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COMPARISON OF YIELD AND QUALITY OF PINEAPPLE FRUIT UNDER IRRIGATED AND RAINFED CONDITIONS IN GHANA: A PERSPECTIVE FROM FARMERS' FIELD CONDITIONS

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Abstract

While most commercial pineapple farms in Ghana cultivate under rainfed conditions, few supplement the rains with irrigation, which is a good agronomic practice. In this study, pineapple fruit yield and quality (brix and weight loss) were assessed in rainfed and irrigated fields in Ghana's Coastal Savannah agroecological zone in 2022 production period at Bomarts Farms. Forty (40) matured pineapple fruits from a 50 × 50 m plot were sampled under drip and rainfed conditions each. Weight of fruits were in the range of 609 g and 1,524 g inclusively. The average least fruit weight for drip-irrigated and rainfed fields were 652 g and 609 g, respectively. The variation of fruits weight under both conditions was not significant (p-value = 0.815). Generally, the weight loss was high in fruits from irrigated (drip) fields during the storage period. The brix for drip-irrigated pineapple was lower (12.8 ^{0}Bx, 15.6 ^{0}Bx and 19.8 ^{0}Bx) than pineapple cultivated under rainfed conditions (13 ^{0}Bx, 16 ^{0}Bx, 21 ^{0}Bx). Annual rainfall in the study area (840.7 mm) compared to requirement (1,000 mm) for pineapple plants poses a challenge to year-round production, and presents an opportunity for farmers to adopt good agronomic practices to sustain production in the coming years.

Key words*: *coastal savannah, irrigation, pineapple, rainfed

INTRODUCTION

More than 95 % of agricultural production in Africa is rainfed, providing employment to about 65 % of the people in the region in the last decade [20]. Projections from other studies [2, 10, 12] have shown that climate variability will worsen in the future because of population growth, urbanization, industrialization, and nature-based extremities such as floods, drought, amongst others [17]. These extremities affect crop production and warrant the adoption of good agronomic practices to sustain production [14].
Pineapple (*Ananas comosus*) is a Crassulacean Acid Metabolism (CAM) plant with a photosynthetic adaptation which makes it drought-tolerant. It is commercially propagated for its nutritious fruit [7] and it is the only specie in the *Bromeliad* family that is widely grown for its fruit [16]. Pineapple is considered as the third most important tropical fruit after banana and citrus, in terms of global production [13]. The exceptional aroma and flavour, appealing appearance, and important nutritional makeup (vitamins, minerals, fibre) makes it the consumer's preferred choice of tropical fruit [1].
Pineapple is an important export crop in Ghana with a well-developed and structured sector [15]. The main production area is the country's Coastal Savannah agroecological zone where most cultivation is rainfed [22]. Its growth can be retarded due to seasonal drought and water shortage [24, 11], and this will affect the fruit yield [3]. According to [8], pineapple cultivated under irrigation produces high fruit yield and good quality. It is therefore important for farmers to consider the incorporation of appropriate irrigation practices, and adjust planting calendar to account for the impact of rainfall variability [24, 14].
Good pineapple fruit quality is attributed to growing sites having a combination of relatively cool night temperatures, sunny days, and high day temperatures [11]. According to [22], climatic conditions such as

rainfall and temperature have a significant impact on pineapple production, especially in the tropics, with a suitable temperature and rainfall range of 18 to 32 °C and 1,000 to 1,500 mm/annum of rainfall, respectively [3]. Generally, according to [4], pineapple requires a minimum monthly rainfall total of 50 to 100 mm. If the annual rainfall is less than 500 mm, irrigation is required for better yield [4]. Thus, tropical countries with enough water available for crop production are found to be most suitable for the fruit's cultivation [3, 24]. In this study, pineapple fruit yield and brix and weight loss were assessed under both rainfed and irrigated fields in Ghana's Coastal Savannah agroecological zone.

MATERIALS AND METHODS

Pineapple production in Ghana is concentrated in the Coastal Savannah (CS) agroecological zone. This zone lies between latitude of 4.5°N and 6°N, and longitude of -0°13'56" to 0°58'42" W, and it is distinguished by its relatively low rainfall of 800 mm distributed in two seasons (major and minor) and grassland savannah vegetation [6]. The study was carried out at Bomarts Farms in the CS agroecological zone, where pineapple is produced both under rainfed and drip irrigation.

