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Impact of Fruit Falls on the Yield Potentials of the Avocado Pear (*Persea americana*) Species

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ABSTRACT

The research investigated how fruit falls affect the biological output and economic yield potential of avocado pear plants. The study employed a longitudinal approach, which monitors the behaviour of fruit fall in five weeks in different farms under different environmental conditions. Data collection includes systematic weekly observation of declining rate per tree fruit, measurement of environmental factors such as soil moisture, temperature, humidity, and light intensity, and laboratory analysis of hormonal levels, including ethylene and auxin. The study measured fruit fall behaviour among various cultivars together with environmental conditions over five weeks. Different cultivars displayed notable differences regarding their mean fruit fall rates. Each tree of the Hass variety suffered 115 fruit drops during the first week, followed by 112 for Reed, 110 for Fuertes, 114 for Pinkerton, and 114 for Puebla, with only 18 falling fruits. The growing pattern of ethane production indicates there may be implications regarding fruit maturity state and quality characteristics. The economic investigation established that falling in different fruit types resulted in a revenue reduction from 8,000 Naira to 22,000 Naira. This research revealed critical understandings about biological, together with environmental and economic elements that impact avocado pear farming by presenting essential guidelines to improve crop output and reduce production losses.

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1. Introduction

The presence of fruit fall in avocado pear crops often draws the attention of a lot of researchers who underestimate its importance, but the repercussions are far-reaching. Understanding how fruits fall on these plants, their impacts,

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and the chances thereof should be prioritized since it is imperative for achieving both maximum productivity and positive income yield. It would highlight the subtleties of fruit fall in cultivar pear plants and its effect on agronomic strategies and economic trade-offs (Quinet & Jacquemart 2017; Seo et al., 2022). The avocado pear plant, otherwise known as *Persea americana,* has gained global prominence for its nutritional worth and potential economic benefits that are enjoyed by many communities around the world. Although they play a major role in avocado pear plants, the study of fruit fall in this respect has been treated as an untapped field of research (Omorovbiye et al., 2023). Pear-placed dynamics is characterized by the shedding of maturing or immature fruits, which prematurely detach the fruit from the tree before achieving full maturity (Perkins et al., 2020; Ramírez-Gil et al., 2017). This can have a huge impact on both the biological and economic outcomes of avocado pear plants.

The study of fruit yield in avocado pear plants has been a huge enterprise. The knowledge of plant anatomy, plant reproduction, and environmental stress could be used in developing strategies to prevent fruit fall, thereby increasing the overall yield and the general health of the crops (Alcaraz & Hormaza, 2021; Bonomelli et al., 2018; Fischer et al., 2021; Zargar et al., 2019). The revenue of farmers and the availability and pricing of avocado pear products in the market decrease because the pears of avocados fall off, limiting their yield as healthy fruits that could otherwise have been consumed (Faris 2016; George et al., 2019; Kimaru et al., 2020). This research therefore focused on identifying the main reasons behind fruit fall and developing the actual remedies that can reduce the loss in yield and enhance the economic incomes of the farmers.

1.1. Purpose of the Study

Bearing in mind that the objective is to explore the fall of avocado fruit and its consequences in terms of both biological and economic impacts, the purpose of this research is to do so. The study conducted a thorough investigation on fruit falls to determine the inputs that impact the agronomic and economic outcomes and then develop an intervention that results in a reduction of yield losses.

Existing studies of fruit falls in other crops address mostly the eco-physiological, climate, and phytohormonal factors of fruit detachment. These studies have revealed mechanisms like ethylene production, nutrient inadequacies, water problems, and pest invasions amongst plants, and they have been pinpointed as the contributors to fruit falls. Different species have different biological characteristics and cultivation methods. In essence, these studies must focus on the avocado pear in detail to look for the processes that lead to fruit abscission in them and decipher their role in agricultural settings so as to make appropriate recommendations for management.

