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AN ASSESSMENT OF THE MICROCLIMATIC IMPACT OF NEEM PLANTATION(*AZADIRACHTA INDICA*) ON FOUR WEATHER VARIABLES AT GUJBA ROAD DAMATURU, YOBE STATE, NIGERIA.

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ABSTRACT

This paper analyzed the impact of Neem (Azadirachta indica) plantation on four weather variables namely: Rainfall, Relative Humidity (R.H), Temperature and Wind Speed at Gujba road Damaturu, Yobe state, Nigeria. To achieve this, meteorological records of these elements were collected from the protected side of the plantation at three growth stages: the first five years (1999 – 2003), the second five years (2004 – 2008) and the last five years (2009 – 2013). Mean values of the four weather variables were computed and compared with the average values of the same elements from the unprotected side of the plantation. Results have shown that between 1999 and 2003, there were insignificant differences among the four weather elements between the protected and unprotected areas. In the second five years however, marked variations, were observed between control values and mean values of these elements measured in the protected area. At this stage, differences between average values of the same weather elements measured in both areas were significant. In the last five years, meteorological records from both areas varied considerably with same trend of changes as in the second five years. The study concluded that there was direct relationship between the microclimatic potentials of Azadirachta indica plantation at Gujba road Damaturu and its canopy density which varied with stages of growth. It is recommended that there is a need for proper understanding of both botany and adaptation of tree species to be involved in programs and projects of environmental management.

Key words: Impact, microclimate, *Azadirachta indica*, weather variables

INTRODUCTION

Generally, Yobe state experiences climatic variability characterized by short rainy season and unpredictable rainfall pattern (YBSES, 2008). Similarly, alarming increases in meteorological values of temperature and wind speed have been reported in recent years (NIMET, 2014). This invariably, decreases both economic and biological productivity of arable land; promotes the development of arid and semi-arid conditions as well as accelerates conversion of Savannah vegetation into Sahel (UNCCD, 1994). Evidently, the continuous decline in agricultural productivity of the area could principally be attributed to such variations in climate (Green Facts, 2015). Apart from climatic variability, the rate of deforestation is startlingly very high and in consequence, desert encroachment devastates marginal land at 0.6 km per annum (FAO, 2009). The gravity of environmental degradation makes both the government and other stakeholders prioritize the environment. In effect, various environmental management programs including afforestation and reforestation projects, sand dune fixation and stabilization programs as well as re-greening urban and rural settlements have been executed (NEAZDP, 2003). Prominent species commonly involved in these programs include *Azadirachta indica*, *Acacia senegal*, *Faidherbia albida*, *Acacia nilotica* and *Eucalyptus camudulensis.* The utilization of these species was principally based on their adaptations and microclimatic potentials (YBSAP & FAO, 2008). Generally, all these species have these attributes but the extent may vary as does the species. For instance, their microclimatic capacities may not be the same. Similarly, adaptation to the same environment may differ among the species. Thus, the utilization of tree species for any purpose must consider its potentialities for that purpose as well as its adaptation to that environment. As a xerophyte, *Azadirachta indica* is adapted to the prevailing environmental degradation in Yobe south (NRC, 1992). Similarly, its microclimatic potentials have been adjudged high (Neem Foundation, 2012). However, the extent has not been specifically studied in Yobe state. Therefore, this paper advocates the need for specific assessment of the microclimatic impact of *Azadirachta indica`s* plantation on four weather variables at Gujba road Damaturu, Yobe state, Nigeria. It can be observed that this impact assessment is restricted to only four (4) weather elements. This is because of their significant effect on desertification (Fish wick and Weber, 2012; FAO and UNEP, 2003).

