 2019 at the Training and Research Farm of the Centre for Dryland Agriculture, Bayero University Kano, Nigeria. The area falls within the savanna agroecology characterized by poor soil fertility and unimodal rainfall patterns with a mean annual rainfall of 800 mm in 2018. The experiment was conducted under polyethylene greenhouse of 604 m^2 using the Jains Irrigation Ltd systems of Labyrinth stakes, emitting pipes (Jain Turbo Excel Plus) and controlled fertigation systems. The structures were supported by galvanized iron and padded at 50% shading.

Before setting the experiments, the field was harrowed, and beds raised at 1.2 m width and 0.30 m height. The gross plot size was 43.2m^2 (1.2 m x 36 m) and the net plot was 9.6 m^2 (1.2 m x 8 m).

Cow dung manure was incorporated at 5 tons ha^{-1} and mulched using polyethylene mulching sheets. Sowing was done on two drip lines on the same beds and spaced at 0.60 m x 0.60 m intra and interplant on 31st March 2019. Each bed measuring 1.2 m x 36 m was considered an experimental plot. The growing cucumber plant was staked by trellising branches at 90° vertical to the iron beam.

The treatments consisted of two hybrid cucumber varieties (Sirana F1 and Marketer) and four pruning regimes (0, 4, 5 and 6 weeks after sowing (WAS)) where 0 WAS represent control (no-pruning). These were laid out in factorial (2 x 4) Randomized Completely Block Design with three replications. Irrigation, staking and fertigation was maintained based on the standard schedule good agricultural practices (GAPs) for cucumber. The cucumber plants were harvested at harvesting maturity by handpicking at 2 days interval from the net plot until full harvest.

Soil characterization and laboratory analyses

Before bed preparation, soil samples were taken and analyzed for initial nutrient status. The soil samples were collected using auger from at least three points in a W-shape to have a representative sampling. The samples were taken from 0-20 cm and then bulked together and passed through a 2 mm sieve to form a composite sample. The composite samples were prepared using standard procedures and analyzed for physical and chemical properties. Total organic carbon was measured using modified Walkley-Black chromic wet chemical oxidation and spectrophotometric method (Heanes, 1984). Total nitrogen (total N) was determined using the micro-Kjeldahl digestion method (Bremner, 1996). Soil pH (S/W ratio of 1:1) in water was measured using the glass electrode pH meter and particle size distribution using the hydrometer method (Gee and Or, 2002). Available phosphorus, available sulphur, exchangeable cations (K, Ca, Mg and Na) and micronutrients (B, Cu, Mn, Fe, and Zn) were analyzed based on Mehlich 3 extraction procedure (Mehlich, 1984) and reading with Microwave Plasma-Atomic Emission Spectrometer (MP-AES, Agilent Devices, US). Exchangeable acidity (H^+ + Al^{3+}) was determined by shaking the soil with 1N KCl and titration with 0.5 N NaOH (Anderson and Ingram (1993). Effective cation exchange capacity (ECEC) was calculated as the summation of exchangeable cations (K, Ca, Mg and Na) and exchangeable acidity (H^+ + Al^{3+}). All the laboratory analyses were carried out at the Analytical Services Laboratory of the CDA, Kano, Nigeria.

Data collection and analysis

Data were collected on plant height (cm) and number of leaves per

Table 1. Descriptive statistics of soil physical and chemical properties of the greenhouse

Soil parameter	Mean	Standard error	Coefficient of variation (%)
Soil fraction (%)			
Sand	66.7	1.38	6.29
Silt	19.8	1.27	19.23
Clay	14.4	0.49	10.15
pH (1:1)	5.7	0.07	3.80
Organic carbon (g kg^{-1})	1.9	0.02	35.43
Macronutrients			
Total Nitrogen (%)	0.02	0.00	56.69
Available S (%)	0.07	0.01	29.72
Available P ($mgkg^{-1}$)	4.05	0.71	52.84
Exchangeable cations ($cmol^{(+)}kg^{-1}$)			
K	0.34	0.06	54.12
Mg	0.26	0.04	44.81
Ca	1.35	0.10	22.47
Na	0.19	0.02	37.50
ECEC	2.20	0.10	13.41
Exchangeable acidity ($cmol^{(+)}$/kg)	0.06	0.01	36.92
Micronutrients (mg kg^{-1})			
Zn	8.40	2.67	95.27
Cu	0.35	0.06	52.01
Fe	71.82	13.14	54.88
Mn	1.71	0.17	30.47