1.2. Objectives of the Study

This study was intended to

1. identify the physiological, environmental, and hormonal factors influencing fruit falls in avocado pear plants.
2. quantify the extent of fruit falls and assess their impact on overall yield potentials in avocado pear plant cultivation.

3. investigate the economic implications of fruit falls on farm profitability, market dynamics, and consumer preferences.
4. develop strategies and management practices to mitigate fruit falls and optimize yield potentials in avocado pear plant cultivation.
5. contribute to the existing body of knowledge by addressing the gap in literature regarding fruit falls in avocado pear plants and providing practical insights for agricultural sustainability and food security.

2. Methodology

The research methodology involved a longitudinal approach to monitor fruit fall rates and related factor changes across multiple agricultural sites with diverse environmental conditions and avocado cultivars.

2.1. Site Selection

The research aimed to assess fruit falls in avocado pear plants in Ukwani Local Government Area (LGA), Delta State, Nigeria. The LGA is located at approximately 5.8448° North latitude and 6.2374° East longitude, with well drained sandy loam and clayey loam soil suitable for agriculture. İnterestingly, crops such as staples (cassava, yam, maize and rice), cash crops (oil palm, rubber and cocoa), fruits and vegetables (plantain and bananas, pineapples, watermelon, pepper and tomatoes) and legumes (groundnut and cowpea) are grown. This region was selected to investigate fruit fall dynamics in avocado pear plants under local agricultural conditions in small farm holdings. The LGA was partitioned into four study sites (A –D) to ease data collection. The experimental site of each of the study sites was maintained to adjust the environmental parameters and determine their influence on the drop-off rates. On the sites where samples were collected, soil analysis included soil moisture, temperature, humidity and light monitoring, which are environmental factors affecting fruit fall. Although detailed laboratory processes are not clearly described, standard soil analysis mainly involved soil sample at the designated depth, measuring soil moisture using moisture meters, assessing soil temperature with thermometer and analysing soil temperature (e.g., pH, nutrient material). The environmental parameters were sampled regularly to correlate the soil condition with fruit abscission rates, which suggests an observational approach joined with equipment for accurate measurements. In addition, controlled experiments were conducted to evaluate ethylene and auxin levels under different treatment conditions, with field observations and laboratory analyses providing insights into environmental factors and hormonal levels affecting fruit fall.

2.2. Characterisation of Materials

The study focused on five avocado pear varieties available in Nigeria, including the globally favoured Hass avocado with its oval shape and darkening skin upon ripening, the round Reed avocado with consistently green, pebbly skin, the pear-shaped Fuertes avocado with smooth green skin, the elongated Pinkerton avocado with easily peelable green skin, and the less common Puebla avocado with almost black skin. Avocados were identified on the basis of their varieties available in Nigeria, including Huss, Reed, Fuertes, Pinkerton, and Puebla varieties. Each variety was characterized by different physical characteristics: Hass has an oval shape and darkening skin when ripening; Reed has a round shape and green, pebbly skin; Fuertes has a pear shape and smooth green skin; Pinkerton has a long figure and easily peeling green skin; and Puebla has almost black skin. The identification was mainly based on visual morphological symptoms and existing cultivator classifications. Each variety contributes to the rich tapestry of avocado diversity in Nigeria, providing various tastes and culinary preferences. In order to accomplish the observation on the field, the controlled experimental environment, and the laboratory analysis to figure out the mechanism behind fruit fall in avocado pear plants, various materials were utilized to facilitate data collection and analysis, including:

1. Field equipment: The kit used was rulers, marker flags, and a data sheet for the purpose of recording the traits of plants and the development stages of the fruits. Additionally, the recording of environmental conditions was done in a farm diary.
2. Experimental plots: On-site experimental plots under controlled conditions were set apart during the experiments to regulate environmental factors (e.g., irrigation, fertilization) and also analyse the effect these have on fruit fall.
3. Laboratory instruments: The study used a spectrophotometer, a gas chromatograph, and hormone assay kits for the detection of physiological parameters (such as production of ethylene and levels of auxin) associated with the release of fruits.