MATERIALS AND METHODS

Damaturu is the administrative capital of Yobe state and occupies the southern part (YBSES, 2008). It is located between latitude 11°39′30′ to 11°47′00′ north and longitude 11°54′00′ to 12°02′00′ east of the equator (Figure 1). The climatic and soil characteristics of Damaturu match those of Sudan Savannah with rainfall ranging from 800mm – 1000mm per annum within a maximum of 140 days (YBSES, 2008). Temperatures are generally very high throughout the year. Mean annual temperature falls between 25 °C and 40 °C; minimum and maximum values respectively (Abubakar, 2007). Relative humidity records are normally high in the rainy season reaching up to 50% or more in some years but during climatic adversity, values as low as 35% have been recorded. Wind moves at an average speed of 17, 167.06 knots per hour due to availability of fairly scattered trees and shrubs that resist and break it (Muhammad, 2016). Soils are mainly impoverished sand with poor textural and structural stabilities attributable to the combined effects of physical and anthropogenic factors (Abubakar, 2007). Gujba road neem plantation Damaturu was purposively selected for the study for being well equipped with modern meteorological gadgets and security outfit. It covers an area of $3km^2$ and was established in 1999 as part of the program of the National Tree Planting campaign. The impact of Neem on weather variables in the study area was assessed by comparing the mean records of rainfall, relative humidity, temperature and wind speed on the leeway side with records of the same weather variables on the windward side (control).The analysis was accomplished in three stages based on the period covered by this study i.e. from 1999 to 2013 as follows: the first five years (1999 – 2003), the second five years (2004 – 2008) and the last five years (2009 – 2013). The statistical significance of the difference between both values was tested using the student`s t- test. This work adopted Buba (2012) method of student`s t – test computation as shown in the formula below

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\delta_1^2}{n_1} + \frac{\delta_2^2}{n_2}}} \text{......... (i)}$$

Where:

t = Student t – test value calculated from meteorological data from both protected and unprotected areas

$\bar{X}_1$ = Mean record of weather variable in the protected area (neem plantation)

$\bar{X}_2$ = Mean record of weather variable in the unprotected area (control)

δ_1 = Variance of neem data from the mean

δ_2 = Variance of control data from the mean

n_1 = Number of data from the protected area used in the analysis

n_2 = Number of data from the unprotected area used in the analysis

The degree of freedom (df) for quantifying the acceptable level of error(s) in the analysis is calculated from the following formula:

$df = n_1 + n_2 - 2$ .... (ii)

Where,

df = degree of freedom; $n_1$and n_2 have already been defined in equation (i) above

RESULTS

Microclimatic Effects on the Weather Variables in the First Five Years (1999 – 2003)

In the first five years, very little differences have been observed between the mean values of the four weather variables measured in the protected area of the species and the control. For instance, only a difference of 0.04 inches of rainfall has been computed between mean values of 54.90 inches and 54.86 inches in the protected and unprotected areas respectively as summarized in Table 1. Relative humidity values also showed similar trend with 0.07% difference between both areas. Temperature difference (- 0.11 ^{o}C) was comparatively much lower than those of rainfall and relative humidity. Above all, wind speed values of 13, 005.66 and 13, 332.71 knots from the respective protected and the unprotected areas yielded the lowest difference of - 327.05 knots. In other words, differences between mean values of the four (4) weather variables measured in both areas were not significant in the first five years (Table 2). Thus, at this stage, the null hypothesis was accepted for obvious reason (Table 2).

Microclimatic Effects on the Weather Variables in the Second Five Years (2004 – 2008)

At this stage, results indicate higher rainfall and relative humidity values in the protected than the control area; whereas temperature and wind speed values were comparatively lower. Thus, mean values of rainfall increased from 55.01 inches (control) to 61.62 inches (protected area) giving rise to a difference of 6.61 inches or an increment of 5.67% (Table 1). Relative humidity values also showed similar incremental trend. However, temperature decreased from 28.22 ^{o}C (control) to 22.91 ^{0}C (protected area), creating an outstanding difference of 5.31 ^{0}C between both areas. The same pattern of decrease has been observed with wind speed values (Table 1). Generally, differences between meteorological records of these weather variables measured in both the protected and unprotected areas were significant leading to the rejection of the null hypothesis (Table 2).

Microclimatic Effects on the Weather Variables in the last Five Years (2009 – 2013)

Considerable variations have been observed between the values of the four weather variables measured in the protected and the control area. For example, rainfall and relative humidity values increased by 12.11% and 12.92% respectively. On the contrary, temperature and wind speed values recorded respective decreases of up to 14.49% and 20.31% (Table 1). Differences between individual values of these elements measured in both areas were not only highest at this stage but also statistically significant. Thus, the null hypothesis was rejected (Table 2).