plant at 2, 4, 6 and 8 WAS physiological maturity, unit fruit weight and total yield (tons ha^{-1}). Plants height was measured as the distance from base neck to the highest point on a plant stem from three tagged plants in the net plot and the average was recorded in centimetres (cm). The measurement was done at 2, 4, 6 and 8 WAS using a meter rule. The number of leaves per plant was counted as those perfectly opened leaves on the three tagged plants and the average was recorded. Counting was done at 2, 4, 6 and 8 WAS.

Unit fresh fruit weight was determined by weighing 5 different fruits on a sensitive weighing balance (Metlar 300) and the average was recorded. Total yield was determined as the summation of the total fruit weight from each harvest from the net plot and was extrapolated to tons per hectare. The data collected were subjected to analysis of variance and significant treatment means were separated using Student Newmann Keul's test at 5% probability level. All statistical analysis was done using JMP Pro version 14 (JMP®, 2019).

RESULTS

Soil characterization of the greenhouse

Wide to moderate variability in soil physical and chemical properties were observed across the study area (Table 1). Soil particle distribution showed wide variability with the sand having the highest fraction (66.7%). Soil pH had low variability (CV<10%) with a mean value of 5.7. The mean soil organic carbon was 0.19% with a CV of 36%. Available P was 4 mg kg^{-1}. All the exchangeable cations showed a high CV (>10%) with exchangeable K having the highest CV (54.12%). Mean micronutrient concentrations showed 8.4 mg kg^{-1} Zn, 0.35 mg kg^{-1} Cu, 71.82 mg kg^{-1} Fe and 1.71 mg kg^{-1} Mn with very high CV (>50%).

Response of cucumber to differential pruning

Table 2 showed the F-probability of the analysis of variance of variety, pruning regime and variety*pruning regime on plant height (cm), the number of leaves per plant, days to physiological maturity, unit fruit weight and total yield. The pruning regime significantly (P<0.05) influenced all the measured variables. The effect of variety was not significant on plant height at 2 WAS (P=0.936), number of leaves per plant at 2 WAS (P=0.104), unit fruit weight (P=0.371) and days to physiological maturity (P=0.259) but significantly (P<0.05) affects plant height and number of leaves at 4, 6 and 8 WAS as well as total yield. Interaction between pruning regime and variety was significant for days to the number of leaves per plant at 4 WAS and unit fruit weight (kg).

Table 2. Probability values (*P*-values) associated with the sources of variation in the statistical analysis of cucumber growth, phenology and yield parameters.

Source of variation	Plant height (cm) (WAS)				Number of leaves per plant (WAS)				Days to physiological maturity (Days)	Unit fruit weight (Kg)	Total yield (tons/ha)
	2	4	6	8	2	4	6	8			
Pruning regime (P)	<0.0001*	0.4577	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.5682	0.0419	0.0271
Variety (V)	0.9367	<0.0001	<0.0001	<0.0001	0.1046	0.0021	0.0064	0.0080	0.2598	0.3714	0.0042
P x V	0.9367	0.0498	0.2421	0.7588	0.3508	0.9703	0.8357	0.7843	0.2471	0.0480	0.1844

*<0.05: Signiant at 5% level of probability using Student Newmann Keul's test; <0.01: Significant at 1% level of probability using Student Newmann Keul's test.

Pruning at 4 WAS produced the tallest plant at 4, 6 and 8 WAS, respectively. The lowest number of leaves per plant at 6 and 8 WAS were observed with pruning regime of 6 WAS. Plants exposed to delayed pruning regime of 6 WAS took a longer time (51 days) to reached physiological maturity and produced the highest total yield (14 tons ha^{-1}) (Table 3). Marketer variety produced the tallest plants at 2, 4 and 8 WAS (10.9, 33.9, 205.3 and 223.3 cm, respectively) and took longer time to physiological maturity (50 days) than Sirana F1. The variety Sirana F1 produced a statistically high total yield (11.78tons ha^{-1}) than the marketer variety (8.98 tons ha^{-1}).

