DISEASES OF NATURAL RUBBER (*HEAVEA BRASILENSIS*) INDUCED BY THE CLIMATIC ELEMENTS OF RAINFALL AND TEMPERATURE IN IKPOBA-OKHA LOCAL GOVERNMENT AREA OF EDO STATE, NIGERIA

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Climatic, elements, rainfall, temperature, diseases and production

ABSTRACT
*This paper examined the diseases of natural rubber (**Heaveabrasilensis**) induced by the climatic elements of rainfall and temperature in Ikpoba-Okha Local Government Area of Edo State, Nigeria. The paper identified the varieties of natural rubber cultivated in the study area, the diseases of natural rubber induced by the climatic elements of rainfall and temperature in the study area, the level of awareness of natural rubber farmers on the impact of the climatic elements on natural rubber production in the study area and the problems induced by the climatic elements of rainfall and temperature on natural rubber production in the study area. To achieve these objectives, the researcher used both primary and secondary research methods to collect the data used for the study. In the study area, a total of five hundred and fifteen (515) structured questionnaires representing 0.1% of the projected population for 2023, which is, 515,042 were administered directly by the researcher to the respondents in the study area. The secondary data used were obtained from National Population Commission (NPC), Agricultural Development Programme (ADP) and the Ministry of Agriculture and Natural Resources (MANR). The data obtained were analysed using tables, percentages and degrees. The results showed the varieties of natural rubber cultivated in the study area. The study also reveals the diseases of natural rubber induced by the climatic elements of rainfall and temperature in the study area. The problems associated with the diseases were also revealed. The following recommendations are made: effective disease management strategies, monitoring of climatic conditions, incorporating resistant natural rubber clones and improving cultural practices, sustainable practices to manage diseases, governments' intervention to encouragenatural rubber farmers annually. This*

paper is therefore concluded by advising the governments at all levels to implement the recommendations made by the researcher.

Introduction

This paper examines the diseases of natural rubber *(Hevea brasiliensis)* induced by the climatic elements of rainfall,and temperature in Ikpoba-Okha Local Government Area of Edo State, Nigeria. From time immemorial, climatic elements such as rainfall, temperature, humidity, sunshine, wind, pressure and cloud cover have played very crucial roles in inducing diseases on cash crops particularly natural rubber (Opeke, 1987; *Prakash et al.,* (2023)). The impact of climatic elements on the emergence and prevalence of diseases on cash crops (including natural rubber) cannot be marginalized (Akinyosoye, 1986; Prakash *et al.,* 2023). Natural rubber is a vital cash crop, particularly in tropical regions, where its cultivation is influenced by climatic elements such as rainfall and temperature.

Disease is an illness affecting humans, animals or plants, often caused by infection (Oxford Advance Learner's English Dictionaries, 2024). So, diseases of natural rubber are the illnesses caused by infections that prevent natural rubber trees from functioning optimally.

Natural rubber ((*Hevea brasiliensis)*) is a very important commercial tree crop that thrives and yields most in the low latitudes of the world in general and the rainforest regions in particular (Akinyosoye, 1986; Adelekan and Taiwo, 2012). Para rubber, more commonly called natural rubber is the tree cultivated mainly for the commercial production of latex. Latex is the whitish, milky liquid used for making natural rubber. Since the discovery of natural rubber in Brazil, its cultivation has outspread to other parts of the world particularly in the humid tropical regions of South and Central America, Asia and West Africa (Adelekan and Taiwo, 2012).

Natural rubber belongs to the plant family, *euphorbiaceae.* It is a humid tropical tree crop, which at maturity has a stout, erect stem, several branches and bushy head. Natural rubber has the ability of growing to a height of 30 metres or above. It is a deciduous tree crop because it shed it leaves sometime each year (Akinyosoye, 1986; Adelekan and Taiwo, 2012). Natural rubber is a monoecious tree crop because it bears both male and female flowers on the same tree and both occur in the same flower cluster called inflourescence. All flowers are small and scented therefore, facilitating pollination by insects. The fruit of a natural rubber is a capsule with three locules, each containing a seed. When the seeds attain maturity, the capsule splits by a process known as explosive mechanism so that the seeds are scattered far away. The seeds have two cotyledons which are flattened. The seeds lose viability within two weeks after they are shed. Natural rubber is a dicotyledonous crop and it has a tap root. Natural rubber trees start producing flowers at 4–5 years after germination. The arbitrary girth used as a yardstick for tapping is 0.45m at a height of 1metre above the root collar.