Table 1: Impact of *Azadirachta indica* on four Weather Elements from 1999 to 2013 at Gujba Road

Growth stage	Weather element	Mean Record *Azadirachta Indica* **	Mean record NIMET (control) ***	Difference between Mean values	Difference between %
1999 – 2003	Rainfall (inches)	54.90	54.86	0.04	0.03
2004 – 2008	"	61.62	55.01	06.61	5.67
2009 – 2013	"	74.15	58.13	16.02	12.11
1999 – 2003	Relative humidity (%)	43.58	43.51	0.07	0.08
2004 – 2008	"	54.25	46.35	07.90	07.89
2009 – 2013	"	65.55	50.55	15.00	12.92
1999 – 2003	Temperature (^{o}C)	24.77	24.88	- 0.11	0.22
2004 – 2008	"	22.91	28.22	- 05.31	10.39
2009 – 2013	"	22.42	30.02	- 07.60	14.49
1999 – 2003	Wind speed (knots/hour)	13, 005.66	13, 332.71	- 327.05	01.24
2004 – 2008	"	10, 995.28	13, 686.07	- 2, 690.79	10.90
2009 – 2013	"	8, 611.42	13, 001.07	- 4, 389.65	20.31

Source: ******* = Secondary data collected by NIMET (1999 – 2013); ** = Secondary data from weather stations in the plantation area of Azadirachta *indica* at Damaturu

Table 2: Test of statistical significance of the Impact of Gujba road neem Plantation Damaturu on four Weather Variables from 1999 to 2013

S/N.	Variable of comparison	Stage of growth	Mean value *A. indica*** ($\bar{X}_1$)	Mean value *Control**** ($\bar{X}_2$)	Diff. b/w mean values	Variance of *A. indica* Data	Variance of Control data	Df	Probability level	t – calculated	t - critical	Decision on H0:
1	Rainfall (inches)	1999 – 2003	54.90	54.86	0.04	0.4914	0.5012	8	0.05	0.04	2.306004	Accepted
	"	2004 – 2008	61.62	55.01	6.61	1.7956	0,2683	8	0.05	4.6011	2.306004	Rejected
	"	2009 – 2013	74.15	58.13	16.02	0.1296	0.2662	8	0.05	25.46	2.306004	Rejected
2	R/H (%)	1999 – 2003	43.58	43.51	0.07	1.0816	0.7225	8	0.05	0.05	2.306004	Accepted
	"	2004 – 2008	54.25	46.35	7.9	0.3969	0.1600	8	0.05	10.59	2.306004	Rejected
	"	2009 – 2013	65.55	50.55	15.00	0.2401	0.2500	8	0.05	21.43	2.306004	Rejected
3	Temp. (^{0}C)	1999 – 2003	24.77	24.88	- 0.11	0.1024	0.1089	8	0.05	0.2393	2.306004	Accepted
	"	2004 – 2008	22.91	28.22	- 5.31	0.0400	0.0256	8	0.05	20.74	2.306004	Rejected
	"	2009 – 2013	22.42	30.02	- 7.6	0.1156	0.0361	8	0.05	19.51	2.306004	Rejected
4	WS (Knots/h)	1999 – 2003	13, 005. 70	13, 332.00	- 326.3	9370.24	103, 041	8	0.05	0.97	2.306004	Accepted
	"	2004 – 2008	11, 004	13, 686	- 2, 682	10, 404	39, 204	8	0.05	12.04	2.306004	Rejected
	"	2009 – 2013	8, 611	10, 661	- 2050	89, 401	274, 576	8	0.05	3.3979	2.306004	Rejected

Source: ** Secondary data from the protected areas of *Azadirachta indica;* *** Secondary data from the protected areas of *Acacia senegal*
Key to abbreviations: diff. = difference, b/w = between, R/H = Relative humidity, H0. = Null hypothesis, WS = Wind Speed, df = degree of freedom

DISCUSSIONS

Impact of botanical structures on microclimate and adaptation

The botanical records of *Azadirachta indica* have great microclimatic implications. For instance, its evergreen attribute in the study area guarantees not only continuous protection to the land surface but also modification of the local weather. Moreover, it`s height at maturity (15 – 30 m) couple with very dense and broad canopy further exerts microclimatic effect on the protected side. This confirms the direct relationship between canopy density and modification power of trees (FAO and UNEP 2003; Fact Net 2005 and Orwa *et al*., 2009). Similarly, its botanical structures have adaptive implications. What makes it adapt the unfavorable agro ecology of the Sahel? What makes it thrive well in that environment? Its specialized adaptation has been attributed to the development of long penetrating lateral root system (up to 15 m deep), presence of thick scaly bark and development of swollen water reservoirs along the shoot system reported in NAS (2010) and the World Neem Foundation (2012).