Interaction of pruning regime and variety on the number of leaves per cucumber plant was statistically significant (P<0.05). No-pruning (0 WAS) produced the highest number of leaves per plant for both Marketer and Sirana F1. Delayed pruning of 4 WAS produced the lowest for the two varieties (Figure 1).

Figure 2 shows the interaction between the pruning regime and variety on unit fruit weight of cucumber. The variety marketer had the highest unit fruit weight (kg) in all the pruning regime except under no-pruning (0 WAS) were Sirana FI produced the highest.

DISCUSSION

Pruning is one of the most important practices in the greenhouse production of cucumber that enhances yield, quality as well as ensures a balance between vegetative and reproductive growth phases. Under greenhouse conditions, training of cucumber plants in the form of trellising and pruning remains critical to achieving high yield and qualitative fruits. When grown under greenhouse conditions, cucumber typically has infinite growth on the main stem and there frequent pruning at the appropriate period for high yield and quality. The defining period of when the pruning should be set remains a question as different cucumber varieties differ in response to such training. No-pruning of branches has been shown to promote slow growth, production of dense foliage and unproductive flowers, reduces yield and enhance the prevalence of pests and diseases (Khoshkam, 2016; Ekwu et al., 2012; Premalatha et al., 2006).

Pruning at the appropriate period has shown reduced competition and increased efficiency of plant photosynthesis and performance of the entire plant through better use of factors influencing growth (Ayala-Tafoya et al., 2019; Shivaraj et al., 2018; Premalatha et al., 2006). Pruning has shown to increase the flow of air around the plant that helps to reduce pests and diseases. In another study, Eifediyi and Remison (2009) stated that pruning enhances marketable yield in terms of the size and weight of the fruit.

In this study, pruning of leaves, side branches, and flower buds at 4 weeks after sowing has demonstrated contribute to better growth in terms of plant height and number of leaves per plant which ultimately enhances yield. Delayed pruning will invariably result in a dense canopy of leaves shades the fruits causing them to pale and therefore needs to be pruned and a sufficient number of leaves maintained on the plant (Ayala-Tafoya et al., 2019). The finding of this research revealed that the appropriate regime for pruning cucumber irrespective of variety that resulted in the highest yield is 5 WAS which coincides with the period where both leaves, side branches, and profuse flowers can be efficiently pruned for better yield and fruit quality. This will result in a few pruning and is in line with the report of Shivaraj et al. (2018) who demonstrated that excess pruning may sometimes cause the plants to cease flowering.

Conclusion

Greenhouse vegetable growers often encounter various problems regarding agronomical aspects of crop production as it relates to growth pattern manipulation for enhancing crop qualitative and quantitative performance. Pruning is one aspect that must be adequately planned in terms of defining the appropriate period of the pruning in order to optimize productivity particularly under

Table 3. Growth, phenology, and yield of cucumber as affected by pruning regime (WAS) and variety under greenhouse.

Effect	Plant height (cm) (WAS)				Number of leaves per plant (WAS)				Days to physiological maturity (Days)	Unit fruit weight (Kg)	Total yield (tons/ha)
	2	4	6	8	2	4	6	8			
Pruning regime (WAS) (P)											
0	9.33	28.33^{b}	168.67^{ab}	187.67^{ab}	5.50	16.17^{a}	81.33^{a}	97.83^{a}	49.67	0.95	6.69^{c}
4	9.42	31.67^{a}	184.50^{a}	196.67^{a}	5.67	5.33^{b}	58.83^{b}	78.17^{b}	48.66	1.19	10.27^{b}
5	9.33	29.50^{b}	155.17^{bc}	169.83^{bc}	5.67	15.67^{a}	39.83^{c}	58.83^{c}	50.16	0.89	10.55^{b}
6	8.50	29.50^{b}	145.67^{c}	158.83^{c}	5.83	15.33^{a}	28.67^{d}	44.00^{d}	51.17	0.98	14.02^{a}
SE	0.244	0.464	6.473	6.948	0.388	0.378	0.809	1.367	0.858	0.133	1.370
Variety (V)											
Marketer	10.92^{a}	33.92^{a}	205.25^{a}	223.33^{a}	7.5^{a}	13.00	48.83^{b}	65.25^{b}	49.66	1.14^{a}	8.98^{b}
Sirana F1	7.38^{b}	25.58^{b}	121.75^{b}	133.17^{b}	3.83^{b}	13.25	55.50^{a}	74.17^{a}	50.17	0.87^{b}	11.78^{a}
SE±	0.148	0.282	4.577	4.913	0.124	0.298	0.497	1.054	0.606	0.094	0.969
Interaction											
P x V	NS	*	NS	NS	NS	NS	NS	NS	NS	*	NS