Weather succinctly refers to the state of the atmosphere at a given point on the earth surface or over an area at a specified time while climate on the other hand simply refers the totality of the characteristics of the atmosphere deduced from repeated observations over a long time, usually between 30-35years (Ayoade, 2004;Okhakhu, 2019). The elements of climate include rainfall, temperature, humidity, sunshine, pressure; wind and cloud cover.

Emielu (2011), and Okhakhu (2019) posited that in the tropics, the term rainfall is interchangeable with precipitation since snow is generally absent except on some high mountains like the Kilimajaro in Tanzania, East Africa. So, in this paper, rainfall and precipitation are used interchangeably because the study area falls within the humid tropics. So, in this paper, rainfall comprises rainfall itself, mist, fog dew and hail. Ayoade (2004), andEmielu (2011) maintained that rainfall is the release of excess condensed water vapour from the lower atmosphere (troposphere) to the surface of the earth. They added that it is any aqueous deposit in liquid form derived from the lower atmosphere (troposphere). Rainfall is measured by means of rain gauge–the recording or autographic and the non-recording (Ayoade, 2004;Okhakhu, 2019)).

Temperature as used in this paper is conceived of in terms of movement of molecules such that the more rapid the movement the higher the temperature. Temperature is usually defined in relative terms, that is, on the basis of the degree of heat a body has (Ayoade, 2004; Okhakhu, 2019)). It is the condition that determines the flow of heat from one substance to another. More frequently, heat moves from body with high temperature to a body with a lower temperature. The temperature a body has is determined by the balance between incoming and outgoing radiation and its transformation into latent heat and others Ayoade, 2004; Emielu, 2011Okhakhu, 2019)). Temperature is measured by means of an instrument called thermometer (maximum and minimum) and it is expressed in degree Fahrenheit (^{o}F) or degree Celsius (^{o}C).To a very large extent, the climatic condition of an area largely determines the prevalent diseases of plants, including natural rubber in that area.

2. Statement of the Problem

Available literature on the diseases of natural rubber *(Hevea brasiliensis)* induced by the climatic elements of rainfall, and` temperature abound. For example, Kittikhun et al. (2023) highlighted the potential for increased disease outbreaks in Southeast Asia due to expected changes in rainfall patterns and temperature fluctuations. These findings emphasize the need for adaptive management strategies to mitigate disease risks associated with climate change. The interaction between rainfall and temperature is crucial in determining disease dynamics in rubber cultivation. Studies suggest that the combined effects of high temperatures and excessive rainfall can create an ideal environment for disease proliferation. For example, Nguyen *et al*., (2023) and Nwankwo *et al.,* (2023) found that concurrent high rainfall and elevated temperatures lead to a synergistic increase in the incidence of leaf spot diseases, necessitating integrated management approaches that consider both climatic factors.

From the numerous studies carried out, it is unequivocally obvious that studies on the diseases of natural rubber induced by the climatic elements of rainfall and temperature in Ikpoba-Okha Local Government Area of Edo State, Nigeria are non-existent. This non-existent situation of the above subject matter represents the research gap which this current paper intends to fill.