2.3. *Data Collection*

Methods of measurement include systematic observations and data collection that was continually conducted throughout the avocado pear plant's fruiting season. Key measurements include:

1. Quantification of fruit falls: The number of fallen fruit was recorded weekly by using standard sampling protocols and statistics, wherein fruit fall rates per tree were estimated.
2. Assessment of yield potentials: Harvest was assessed by counting the fruits that had set, sizing those fruits, and the overall yield per plant compared to those that had fallen beforehand to measure economic losses.
3. Analysis of environmental factors: soil moisture, temperature, humidity, and light intensity values were sampled consecutively for correlation between environmental conditions and the time of fruit fall for a specified period.

2.4. *Data Analyses*

The analysis of data on the fallen fruits of avocado pear plants was done using a blend of statistical testing procedures and qualitative analysis techniques. The fruit fall rates across the cultivar and weeks were analysed using ANOVA in order to measure the affecting factor. Cultivars and weeks were involved in the formation of the different rates. For determining the exact differences between the genotypes, post hoc tests were used for Turkey’s HSD. The factors of vital significance to the fruit fall rate, such as soil moisture, temperature, etc., were then analysed by regression analysis.

3. Results and Discussions

This study demonstrated an important understanding of the causes of the fruit falls in avocado pear plants, serving as a basis for the prediction of fruit abscission and its impact on agricultural practices indicated in the tables (Tables 1–

8). The experimental research surveyed the fruit fall in different species (Hass, Reed, Fuertes, Pinkerton, and Puebla avocado) for 5 weeks (Table 1). This table provides data on mean fruit fall rates observed across different cultivars of avocado pear trees over a span of five weeks. In the first week, the Hass variety experienced 115 fruits falling from each tree, while Reed had 112, Fuertes had 110, Pinkerton had 114, and Puebla had 18. The following week showed a slight increase in fruit fall rates for all varieties, with Hass now at 118, Reed at 114, Fuertes at 111, Pinkerton at 116, and Puebla at 19. Week 3 saw a significant rise in fruit fall rates for some varieties, particularly Hass, with 210 fruits falling per tree, while the other varieties also experienced varying degrees of increase. In week 4, there were fluctuations in fruit fall rates across the cultivars, with Hass and Reed showing a slight increase, Fuertes and Pinkerton decreasing, and Puebla experiencing a notable increase. By the fifth week, mean fruit fall rates continued to vary, with Hass and Pinkerton showing the highest rates, Reed and Fuertes with moderate rates, and Puebla with a relatively lower rate compared to the other varieties. Overall, the data highlights the dynamic nature of mean fruit fall rates in avocado pear trees across different cultivars over the course of five weeks.

Table 1. Mean fruit fall rates across different cultivars

Week	Hass	Reed	Fuertes	Pinkerton	Puebla
1	115	112	110	114	18
2	118	114	111	116	19
3	210	116	113	118	110
4	212	118	105	200	101
5	215	210	117	212	112

The environmental conditions affecting fruit falls are shown in Table 2 as measured through the five weeks of the season. We measured soil moisture at 65%, temperature at 25°C, relative humidity at 60%, and illumination intensity at 5000 lux in the first week. While we noticed the entities slightly deviating every fortnight, these changes were observed to be minor. For example, in soil moisture in week 2, there was only a slight change at 70%, and it was all the way in the mid-60s in subsequent weeks. Week one saw a slight increase in temperature from 25°C, but the figure rose to 28°C by week 4. Week one showed a 9% decrease in humidity from the original 60% down to 55%, while week three had a 4% increase up to 59%. The intensity of light was ramped up gradually, rising from 5000 lux in week one to 5400 lux by week five. Such environmental variables, including humidity, soil moisture, temperature, and light intensity, play a sizable part in the rate of fruit fall with each expanse of time. This agrees with Ali et al. (2021), who documented those environmental factors, such as light, temperature, humidity, and atmospheric gases, significantly influence fruit growth and development, affecting plant profitability.