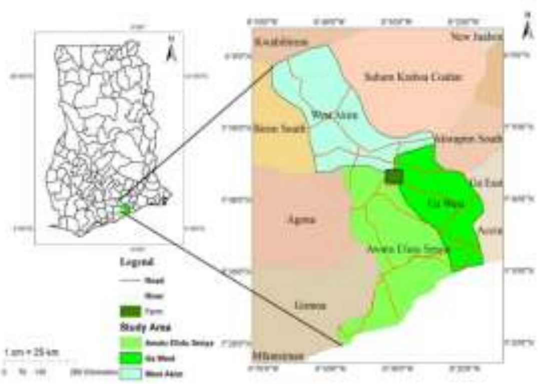

Fig.1. Map of Study Area Showing Bomarts Farms in the Coastal Savannah (CS) agroecological zone
Source: Author, 2022.

The average yearly rainfall in the agroecological zone is 800 mm. While the minor season's rainfall peaks in October and its dry phase lasts from December to March, the major rainy season spans from April to mid-July and is followed by a one-to-two-month dry period. The rainfall dispersion varies and rainfall fluctuations are a major setback for agricultural production. The zone experiences high temperatures which are about 26.5 °C on average throughout the year. Humidity is high in general (65–95 %), although it is lower during the warmer months, especially in January, when the northeast harmattan winds are prevailing [18]. Pineapple cultivation is supported by the type, texture, and composition of the soil in this area, which is home to a number of sizable pineapple farms, including Bomarts Farms, which was chosen for this study. Climate data (1989 – 2019) for the Coastal Savannah Agroecological zone, presented in Table 1 were sourced from the Ghana Meteorological Agency.

Table 1. Monthly means of climate data for the Coastal Savannah Agroecological Zone, from 1989 to 2019

Month	T_{min} **°C**	T_{max} **°C**	Humidity **%**	Wind **km/day**	Sun **hours**	Rainfall **mm**
Jan	23.0	32.3	88	210	6.5	12.0
Feb	24.3	33.0	89	273	7.4	27.1
Mar	24.5	33.0	90	261	7.1	56.4
Apr	24.5	32.8	90	240	7.5	99.0
May	24.1	31.9	91	226	6.9	164.9
Jun	23.6	30.1	92	230	5.3	204.0
Jul	23.0	29.0	93	274	5.2	65.1
Aug	22.6	28.9	93	276	4.5	22.0
Sept	23.1	30.0	92	304	5.5	45.3
Oct	23.3	31.0	91	273	7.4	85.9
Nov	23.5	32.1	90	219	8.1	38.0
Dec	23.4	32.3	89	187	7.4	21.0
Avg/Tot.	**23.6**	**31.4**	**91**	**248**	**6.6**	**840.7**

Source: Ghana Meteorological Agency, 2022.

As shown in Table 1, from 1989 to 2019, minimum daily temperature was about 23.6 °C and maximum 31.4 °C, with relative humidity ranging between 88 % and 93 %, with an average of 91 %. January had the lowest monthly rainfall (12.0 mm), while June had the greatest (204 mm). Six months (January, February, August, September, November, and December) had rainfall values below 50 mm, and this is below the monthly water requirement for pineapple plants in the tropics. [3] considers annual rainfall of 1000-1,500 mm as suitable for proper growth and good yield, and in every month, according to [4], rainfall of 50-100 mm is appropriate.

Pineapple Yield and Fruit Quality Assessment

Fruit Yield and Percent Weight Loss

(i). Fruit yield: Forty (40) matured fruits were sampled from a 50 x 50 m area under both rainfed and rainfed conditions during harvesting. The fresh weight for both conditions were determined and the yield for the two fields were computed as:

$$Y_{FF} = \frac{FF}{A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where:
Y_{FF} – Fresh fruit yield [t ha^{-1} or kg m^2],
FF – Total pineapple fresh fruit harvested [ton or kg],
A – Area covered by crops used in FF sampling [ha or m^2]

(ii). Percent weight loss of fruit: Percent weight loss was calculated by using the following formula:
Percent weight loss (%WL) =

$$\frac{IW-IF}{IW} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where:
%WL – percent weight loss,
IW – Initial fruit weight with crown and
FW = Final fruit weight with crown

Moisture content: The percent moisture content was calculated using the following formula:

$$\text{Percent moisture} = \frac{IW-IF}{IW} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where:
IW – Initial fruit weight with crown and
FW – Final fruit weight with crown

Fruit Quality

Five (5) fully grown pineapple fruits that had not yet turned yellow at the base and had fresh, green crown leaves were randomly chosen from a 50 m × 50 m drip-irrigated pineapple field and that of rainfed field each. The same storage conditions (temperature and relative humidity) were applied to these fruits. Using a digital thermometer-hygrometer clock, the temperature and relative humidity (RH) in the storage area were recorded three times a day – at 6:00 am, 12:00 pm, and 6:00 am – during the course of the 14-day storage period. Before storing each fruit, its weight and diameter were measured using a vernier calliper and a measuring scale, respectively. These measurements were taken every two days. Using a handheld refractometer, the total suspended solids (Brix) was measured.