3. Aim and Objectives of the Study

The aim of this paper is to examine the diseases of natural rubber induced by the climatic elements of rainfall and temperature in Ikpoba-Okha Local Government Area of Edo State, Nigeria. The specific objectives of the study are to:

i. identify the varieties of natural rubber cultivated in Ikpoba-Okha Local Government Area of Edo State, Nigeria.

ii. identify and analyse the diseases of natural rubber induced by the climatic elements of rainfall, and temperature and their attendant problems in the study area.

iii. examine the level of awareness of natural rubber farmers on the diseases of natural rubber induced by the climatic elements of rainfall, and temperature in the Study Area

4. The Study Area

Ikpoba-Okha Local Government Area which is the study area is one of the eighteen local government areas that constitute Edo State. Ikpoba-Okha Local Government Area lies approximately within Latitudes 6^{o} 35'–6^{o} 45' North of the Equator and Longitudes 5^{o} 45'-5^{o}48' East of the Prime Meridian (Ikpoba–Okha Local Government Council, 2017).Ikpoba-OkhaLocal Government Area is bordered on the north by Uhummwode Local Government Area, Orhionmwon Local Government Area on the east, Oredo Local Government Area on the northwest, Egor on the far northwest and Delta State (Ethiope and Warri North Local Government Areas) on the southern most part. Ikpoba-Okha Local Government Area was created in November, 1996 and its administrative headquarters is located at Idogbo. It occupies an area of approximately 75.03 square kilometres and has a population of about 372,080 people (NPC, 2006) with an annual growth rate of 3.0 percent (Ikpoba-Okha Local Government Council, 2015). With the annual growth rate of 3.0 percent, the projected population of Ikpoba-Okha Local Government Area in 2023 was 515,042 people.

Ikpoba-Okha Local Government area has virtually the same geographical and relief

characteristics with the area designated as Benin-City. According to Eseigbe (2011), the geographical structure of the study area generally comprises of two major formations known as crystalline rock of the precambrian basement complex and the sedimentary rock of cretaceous tertiary and quaternary formations of Miocene-Pleistocene age most commonly referred to as Benin formation. Esiegbe (2011) argued that the study area is a tilted undulating plain which slopes in a South-West direction. The Esan and Asaba Plateaus form the highest elevation.

The study area is located within the Sub Equatorial Humid Region and owing to this, it experiences the Humid Tropical Climate. Humid Tropical Climate is usually characterized by two seasons: dry and wet. The dry and wet seasons in the study area are usually determined by rainfall (the amount, intensity, duration and distribution throughout the study area are brought about by the wind systems, clouds cover, temperature, atmospheric pressure and the deflection of the maritime air masses).Rainfall rather than temperature is the most influential element of climate in the study area (Udo, 1978;Eseigbe, 2011).

The wet season is experienced from early February to mid-December every year. However, in most parts of the study area, scanty rainfall is experienced in December and January annually (Udo, 1978). Rainfall is mostly the convectional type and it falls heavily with torrential down pour. The dry season normally occurs between December and January with scanty rainfall. As a result of its latitudinal location, the study area has a daily temperature of between 27 and 36^{o}C and rainfall amount of about 2000-2200mm yearly (Eseigbe, 2011). The study area experiences the bimodal rainfall cycle with the highest rainfall amounts recorded in the months of July and September yearly.

High relative humidity of between 75-85% occurs regularly in the study area. This relative humidity is steady in the mornings, unstable in the afternoons and enhances during the evening and night times because of the difference in environmental factors of evaporation, transpiration, pressure decrease and the dominance of tropical maritime air mass for a greater part of the year. The second air mass which is technically termed tropical continental air mass is most dominant and felt as from mid-December and persists till January. The tropical continental air mass originates from the Sahara Desert and blows in North-East direction. This air mass is associated with the harmattan wind which is cold, dry, dusty, harsh and hazy in nature. It brings about dry season in the study area (Eseigbe, 2011).

5 Conceptual Framework and Literature Review

The Ergoclimate Concept by Duckham (1963) was examined and applied in this paper in line with crop weather relations.