Means within a column followed by the same letter(s) are not statistically different at *P*<0.05 using Student Newmann Keul's (SNK) test; NS – Not significant at *P*<0.05; * Significant at *P*<0.05.

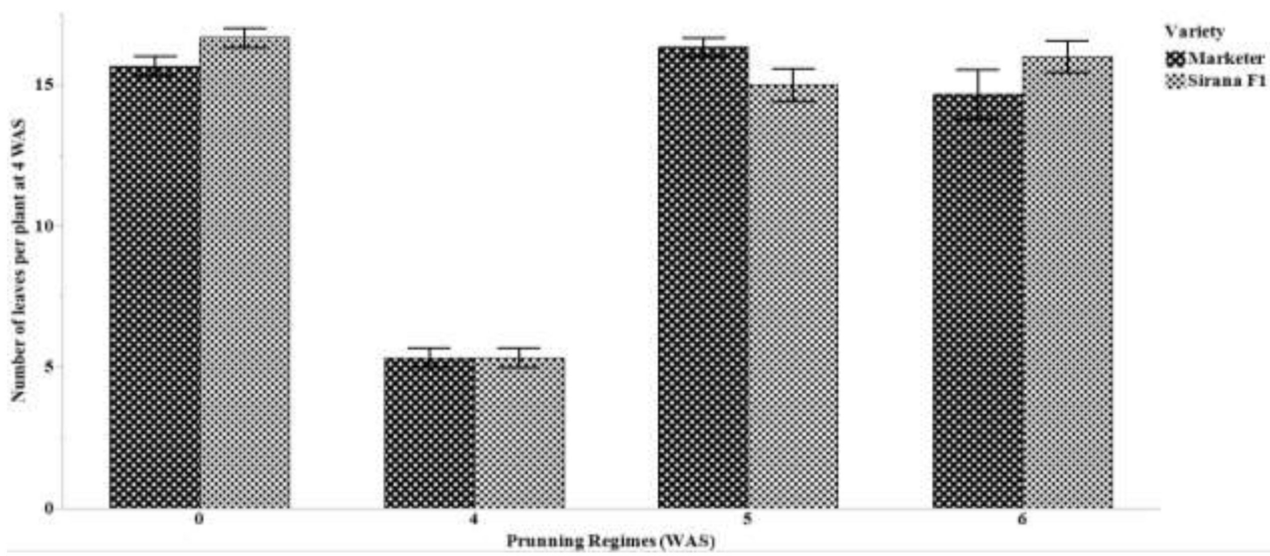

Figure 1. Interaction of pruning regime (WAS) and variety on cucumber number of leaves per plant at 4 WAS under greenhouse.