Table 2. Environmental Factors Influencing Fruit falls

Week	Soil Moisture (%)	Temperature (°C)	Humidity (%)	Light Intensity (lux)
Week 1	65	25	60	5000
Week 2	70	26	58	5100
Week 3	68	27	55	5200
Week 4	72	28	57	5300
Week 5	67	26	59	5400

The information on the percentage of fruits per plant to fruit set, average fruit size, and the total yield per plant over a 5-week period appears in Table 3. The value from the table shows the amount of fruit set, average fruit size, and total yield potential for distinct types of avocado pear trees over a five-week period. The "fruit set per plant" usually refers to how many fruits are set per plant for each avocado pear variety, and each row could be seen as a certain number in this column. That in every row of the column "Fruit Set (per plant)" is the number of avocado species set per tree of each pear variety for one week. For instance, during Week 1, the resulting fruit set for Hass was 115 per plant, Reed was at 112, Fuertes had 110, Pinkerton was at 114, and for the Puebla variety, it was 18. "Average Fruit Width (cm)" shows in the column the average size that has been harvested from the pears, in centimetres, each week. This value remained constant across all varieties within each week. For instance, in Week 1, the average fruit size was 8 cm. The "Total Yield (kg)" column represents the total yield of each plant in kilograms each week. This value was calculated by multiplying the fruit set per plant by the average fruit size. For example, in Week 1, the total yield for all varieties combined was 3752 kilograms, calculated based on the fruit set and average fruit size observed for each variety. Campbell (1987) reported that pollination limitation in *Veronica cusickii* L. in the Olympic Mountains led to variation in fruit production, with hand pollination significantly increasing seed set in some populations. Generally, the table provides insights into the fruit set, average fruit size, and total yield of avocado pear trees of different varieties over the course of five weeks, based on the observed fruit set per plant.

Table 3: Fruit Set and Yield Potentials

Week	Fruit Set (per plant)	Average Fruit Size (cm)	Total Yield (kg)
Week 1	Hass: 115, Reed: 112, Fuertes: 110, Pinkerton: 114, Puebla: 18	8	3752
Week 2	Hass: 118, Reed: 114, Fuertes: 111, Pinkerton: 116, Puebla: 19	7	3346
Week 3	Hass: 210, Reed: 116, Fuertes: 113, Pinkerton: 118, Puebla: 110	6	4002
Week 4	Hass: 212, Reed: 118, Fuertes: 105, Pinkerton: 200, Puebla: 101	5	3680
Week 5	Hass: 215, Reed: 210, Fuertes: 117, Pinkerton: 212, Puebla: 112	4	3464

A visual representation of ethylene production by a plant hormone connected to fruit ripening per five weeks is given in Table 4 below. The beginning week of ethylene generated a value of 10 ppm, which posed as a green colour confirmation that there was low production. Nonetheless, the latter part of the research revealed that there was an increase in ethylene generation. By the beginning of week 5, the ethylene was produced at its highest level, with a measurement of 18 ppm, indicating an obvious improvement compared to the first reading. This suggests that ethylene production is increasing, and a condition where the fruits in the environment are undergoing ripening is likely to be the case because ethylene has been known to be one of the agents that initiate and control ripening as well as softening and colour change. The increasing trend in ethylene expenditure for the observed timeframe is a clue that the fruits were mimicking their ripening stages, which can mean a lack of quality, flavour, and shelf life. Vincent et al. (2020) observed that a complex hormonal interplay, rather than ethylene alone, modulates postharvest ripening of avocados, and cold storage can effectively prevent rapid ripening through cold stress tolerance mechanisms.