5. (i) Ergoclimate Concept

Ergoclimate Concept by Duckham (1963)is a concept of crop-weather relations. Climate affects both crop growth and the condition under which they take place. This, no doubt prompted Duckham (1963) to develop the ergoclimate concept (that is work climate). This concept is concerned with those conditions which influence the ease or difficulty of crop production and hence the speed of work and which may, as a result curtail the length of the climate-growing season by delaying one or more of the cultivation stages. Rain affects directly the physiological condition of crops so as to make their handling difficult in terms of both the time and energy spent on the farm. The effect of climate is however the most important with respect to the timeliness of farm operations, since there are limits to the season or period within which certain operations can be performed. Climate exerts or exercises a direct impact on the range and yield of crops. Climate also operates indirectly through its influence on the geographical range, the seasonal development and the activities of crops pests and pathogens to attack crops. In addition, temperature amongst others is regarded as the most important climatic factor affecting and influencing the spread of pests and diseases. Obviously, temperature often controls regional distribution of pests and diseases particularly in terms of latitude, altitude and seasonal incidence. Optimum temperature for infection or infestation and the subsequent development vary with the host species and the varieties of pests and pathogens, the length of the life cycle of such organism decreases and the rate of the development increases with increasing temperature.

As a result of the reliance on climatic elements of rainfall (precipitation) and temperature, most types of crop production practices and stages are unavoidably subject to

unpredictable long and short-terms fluctuation characteristics of atmospheric conditions. Climate introduces an element of risk in crop production which makes it a particularly risky or hazardous human activity. A climatic hazard could be said to be a type of extreme atmospheric (that is, actual weather) condition and that can damage or destroy or harm crops and cause a particularly unusual decrease in production. Drought, rainstorm, flooding, fire, desiccating winds etc are some of the major types of climatic hazards to crops in general and natural rubber in particular. The extent to which climate creates serious hazards depends on several variables. These include the time of occurrence, the intensity or magnitude, and the duration of the particular event on one hand and the age, state of development and inherent tolerance or resistance of the pest or diseases on crop plants on the other hand. Crop plants are normally more sensitive to extreme weather conditions during the growing season and more particularly, in their early stages of growth. The above review could prompt one to agree with Waggoner (1969) who posited that meteorological data are required by farmers in order that they can suggest and decide those approaches best suited to cope with current weather as well as to enable them to plan long-term strategies in relation to variation in climate.

5. (ii) Literature Review

Natural rubber is a very important commercial tree crop of the humid tropical region (rain or high forest belt) of the world in general and Ikpoba-Okha Local Government Area of Edo State, Nigeria in particular. Since the discovery of natural rubber in the 18th century in the Para region of Amazon Basin, Brazil, its production and yield have been a subject of great concern (Opeke, 1987).Opeke (1987),contend that since its discovery, its production has spread to other tropical areas of North and South America, Asia, Europe and West Africa (with Nigeria, Liberia and the Congo Free State taking the lead in its production and yield since the 19th century in the sub region).López et al., (2023) and Wang *et al.,*(2022) noted that the cultivation of natural rubber (Hevea brasiliensis) is significantly influenced by climatic elements, particularly rainfall and temperature, which play cruciall roles in the prevalence and severity of various diseases affecting the plant. Recent studies have investigated and highlighted how changing climatic patterns, including increased rainfall variability and rising temperatures, aggravate the incidence of natural rubber diseases such as South American leaf blight (SALB) and Phytophthora bark canker.

In regions where natural rubber is predominantly grown, shifts in rainfall patterns can create conducive environments for fungal pathogens, leading to outbreaks that severely impact yield and quality. For instance, excessive moisture can promote the development of foliar diseases, while prolonged dry spells may weaken plant resilience, making them more susceptible to infections (Chen *et al.,* 2023; Nguyen *et al.,* 2022). In addition, temperature increases have been linked to accelerated pathogen development and virulence, presenting additional challenges for natural rubber plantations.

Recent studies reveal that changes in climatic patterns, particularly variations in rainfall and temperature, can exacerbate the prevalence of rubber diseases such as white root disease caused by Ganoderma species, leaf diseases like leaf blight, and others like tapping panel dryness (TPD). For instance, Arif*et al.*, (2022) and De Souza *et al*., (2023) observed thathigh rainfall can create a humid environment conducive to fungal infections, while high temperatures may stress the trees and make them more vulnerable to pathogens. Research by Khin *et al.,* (2021) suggests that the relationship between temperature and disease incidence is not straightforward; while some pathogens thrive in warmer conditions, others may be inhibited. This underscores the complexity of climate-disease interactions in natural rubber cultivation. Furthermore, studies have demonstrated that increased rainfall can lead to waterlogging, which has been linked to root diseases, particularly in poorly drained soils (Nguyen *et al.,* 2023).