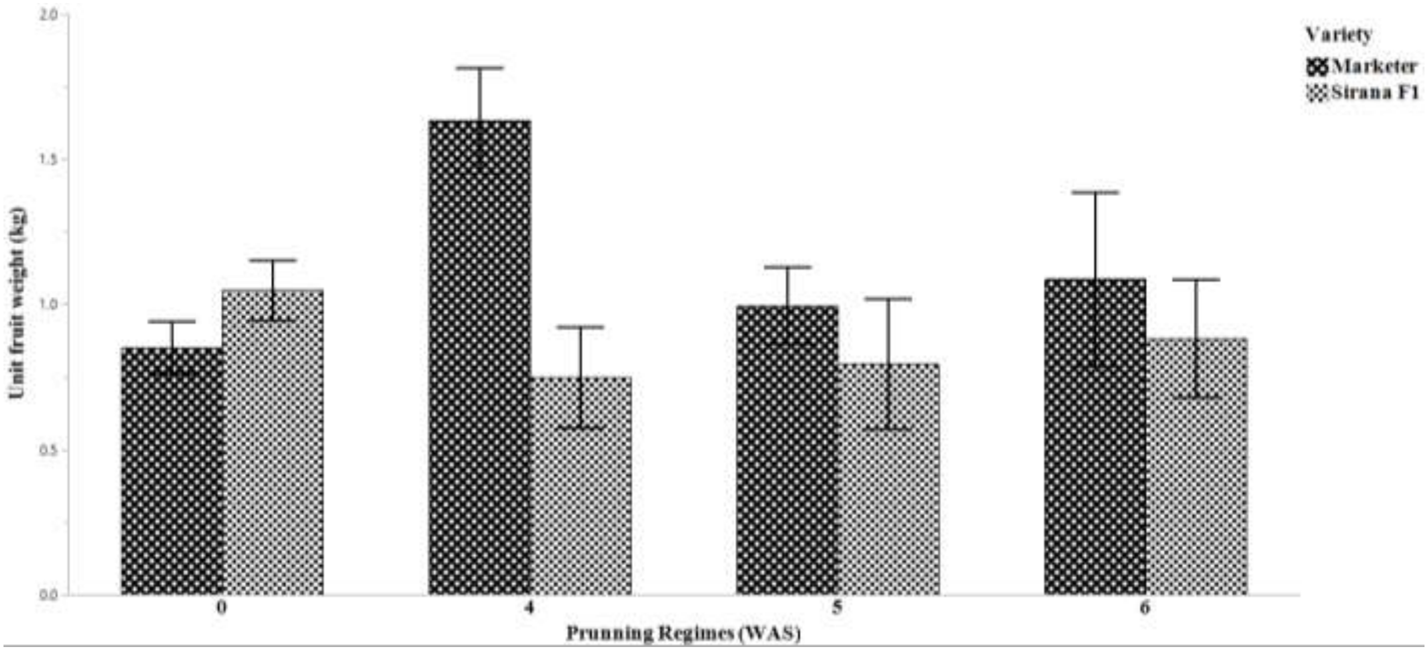

Figure 2. Interaction of pruning regime (WAS) and variety on cucumber unit fruit weight (kg) under greenhouse.

the greenhouse condition where intensive resources and management practices are required. The findings of this research revealed that for better growth and yield in hybrid cucumber varieties under greenhouse conditions, pruning should be delayed until 4th to 6th week after sowing. With the increasing interest of vegetable growers to ensure an all-year supply of fresh vegetables through the adoption of protected cultivation in form of greenhouses, this paper provides an initial basis for establishing an in-depth agronomic recommendation for protected crop production in the study area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Anderson JM, Ingram JSI (1993). Tropical Soil Biology and Fertility (TSBF). A handbook of methods 2nd Eds.; CABI International: Wallingford, UK P 221.

Ayala-Tafoya F, López-Orona CA, Yáñez-Juárez MG, Díaz-Valdez T, Velázquez-Alcaraz T, Delgado JMP (2019). Plant density and stem pruning in greenhouse cucumber production. Revista Mexicana de Ciencias Agrícolas 10(1):79-90

Bremner JM (1996). Nitrogen-Total. In: Methods of soil analysis: chemical methods; Sparks DL.; American Society of Agronomy and Soil Science Society of America: Madison, WI., USA, pp. 1085-1121.

Eifediyi EK, Remison SU (2009). Effect of Time of Planting on the Growth and Yield of Five Varieties of Cucumber (*Cucumis sativus* L). Report and Opinion 1(5).

Ekwu LG, Nwokwu GN, Utobo EB (2012). Effect of mulching materials and pruning on growth and yield of cucumber (*Cucumis sativus* L). International Journal of Agriculture and Rural Development. 15(2):1014-1021.