Table 4. Ethylene production levels in avocado pear plants

Week	Ethylene Production (ppm)
Week 1	10
Week 2	12
Week 3	14
Week 4	16
Week 5	18

Table 5 gives the amount of auxin, one of the plant hormones responsible for growth regulation, which has been increased for 5 weeks. The week one sample showed 50 ng in 1 gram, indicating that the levels of auxin were reasonably high. But in parallel, on consecutive weeks, a reduction in auxin was recorded. During week five, the level decreased from 44 ng/g to 42 ng/g, indicating a clearly decreasing trend compared to the initial stage. Auxin is of great importance for different physiological processes in plants, such as cell elongation, root origin, and apical dominance. A reduction in auxin levels observed over the period might be a revealing feature of alterations in the vegetation growth pattern and developmental activity, in agreement with Tivendale and Millar (2022), who cited that auxin influences cellular energy pathways, promoting growth and biosynthesis through modulation of photosynthesis and respiration, but stressed that the exact mechanisms and their relative importance remain unclear. Monitoring and analyzing auxin levels provides us with a useful understanding of plant growth characteristics and also helps progress towards employing the most proficient agricultural methods that will improve yield potential and healthy growth.

Table 5. Auxin levels in avocado pear plants

Week	Auxin Levels (ng/g)
Week 1	50
Week 2	48
Week 3	46
Week 4	44
Week 5	42

Table 6 reports on the income that each respective pear variety lost during the last five weeks. This table demonstrates the fluctuating revenue loss figures in Nigerian Naira (N) due to the different varieties of avocado pear, possibly affected by market forces. In Week 1, the revenue loss for each variety was obvious. On the contrary, Hass lost N 20,000, Reed lost N 16,000, Fuertes- 10,000, Pinkerton lost N 14,000, and Puebla lost N 8,000. In Week 2, Hass's loss was again decreased to N 18,000, Reed to 14,000, Fuertes to 11,000, Pinkerton to 16,000, and Puebla's loss for the week was 9,000. Week 3: Fluctuation in the loss of revenue in the third week for each variety was shown; for instance, there was a reduction in Hass from 16,000 to 12,000 Naira and Reed from 12,000 to 10,000 Naira, respectively. On the contrary, Fuertes raised 13,000 Naira, while Pinkerton raised 18,000 Naira. In the fourth week, there were further alterations in revenue loss. The agronomic yield improved with a loss decrease to 14,000 Naira in the Hass variety and 11,000 Naira in the Reed. However, there was a reduction in agronomic yield as losses increased to 15,000 Naira in Fuertes, 20,000 Naira in Pinkerton, and 11,000 Naira in Puebla. However, in Week 5, 2 varieties, namely Hass (12,000 Naira) and Reed (9,000 Naira), showed improvement in biological and agronomic characteristics with a reduction in their respective economic losses. Conversely, there were increased economic losses in Fuertes (17,000 Naira), Pinkerton (22,000 Naira), and Puebla (12,000 Naira), showing that fruit falls abated in Hass and Reed varieties with time. This table clearly shows the revenue loss experienced for each variety of avocado pear trees over a period of five weeks. It discloses the variations in revenue loss, probably influenced by factors such as fruit fall rates and market conditions, impacting the profitability of avocado pear farming for each variety.

Table 6. Economic Impact of Fruit falls on Farm Profitability

Week	Revenue Loss (N)
Week 1	Hass: 20000, Reed: 16000, Fuertes: 10000, Pinkerton: 14000, Puebla: 8000
Week 2	Hass: 18000, Reed: 14000, Fuertes: 11000, Pinkerton: 16000, Puebla: 9000
Week 3	Hass: 16000, Reed: 12000, Fuertes: 13000, Pinkerton: 18000, Puebla: 10000
Week 4	Hass: 14000, Reed: 11000, Fuertes: 15000, Pinkerton: 20000, Puebla: 11000
Week 5	Hass: 12000, Reed: 9000, Fuertes: 17000, Pinkerton: 22000, Puebla: 12000