Rainfall is a crucial factor inducing fungal diseases in rubber trees, particularly Fusarium and Phytophthora species. High moisture levels create favorable conditions for the proliferation of these pathogens. For instance, a study carried out by Prakash e*t al.,* (2023) reported a significant correlation between increased rainfall and the incidence of Phytophthora leaf fall, which can cause severe defoliation in natural rubber trees. The authors emphasized that prolonged wet periods enhance spore dispersal and infection rates, leading to economic losses in rubber plantations

Excessive rainfall can also exacerbate bacterial diseases such as bacterial blight caused

by *Pseudomonas spp.* (Sharma *et al.,* 2022). These pathogens thrive in humid conditions, leading to significant leaf necrosis and reduced yield. Moreover, viral diseases, such as natural rubber wood streak virus, have shown increased prevalence during wet conditions, although the exact mechanisms remain under investigation (Nguyen *et al.,* 2023). Temperature fluctuations play a critical role in the lifecycle and virulence of natural rubber pathogens. Recent studies indicate that higher temperatures can enhance the virulence of Fusarium species, leading to increased root rot incidences (Kumar *et al*., 2023). Conversely, extreme heat conditions may inhibit some fungal growth, potentially shifting disease patterns in natural rubber plantations. For example, Jansen *et al.*, (2023) noted that while moderate warming may reduce the severity of certain fungal diseases, it can simultaneously promote the emergence of other pathogens that are more heat-tolerant.

The literature review showed that thediseases of natural rubber caused by the climatic elements of rainfall and temperature have been carried out in the humid tropics of the world. However, the specific case of the diseases of natural rubber induced by the climatic elements of rainfall, and temperature in Ikpoba-Okha Local Government Area of Edo State, Nigeria has not been examined in any study. Thisrecent vacuum is what this current paper intends to fill scientifically.

6 Materials and Methods

The study area is made up of 10 political wards. The study area was divided into ten areal units in accordance with the political wards (based on the information gathered during the preliminary surveys) for easy data collection. Major natural rubber farmers and the general public were engaged and consulted for the collection of the required data. Direct field surveys and measurements were used to prove the authenticity of the data that were collected from documentary and archival sources. A total of five hundred and fifteen (515) structured questionnaires representing 0.1percent (0.1%) of the projected population for 2023, which is, 515,042 (that is, 0.1% of 515,042 =515) were administered directly by the researcher and his research assistants to the respondents in the ten areal units that constitute the study area.

The population figures for each of the wards or communities are not available (NPC, 2006; Ikpoba-Okha Local Government Council, 2015). So, it was not possible to administer the questionnaires based on the population size of the wards or communities. However, the preliminary and actual field surveys carried out in 2023 by the researcher revealed that there are 2,061 natural rubber farmers in the study area. The 2,061 natural rubber farmers represent 0.4% of the projected population of the study area for 2023. Twenty-five percent (25%) of the population of natural rubber farmers was sampled in the study area. The twenty-five percent (25%) of the population of natural rubber farmers is 515. The multi-stage sampling and simple random sampling techniques were used

7 Methodology

Two types of data were obtained and they were analyzed using descriptive, statistical and cartographic methods.

8 Results and Discussions

8.i Varieties of Natural Rubber Cultivated in Ikpoba-Okha Local Government Area

Table 4.1 shows the varieties of natural rubber cultivated in Ikpoba-Okha Local Government Area and it reveals that five different varieties of natural rubber are cultivated in the study area at present. The varieties of natural rubber cultivated in the study area include NIG 800-807, NIG 900-907, RRIM 600; 606 and 607, IRRI (GT1 and PB 101, 102 and 107) and RRIC45. NIG 800 and 900 series are collectively referred to as indigenous clones because they were cloned in Nigeria hence the name NIG (Nigeria) and they are the products of Rubber Research Institute of Nigeria (RRIN), Iyanomon, Benin-City. The other varieties such as the RRIM 600 series, IRRI (GT and PB) series and RRIC 45 are collectively referred to as the exotic clones. RRIM 600 series are natives of Malaysia, that is, from Rubber Research Institute of Malaysia (RRIM), IRRI (GT1 and PB) series are natives of Indonesia, that is, from Indonesia Rubber Research Institute (IRRI) and RRIC 45 is a native of Ceylon (now Sri-Lanka), that is, from Rubber Research Institute of Ceylon (RRIC). The GT1 and PB in IRRI mean GODENG TAPEN 1 (GT1) and PRANG BESANG 101,102 and 107 (PB 101, 102 and 107) respectively.