Gee GW, Or D (2002). Particle-size analysis. In: J. H. Dane and G. C. Topp (Eds.) methods of soil analysis. Part 4. Physical methods. Madison, WI: Soil Science Society of America Book Series 5:255-293.

Gruda N, Tanny J (2015). Protected crops e recent advances, innovative technologies, and future challenges. Acta Horticulturae. (ISHS.) 1107:271-278. https://doi.org/10.17660/ActaHortic.2015.1107.37

Gruda N, Tanny J (2014). Protected crops, pp. 327-405. In: G.R, Aldous, D.E. (Eds.), Horticulture: Plants for People and Places, Volume 1 Dixon. Springer, Netherlands. https://doi.org/10.1007/978-94-017-8578-5_10.

Heanes DL (1984). Determination of total organic-C in soils by an improved chromic acid digestion and spectrophotometric procedure. Communication in Soil Science and Plant Analysis 15:1191-1213.

JMP® (2019). JMP® Version 14. SAS Institute Inc., Cary, NC, 1989-2019.

Khoshkam S (2016). The effect of pruning and planting density on yield of greenhouses cucumber in Jiroft. International Journal of Scientific Engineering and Applied Science 2(8):212-227. www.ijseas.com

Maboko MM, Du Plooy CP, Chiloane S (2011). Effect of plant population, fruit and stem pruning on yield and quality of hydroponically grown tomato. African Journal of Agricultural Research 6(22):5144-5148. https://doi.org/10.1080/02571862.2008.10639914.

Malhotra SK, Srivastva AK (2014). Climate-smart horticulture for addressing food, nutritional security and climate challenges. (In) Shodh Chintan- Scientific articles, by Srivastava AK et al. ASM Foundation, New Delhi, 14:83-97. Horticultural crops and climate change: A review. Available from: https://www.researchgate.net/publication/312937658_Horticultural_crops_and_climate_change_A_review [accessed Dec 31 2019].

Max JFJ, Schmidt L, Mutwiwa UN, Kahlen K (2016). Effects of shoot pruning and inflorescence thinning on plant growth, yield and fruit quality of greenhouse tomatoes in a tropical climate. Journal of Agriculture and Rural Development in the Tropics and Subtropics 117(1):45-56.

Mehlich A (1984). Mehlich 3 soil test extractant: A modification of

Mehlich 2 extractant. Communication in Soil Science and Plant Analysis 15:1409-1416.
Mendoza-Pérez C, Ramírez-Ayala C, Martínez-Ruiz A, Rubiños-Panta JE, Trejo C, Vargas-Orozco AG. (2018). Effects of number of stems on the production and quality of tomato grown in the greenhouse. Mexican Journal of Agricultural Sciences 9(2):355-366. DOI: 10.29312/remexca.v9i2.1077.
Olalde GVM, Mastache LAA, Carreño RE, Martínez SJ, Ramírez LM (2014). The tutored and pruned system on cucumber performance in a protected environment. Journal of Science and Technology of America.39(10):712-717
Premalatha MGS, Wahundeniya KB, Weerakkody WAP, Wicramathunga CK (2006). Plant Training and Spatial Arrangement for Yield Improvement in Greenhouse Cucumber (*Cucumis sativus* L.) varieties. Tropical Agricultural Research 18:346-357.
Shivaraj D, Lakshminarayana D, Prasanth P, Ramesh T (2018). Studies on the Effect of Pruning on Cucumber cv. Malini Grown Under Protected Conditions. International Journal of Current Microbiology and Applied Sciences 7(3):2019-2023. DOI: https://doi.org/10.20546/ijcmas.2018.703.237
Smitha K, Sunil KM (2016). Influence of growing environment on growth characters of cucumber (*Cucumis sativus* L.). Journal of Tropical Agriculture 54(2):201-203.
Somarribaa E, Cerdaa R, Orozcoa L, Cifuentesa M, Dávila H (2013). Carbon stocks and cocoa yields in agroforestry systems of Central America. Agriculture Ecosystems and Environment 173:46-57.
Umeh OA, Ojiako FO (2018). Limitations of Cucumber (*Cucumis sativus* L) Production for Nutrition Security in Southeast Nigeria. International Journal of Agriculture and Rural Development 21(1):3437-3443.