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 (Somarrriba 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
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 m² 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 were raised at 1.2 m width and 0.30 m height. The gross plot size was 45.2 m² (1.2 m x 36 m) and the net plot was 9.6 m² (1.2 m x 8 m). Cow dung manure and other amendments were incorporated on the surface 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) Completely 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 sample. 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, Mn, Fe, Cu, Ni, Zn) was determined based on Mehlich 3 extraction procedure (Mehlich, 1984) and reading with Microwave Plasma-Atomic Emission Spectrometer (MP-AES, Agilent Devices, US). Exchangeable acidity (H⁺ + Al³⁺) 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⁺ + Al³⁺). 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
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).
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\textsuperscript{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 (11.78 tons ha\textsuperscript{1}) than the marketer variety (8.98 tons ha\textsuperscript{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 F1 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, Eifiedy 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.

**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.

**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       | 18.67ab    | 18.67ab     | 81.33a     | 97.83ab    | 49.67      | 0.95       | 6.69c      |                                  |                                  |
| 4                           | 9.42       | 18.45a     | 19.66a      | 8.50       | 15.67a     | 50.16      | 0.89       | 10.55b     |                                  |                                  |
| 5                           | 9.33       | 15.67a     | 16.83c      | 5.83       | 15.33a     | 51.17      | 0.98       | 14.02a     |                                  |                                  |
| 6                           | 8.50       | 15.67c     | 15.83c      | 28.67d     | 44.00d     | 81.33      | 13.00      | 48.83b     |                                  |                                  |
| SE                          | 0.244      | 0.464      | 0.647       | 0.388      | 0.378      | 0.858      | 0.133      | 1.370      |                                  |                                  |
| Variety (V)                 |             |             |             |             |             |             |             |             |                                  |                                  |
| Marketer                    | 10.92a     | 33.92a     | 205.25a     | 13.00      | 48.83b     | 65.25b     | 49.66      | 1.14a       | 8.98b      |                                  |                                  |
| Sirana F1                   | 7.38b      | 25.58b     | 121.75b     | 13.25      | 55.50a     | 74.17a     | 50.17      | 0.87b       | 11.78a     |                                  |                                  |
| SE±                         | 0.148      | 0.282      | 0.577       | 0.124      | 0.298      | 0.497      | 0.606      | 0.094       | 0.969      |                                  |                                  |
| Interaction                 |             |             |             |             |             |             |             |             | * 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.
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.

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