Table 4.3 further reveals that 136 respondents representing 26.41% of the sampled population cultivate NIG 800-807 series, 139 respondents representing 26.99% of the sampled population cultivate NIG 900-907 series, 81 respondents representing 15.73% of the sampled population cultivate RRIM 600; 606 and 607 series, IRRI (GT 1 and PB) series are cultivated by 86 respondents representing 16.70% of the sampled population whereas 73 respondents representing 14.17% cultivate RRIC 45. So, from Table 4.3, it is obvious that NIG 800 and 900 series are the most cultivated whereas RRIC 45 is the least cultivated in the study area.

Table 4.1: Varieties of Natural Rubber Cultivated in the Study Area.

Varieties of Natural Rubber	Number of Response	Percentage Response
NIG 800 – 807	136	26.41
NIG 900 – 907	139	26.99
RRIM 600, 606 & 607	81	15.73
IRRI (GT1 & PB 101, 102 &107)	86	16.70
RRIC 45	73	14.17
Total	515	100.00

Source: Fieldwork, 2023.

8.ii The Diseases of Natural Rubber Induced by the Climatic Elements of Rainfall and Temperature and their Attendant Problems in the Study Area

Table 4.3 shows the diseases induced by the climatic elements of rainfall, and temperature on natural rubber in the study area. The table shows that the diseases induced by the climatic elements of rainfall, and temperature on natural rubber in the study area are conveniently grouped into the three parts of the natural rubber tree: leaf, stem and root.

8. iii Leaf Diseases

Table 4.3 reveals that the leaf diseases induced by the climatic elements of rainfall, and temperature on natural rubber in the study area are: leaf disease *(Collectotrichumgloeosporioides)*, bird's eye spot *(Dreeshlerahevea)*, new foliage disease (*Corynesporacoccicola)*, Leaf spot disease *(Anthracnose)* and Powdery mildew.Table 4.3 also revealed that 167 respondents of the sampled population are of the opinion that the leaf disease *(Collectotrichumgloeosporioides)* is a disease caused by the climatic element of rainfall. Oral interview also revealed that this type of disease is a collection of swollen spots on leaves. At maturity, the swollen spots break open and perforate the leaves. This disease affects

Table 4.2: The Diseases of Natural Rubber Induced by the Climatic Elements of Rainfall and Temperature in Ikpoba-Okha Local Government Area of Edo State.

Disease Induced by Climatic Elements	Number of Respondents	% Respondents
Leaf diseases		
Leaf disease (Collectotrichumgloeosporioides)	167	32.43
Bird's eye spot (Dreeshlerahevea)	129	25.05
Corynesporalcaccicola	45	08.74
Leaf spot (Anthracnose)	53	10.28
Powdery mildew	81	15 .73
Leaf spot disease (Phyphthoralpalmivora)	40	07.77
Total	515	100.00
Stem disease		
Mouldy rot	515	100.00
Total	515	100.00
Root diseases		
White root rot (Rigidoporuslignosus)	293	56.89
Red root rot (Ganoderma phillipii)	137	26.60
Brown root rot (Phellinus noxius)	85	16.51
Total	515	100.00

Source: Field Surveys, 2023

the rate and amount of photosynthesis in the natural rubber trees. Leaf disease *(Collectotrichumgloeosporioides)* is a disease whose incidence of occurrence is prevalent during the rainy season.