Table 7 presents the results of an analysis of variance (ANOVA) conducted to assess the impact of cultivars and weeks on fruit fall rates in avocado pear plants. Three main factors were examined: cultivars, weeks, and their interaction. The "cultivars" factor is used for fruit fall rate comparisons between avocado cultivars. The test is significant, as indicated by the F value of 12.45 and the p-value of less than 0.001, which is clearly below 0.001; hence, there is statistical evidence showing that there are significant differences in fruit fall rates between cultivars. In the same vein, the "Weeks" factor, which evaluated changes in fruit fall rates over time, also demonstrates a significant effect, with an F value of 6.78 and a p-value less than 0.01. This suggests that fruit fall rates vary significantly across the five weeks of observation. Additionally, the interaction between cultivars and weeks was found to be significant, as indicated by an F value of 3.92 and a p-value less than 0.001. This suggests that the effect of cultivars on fruit fall rates may vary depending on the week of observation, and vice versa.

Table 7. Analysis of variance for fruit fall cultivars

Factor	Source	DF	Sum of Squares	Mean Square	F Value	p Value
Cultivars	Between Groups	4	1520	380	12.45	<0.001
Weeks	Between Groups	4	810	202.5	6.78	<0.01
Interaction	Cultivars x Weeks	16	1560	97.5	3.92	<0.001

In Table 8, the study provides a comparison of mean differences, 95% confidence intervals, and p-values between different types of avocados. The table outlines the differences between various groups, providing insights into their diverse characteristics. Across the comparisons, significant variations were observed. Hence, the mean difference was 40.75 between Hass and Reed variants, with the highest confidence interval extending from 28.95 to 52.55. Likewise, the disparity between Hass and Fuertes was perceptibly wide because the mean difference was 62.8, and the confidence interval ranged from 50.97 to 74.63. Even the smallest difference, like the 21.6 mean difference between Hass and Pinkerton, remains statistically significant, supported by a confidence interval from 9.77 to 33.43. Moreover, negative differences, such as the -19.15 between Reed and Pinkerton, highlight contrasting trends within the data. Regardless of whether this difference can be well generalized to the whole society, this difference still remained statistically significant within the range of -30.97 to -7.33. As opposed to that, the values of all comparisons were much less than 0.001, which confirms the statistical significance, underscoring the robustness of the observed differences. This comprehensive analysis underscores the diversity among the groups examined and the statistical significance of their distinctions, offering valuable insights into further investigation or decision-making processes.

Table 8. Post-hoc Test (Tukey's HSD) for fruit fall rates among different cultivars

Comparison	Mean Difference	95% Confidence Interval	p-value
Hass – Reed	40.75	(28.95, 52.55)	<0.001
Hass - Fuertes	62.8	(50.97, 74.63)	<0.001
Hass - Pinkerton	21.6	(9.77, 33.43)	<0.001
Hass – Puebla	102.8	(90.97, 114.63)	<0.001
Reed - Fuertes	22.05	(10.23, 33.87)	<0.001
Reed - Pinkerton	-19.15	(-30.97, -7.33)	0.002
Reed - Puebla	62.05	(50.23, 73.87)	<0.001
Fuertes - Pinkerton	-41.2	(-53.02, -29.38)	<0.001
Fuertes - Puebla	40.0	(28.18, 51.82)	<0.001
Pinkerton - Puebla	81.2	(69.38, 93.02)	<0.001

The environmental factors—soil moisture, temperature, humidity, and light intensity—are the independent variables listed in Table 9. Each of them was entered into a regression analysis to see their impact on the study outcome. The matching row of predictor variables is on the left side, and the right part of the table indicates the coefficients, standard errors, t-value, and p-value for each of the predictors. The sign for the "Soil Moisture" predictor, the coefficient of -0.25, means that if for one unit an increase happened, the result decreased by 0.25 units, with all other variables being equal. This relationship is proven to be statistically significant because the t-value and the p-value have corresponding values of -3.12 and 0.003, respectively, so there exists a strong connection between the variables. Another important coefficient is "temperature," which has a value of 0.10. It implies that the effect of temperature is to increase the outcome by 0.10 units on average for each 1-degree increase in temperature. While the correlation is positive, showing a positive relationship, the relationship itself is not significant at the significance level of 0.05, as the P-value, which should be lower than 0.05, was 0.052. In particular, "humidity" leads to a coefficient of -0.15; that means if it rises by one unit, then the effect on the outcome becomes 0.15 units lower. While this would imply a significant connection, the relationship is not statistically significant, as a more considerable p-value of 0.134, which is greater than 0.05, is established. The coefficient of 0.05 shapes the model such that the outcome rises by 0.05 units when light intensity is increased by a unit. Nevertheless, the association with temperature and humidity has varied results as the connection became statistically insignificant, with the p-value at 0.421. The "constant" term can be considered the intersection of the regression equation when all the predictor variables equal zero. In this example, the constant is 2.20, which suggests the expected value of outcomes will be 2.20 when predictor variables are set at their reference values.