RESULTS AND DISCUSSIONS

Fruit Weight and Yield

The weight (g) of 40 matured pineapple sampled under drip irrigation and rainfed conditions is presented in Figure 2. The area coverage of the field during the sampling of fresh fruits was 50 m × 50 m.

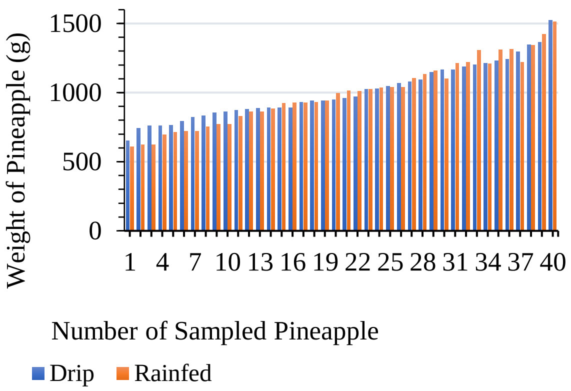

Fig. 2. Weight of fruits from drip irrigated and rainfed plots
Source: Field Studies, 2022.

Fruit weight ranged from 609 to 1,524 g, with 652 g and 609 g, respectively, being the lowest weight of examined fruits from drip-irrigated and rainfed farms. The highest fruit weights from rainfed and drip-irrigated crops were 1,512 g and 1,524 g, respectively. Under drip irrigation, most (10) of the sampled fruits were in the 800 g range as shown in Figure 3. The highest fruit weight was in the 1,500 g range, same as for fruits under rainfed conditions.

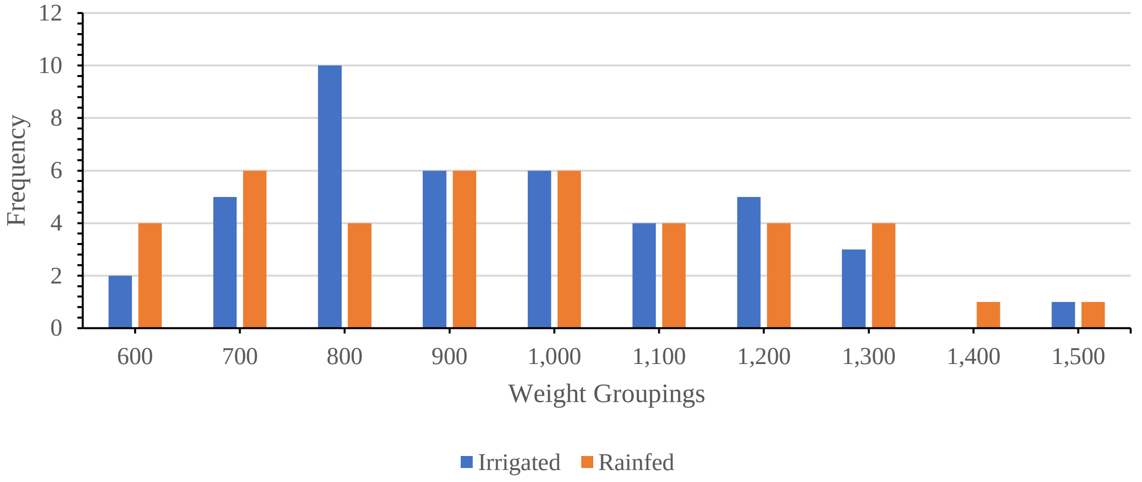

Fig. 3. Pineapple weight distribution under rainfed and drip irrigation
Source: Field Studies, 2022.

As seen in Figure 3, fruit samples from the rainfed field were distributed in weights ranging from 600 to 1,500 g. From drip-irrigated fields, most fruits weighed around 800 g. This could be profitable in instances when the customers require particular fruit size. The outcome of the study agrees with a study by [5] who investigated the effect of irrigation frequency on the growth and yield of pineapple. [9] and [4], indicated that the minimum monthly water requirement of pineapple for good growth and yield is around 50 mm, and if this quantity is not met, the average fruit weight will be compromised. Table 2 presents the statistics of pineapple weight under both conditions. There was very little variation (11.4 g) in the average fruit weight between the two settings.

Table 2. Statistical analysis of pineapple fruit weight

Variable	Obs	Mean	Std. Dev.	Min	Max	Mean Diff
Weight (g)						11.49
Drip Irr.	40	1,006.4	198.78	652	1,524	
Rainfed	40	995	234.06	609	1,512	

Source: Field Studies, 2022.