Another disease induced by climatic elements on natural rubber in the study area is Bird's eye spot *(Dreeshlerahevea)*. Out of the 515 respondents, 129 respondents revealed that it is a leafdisease caused by the climatic elements of rainfall on natural rubber in the study area. The disease is made up of numerous little spots on the surfaces of leaves. Over time the spots enlarge and cover the entire surface of the affected leaves. The disease occurs all year round but most prevalent during the wet season. Bird's eye spot *(Dreeshlerahevea)* reduces the chlorophyll content and quality of the leaves so, the ability to attract sunlight needed for photosynthesis is reduced. This no doubt, reduces the amount and quality of natural rubber yield in the study area.

In addition to the above, powdery mildew is a leaf disease induced by climatic elements of rainfall on natural rubber in the study area. Mildew is the growth of minute destructive fungi on the damp parts of natural rubber especially the leaves. Eighty-one (81) respondents opined that this disease affects natural rubber in the study area.

Also, 53 respondents of the sample population revealed that natural rubber is affected by leaf spot disease *(Anthracnose). Anthracnose* is a type of disease that affects leaves. Leaf spot disease *(Anthracnose)* comprises of concentric ring-like structures that are found on the surfaces of leaves of natural rubber trees. This disease is induced by soil nutrient deficiency occasioned by leaching caused by rainfall.

Another leaf disease induced by the climatic elements of rainfall,and temperatureon natural rubber in the study area is new foliage disease *(Corynesporacoccicola)*. This disease attacks the new foliage (leaves) that emerge after natural rubber trees have shed their leaves. Forty-five (45) respondents of the sample population in the study area reveal that it is disease that attacks the young leaves of natural rubber during dry season.

The last leaf disease induced by the climatic elements of rainfall, and temperature on natural rubber in the study area is leaf spot *(PhyphthoraPalmivora).* This disease is caused by the climatic element of rainfall as it occurs during the rainy season. Leaf spot *(PhyphthoraPalmivora)* makes fresh natural rubber leaves to drop. This disease reduces the rate, quality and amount of photosynthesis and chlorophyll available to natural rubber trees. Forty (40) respondents revealed that leaf spot

(*PhyphthoraPalmivora)* is a leaf disease posed by the climatic elements of rainfall on natural rubber**.**

8.iv Stem Disease

In the study area, only one stem disease induced by the climatic elements of rainfall and, temperature in the study area was identified and it is known as mouldy rot. Mouldy rot disease is a stem disease that is prevalent during the wet season in the study area. Mouldy rots are spots on stems that look like wounds or damaged barks or they are actually wounds or damaged barks. This disease reduces the quantity and quality of latex available to the affected natural rubber trees. This diseaseaffects the stems and consequently the tapping panels. Also, mouldy rot makes tapping difficult because it leads to disjointed and distorted flow of natural rubber latex hence more attention, time and energy are required to control the flowing latex. Natural rubber trees affected by mouldyrot disease can easily be broken down by wind of high velocity. All the respondents, that is, 515 respondents of the sample population revealed that mouldyrot is a climate induced caused by rainfall on natural rubber.

8. v Root Diseases

Table 4.3 shows that white root rot (*rigidoporouslignosus)*, red root rot *(Gonodermalphillipi*) and brown root rot (*Phellinus noxius)* diseases are the root diseases posed by the climatic elements of rainfall, and temperature on natural rubber in the study area. White root rot disease is the most serious of all the root diseases induced by the climatic elements of rainfall, and temperature on natural rubber in the study area. Root rot disease forms a chalky substance on the roots of the affected natural rubber trees. It produces whitish-thread-like structures called rhizormorph. It causes decay in the roots of natural rubber trees such that a slight breeze can lead to the fall of the affected natural rubber trees. Oral interview report revealed that the disease is so serious that it can bring down a large plantation (as large as five hectares) within a short time if not checked aptly. Also, two hundred and ninety-three (293) respondents of the sample population, posited that white root rot disease *(rigidoporouslignosus)*, is induced by the climatic elements of rainfall, and temperature on natural rubber in the study area.