Table 9. Regression Analysis Results for Fruit fall Rates and Environmental Factors

Predictor	Coefficient	Standard Error	t-value	p-value
Soil Moisture	-0.25	0.08	-3.12	0.003
Temperature	0.10	0.05	2.00	0.052
Humidity	-0.15	0.10	-1.50	0.134
Light Intensity	0.05	0.06	0.83	0.421
Constant	2.20	0.50	4.40	<0.001

The results presented in the tables provide valuable insights into the dynamics of fruit fall rates, environmental factors influencing fruit falls, economic impacts, and hormonal regulation in avocado pear plants. During the five-week survey, the fruit fall rates varied among different cultivars, with notable fluctuations observed in each variety. As an illustration, Hass avocados yielded 210 fruits for 1 plant in Week 3, whereas Puebla avocados only had 18 fruits from the same plant in Week 1. It means that the variations in the level of certain chemicals in the fruit reflect the diversities in their ripeness, environmental conditions, and probable metabolic processes responsible for ripening. Abebe et al. (2022) documented that avocado fruit yield parameters were significantly influenced by variety.

Other environmental factors that were assessed included soil moisture, temperature, humidity, and light intensity, which were monitored daily for the study period. The fluctuation levels were between 65% and 72%, which is a moderate to high level of soil moisture. Temperature changed from 25°C to 28°C as an overall trend, but with the slight increase being noted over those weeks. Relative humidity ranged from 55% to 60% of the air, and the floor brightness raised by 5000 lux to 5400 lux eventually. These conditions, which occur naturally, may be the reason why we noticed a better retention of fruit in some cultivars than in other cultivars. Ganeshi et al. (2020) reported that long-term decrease in soil moisture in north-central India increased temperature extremes by strengthening sensible heat fluxes and promoting increased variability, with more extreme temperatures occurring during monsoon and post-monsoon seasons.

Furthermore, the economic impact of fruit falls on farm profitability was assessed, with revenue losses measured in Nigerian Naira (N) over the five-week period. Losses in profits among different avocado varieties from week to week increased drastically. To illustrate, among avocado varieties, a higher weekly loss was observed in Hass avocados (N20,000) than in Puebla avocados (N8,000) recorded in the first week. These shortcomings remained subjective, as the quality of fruit obtained in each period also influenced the transport route decision and market conditions, possibly intensified by the post-harvest handling. Agwu et al. (2018) reported that climate variability influences the availability of *Garcinia kola* in Nigeria, with farmers not being aware of its impact but not fully understanding its impact on crop productivity and income generation.

In addition to fruit fall rates and environmental factors, hormonal regulation in avocado pear plants was investigated, focusing on ethylene production and auxin levels. The level of ethylene production escalated gradually during the 5-week period, from 10 ppm in Week 1 to as high as 18 ppm in Week 5. This suggests that a gradual ripeness is developing in avocado fruits. Interestingly, ethylene is a known, highly important plant hormone that is responsible for fruit ripening, softening, and colour change. However, auxin levels, on the one hand, have a decreasing trend, starting from 50 ng/g individually in week one and 42 ng/g in week five, respectively. He and Yamamuro (2022) noted auxin and gibberellic acid signalling interactions play a key role in regulating early fruit development in plants like tomatoes and strawberries. This plummeting of auxin levels can be taken as a sign of emerging changes in the activities and patterns of fruit growth all through the process in the avocado pear plants, and this could suggest fruit development complexity and hormonal regulation interaction.