Fruit weights under drip irrigation and rainfed conditions did not differ significantly at a 95% confidence interval, according to the independent samples t-test presented in Table 2 (p-value = 0.815).

Weight loss over time

Figure 4 shows pineapple weight loss over a period of 14 days under ambient conditions (28-31 ^{0}C and 60-75 % RH).

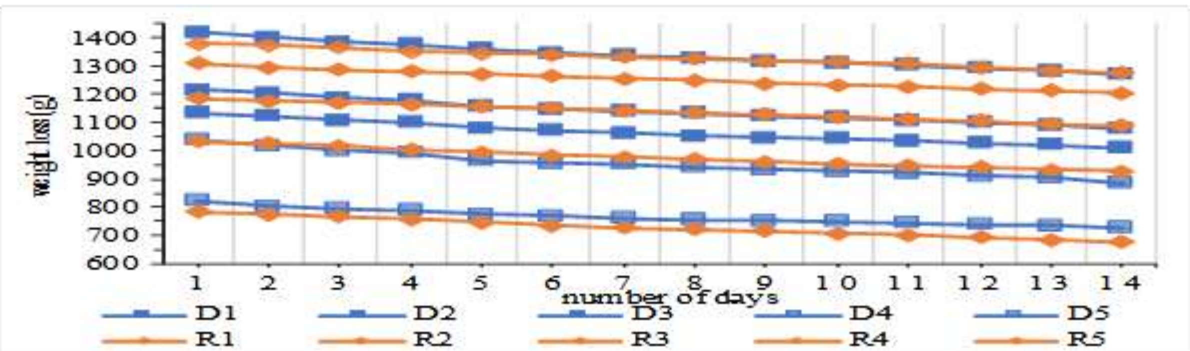

Fig. 4. Weight loss in sampled fruits under each condition, rainfed and drip-irrigation (R1, R2, R3, R4 and R5) and (D1, D2, D3, D4 and D5), respectively over a 14 days period
Source: Field Studies, 2022.

During storage, a noteworthy decrease in the overall weight of pineapples grown with drip irrigation was observed. Fruits from fields with drip irrigation often lost more weight overall over the course of storage (Figure 4). For pineapple grown with drip irrigation, weight loss was greater in the first seven days of storage than it was in the next seven. In contrast to irrigated fruits, fruits grown under rainfed settings showed a range of weight loss values during the course of the storage period. This tendency was different for these fruits. However, the common effect across both drip irrigated field and rainfed field is that the highest weight loss was seen in bigger fruits. These findings supported the work of [19]. Maturity stage and storage conditions play a crucial role in the weight loss of food crops.

Brix content over the storage period

Table 3 Pineapple brix cultivated in rainfed and drip irrigation conditions

Test days	Brix, ^{0}Bx		
	Day of harvest	7th day	14th day
Drip Irrigated	12.8	15.6	19.8
Rainfed	13	16	21

Source: Field Studies, 2022.

Three days during the storage process were used to measure the brix: the day of harvest, which also signalled the start of the pineapple's storage; seven (7) days after harvesting; and fourteen (14) days after harvesting. On harvest day, the pineapple planted with drip irrigation had a brix of 12.8 ^{0}Bx, whereas the pineapple grown with rainfed circumstances had a brix of 13 ^{0}Bx as shown in Table 3. After seven days, the readings for pineapple that was grown under rainfed and drip irrigation rose to 15.6 ^{0}Bx and 16 ^{0}Bx, respectively. Customers' chosen range of values was represented by the brix readings in the first week following harvest. Yet, following the first week, the brix values increased significantly to 19.8 Bx for drip feeding circumstances and 21 Bx for rainfed conditions, respectively. The common trend of increase in Total Soluble Solids (TSS) content whilst the fruit changes colour from dark green to yellow has been observed in this and several other studies [21, 23]. In the study by [21], the TSS for ‘Mauritius’ pineapple variety was observed to be 14.73 % whilst the pineapple shell was 100 % dark green. Nonetheless, the TSS was recorded as 17.32 % after 20 % of the shell became yellow, which is consistent with the pattern seen in this investigation.

CONCLUSIONS

Ghana’s coastal savannah is the production hotspot for pineapple cultivation. However, annual rainfall in this area poses a challenge to year-round production. Field study carried on Bomarts Farms showed no significant difference between the weight of pineapple cultivated under drip irrigation and rainfed conditions. Irrigation adoption alone will not produce the desired outcome if other important agronomic practices are not adopted.

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