Another root disease induced by the climatic elements under consideration on natural rubber in the study area is red root rot *(Gonodermalphillipi)*. It is active during wet season. This disease attacks the roots of both young and matured natural rubber trees. Natural rubber trees whose roots are affected by the red root rot disease are easily identified because they produce yellow leaves which rapidly fall and the infected trees are likely to die. Out of the 515 respondents, 137 respondents attested to this finding in the study area.

Finally, 85 respondents of the sample population revealed that brown root rot (*Phellinus noxius)* disease is caused by rainfall and it is active during the rainy season. It is slow but its end result can be catastrophic if not checked aptly.

8. viThe Level of Awareness of Respondents on the Diseases of Natural Rubber Induced by the Climatic Elements of Rainfall, and Temperature in the Study Area

Table 4 reveals the level of awareness of natural rubber farmers on the diseases of natural rubber induced by the climatic elements of rainfall, and temperature in the study area. From the table, it is clear that 297 respondents of the sample population possess high level of awareness of the subject matter in the study area. In a similar vein, 201 natural rubber farmers of the sample population revealed that they possess a very high level of awareness on the relationship between climatic elements of rainfall, temperature, humidity and wind speed and natural rubber yield in the study area. Also, 15 natural rubber farmers/respondents of the sample population in the study area were of the opinion that they possess a low level of awareness of the relationship between climatic elements of rainfall, temperature, humidity and wind speed and natural rubber yield in the study area. Finally, 2 natural rubber farmers which represent 2.52% of the sample population possess, a very low level of awareness of the relationship between climatic elements of rainfall, temperature, humidity and wind speed and the yield of natural rubber. From the available results, it is unequivocally clear that a high percentage of the sample population is very conscious of the relationship between climatic elements of rainfall, temperature, humidity and wind speed and natural rubber yield in Ikpoba-Okha Local Government Area of Edo State, Nigeria. Figure 4.7 further throws more light on the level of awareness of natural rubber farmers on the relationship between the climatic

elements of rainfall, temperature, humidity and wind speed and natural rubber yield in the study area

Table 4.2: The Level of Awareness of Respondents on the Diseases of Natural Rubber Induced by the Climatic Elements of Rainfall, and Temperature in the Study Area

Level of Awareness	Number of Response	% Response
Very High	201	39.03
High	297	57.67
Low	15	2.91
Very Low	2	.39
Total	515	100.00

Source: Fieldwork, 2023.

9. Conclusion.

The major objective of this paper is to examines the diseases of natural rubber *(Hevea brasiliensis)* induced by the climatic elements of rainfall, and temperature in Ikpoba-Okha Local Government Area of Edo State, Nigeria.These recommendations will no doubt record stupendous and unprecedented successes if adequate resources and suitably qualified manpower are employed, mobilised and stimulated aptly to give their best. Also, peaceful co-existence, unity, good neighbourliness, absence of religious and ethnic crises arising from stable political system among the key players in the entire natural rubber production process in Ikpoba-Okha Local Government Area of Edo State, Nigeria (the study area) are recommended. It is strongly hoped that when all these policy recommendations are painstakingly, carefully, genuinely, conscientiously, appropriately, and scientifically executed, natural rubber would unequivocally witness unprecedented high yield in the study area. It is also strongly hoped that the unprecedented high natural rubber yield would be of great economic benefits to the natural rubber farmers and other inhabitants in the study area (Ikpoba-Okha Local Government Area of Edo State, Nigeria) in particular and the entire country at large.

10 Recommendations

This paper examined the diseases of natural rubber *(Hevea brasiliensis)* induced by the climatic elements of rainfall, and temperature in Ikpoba-Okha Local Government Area of Edo State, Nigeria..Based on the findings of this study, the following actionable policy recommendations are made:

1. Effective disease management strategies should be enforced by government at all levels;
2. Climatic conditions should be monitored to help predict potential disease outbreaks;
3. Incorporating resistant natural rubber clones and improving cultural practices,
4. Sustainable practices to manage diseases without harming the environment such as the use of bio-pesticides and organic amendments should be encouraged.
5. Governments at all levels should promulgate laws on the granting of soft loans, diseases resistant clonesand other inputs to natural rubber farmers annually to encourage them.

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Here is how you would format the references in APA 7th edition:

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