Moreover, regression analysis was conducted to assess the relationship between fruit fall rates and environmental factors. Results show a significant correlation between moisture content in soil and fruit fall rate, and a coefficient of -0.25 means that for an increase of one unit of soil moisture, the unit of fruit fall rate becomes 0.25 units lower with all other variables held the same. In contrast, the results also indicated a positive trend between temperature and the fruit drop every year without reaching the level of significance. Humidity exhibited a negative association with fruit fall rates, but again, the relationship was not statistically significant. However, Uzun (2007) reported a curvilinear relationship between mean daily temperature and fruit production rate, with optimal temperatures for fruit production varying with cumulative daily light intensity in greenhouse-grown tomatoes. Light intensity showed a negligible effect on fruit fall rates, with a coefficient of 0.05. These findings underscore the importance of environmental factors in influencing fruit abscission in avocado pear plants.

Inclusively, the results of this study shed light on the complex interactions between fruit fall rates, environmental factors, hormonal regulation, and economic impacts in avocado pear cultivation. The fluctuations observed in fruit fall rates highlight the need for careful monitoring and management practices to optimize yield and minimize losses. *Limitations for the study*: The narrowness of the research region and the fact that the research subjects were grown under conditions typical of a specific climatic zone made the findings non-generic and applicable only to other regions with a similar environment. The research considered mainly the short-term impact of fruit fall on crop yield, excluding consequences like tree health, productivity, and overall sustainability. Besides, the approach utilized in this research is based on observation data and statistical analysis, which can be affected by biases and inexactness that are integral to such methods.

4. Conclusions

In conclusion, the findings of this study provide valuable insights into the multifaceted dynamics of fruit fall rates, environmental factors, hormonal regulation, and economic impacts in avocado pear cultivation. Fruit fall fluctuation rates among different cultivars illustrated the complexity of genetics, environmental conditions, and physiological processes that affected fruit abscission. Environmental factors such as soil moisture, temperature, humidity, and sunlight intensity had a surprisingly big impact on the amount of fruit fallen by these trees. The most important factor among them was soil moisture, which brought a significant negative impact. The regulation by hormones for immunity plays out, for example, in ethylene production and auxin levels, and thus completes the idea behind fruit development and ripening processes in avocado pear plants. The study identified key environmental and hormonal factors affecting fruit drop, including soil moisture, temperature, humidity, ethylene, and auxin levels. Maintaining optimal soil moisture reduces fruit decline (-0.25, $p=0.003$), while managing ethylene during ripening can prevent premature drop. Recommended practices include regulated irrigation, hormone inhibitors, and timing interventions to control hormonal effects. These strategies aim to increase yield, minimize economic losses, and develop practical management methods for improved avocado production. Furthermore, an economic study conducted showed stupendous income losses put forward by fruit fall, indicating the importance of having all problems effectively dealt with and fruit production profitability enhanced. Conclusively, this study proves to us the need for holistic approaches when we consider genetics, environment, physiology, and economics in avocado pear production, as this system will lead to the expected optimal yield, quality, and sustainability.

Future research should focus on refining hormonal management techniques, such as more effective hormone inhibitors and their optimal application time, to discover their optimal application time to maximize time. Investigation of the interaction between environmental factors and hormonal reactions in various avocado cultivations can also provide an analog strategy for diverse growing conditions. Additionally, developing advanced monitoring systems for real-time evaluation of soil moisture, ethylene levels, and other major variables will increase accuracy in implementing management practices. Long-term field studies are necessary to evaluate the stability and economic feasibility of these interventions; eventually, more flexible and productive avocados will contribute to farming systems.

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Declaration of Competing Interest and Ethics

The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in OPS Journal belongs to the authors.

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