Impact of *Azadirachta indica* on weather variables at Gujba road, Damaturu

As already highlighted and summarized in Tables 1 and 2, insignificant differences have been observed between the mean values of the four (4) weather variables measured in both areas in the first five years. These insignificant differences have been attributed to the low canopy density that could have modified weather variables in the protected areas of the species. The greater the canopy density, the greater the microclimatic effect and vice versa. This further confirms the direct relationship between canopy density and modification power of trees Therefore, the impact of the neem plantation on the four weather variables was insignificant in the first five years.

In the second five years however, mean values of the same weather elements on the leeway side had shown marked variations from the control record (Windward side). This is due to the development of matured canopies that greatly modified weather variables in the protected area. Thus, there was considerable increase in the amounts of rainfall and R.H in the second five years and the differences between mean values of these elements in both areas were significant. This contradicts the earlier work of Milan *et al*. (2004) accomplished in India where the impact of neem plantation on the same weather variables at the same stage of growth was insignificant inspite of the higher records of the same variables compared to the control. Temperature reduced considerably in the protected fields of *Azadirachta indica* in the second five years. The difference in temperature between the protected and unprotected areas was 5.31 ^{o}C which was much lower than 10 ^{0}C reported in India at the same stage of growth (World Neem Conference 2012). This means that at maturity, the temperature modification power of *Azadirachta indica* in India almost doubles that of the Sahelian parts of Nigeria. This can be attributed to the prevailing climatic variability in the area where alarming increases in temperature values and other climatic variables have recently been reported (NIMET, 2014). The implication of this is that if an average Neem tree can do the job of 10 air conditioners in India (World Neem Foundation, 2012), then it can do the job of only 5 air conditioners in the Sahel. Wind speed recorded higher reduction compared to temperature. Same trend has been reported from many locations in the northern hemisphere at maturity (Vautard *et al.,* 2010). Suffice therefore to state that high wind speeds have declined by a greater proportion on the leeway side of Neem plantation in the study area. Like rainfall and R.H, differences between mean values of these weather variables in both areas were significant. This also confirms increased microclimatic effect of tree plantation with stage of growth reported in the earlier works of Carter, (2005); FAO, (2009); Adekoya, (2007) and Zira, (2014).

In the last five years, mean values of weather variables under the shelters of *Azadirachta indica* had shown highest variations from the control records. This is because at this stage, all growth structures responsible for environmental modification were fully matured leading to the development of broadest and densest canopies. For instance, tree height increased considerably from 15m to 30m (Fact Net, 2005); while stem diameter changed from 35cm to 90cm (FAO and UNEP, 2003). Thus, the impact of Neem plantation on the four-weather variables in the last five years was greatest than in the first and second five years. Similarly, differences between records of the 4 weather variables measured in both areas were significant.

CONCLUSION

Azadirachta indica is the dominant tree species commonly used in program and projects of desertification control both in the Sahel and Sub-Sahara Africa. Its xyrophytic properties make it a reliable species for sand dune fixation and stabilization as well as other projects of environmental management. Its botanical structures have both microclimatic and adaptive implications. It's wide spread utilization in Damaturu and other areas in the Sahel could probably be attributed to its capacity to modify extreme high winds and temperature responsible for cyclical drought in the area. The impact of the plantation of *Azadirachta indica* on the four weather variables in the first five years was not significant due to immaturity of growth structures responsible for the creation of microclimate. However, as the tree developed denser and broader canopies, the plantation exerted greater significant impact on the four weather variables in the second five years. At full maturity (2009 – 2013), the impact was significantly greatest attributable to full maturity of all botanical structures that perform the microclimatic function through increased evapotranspiration and aerodynamic roughness. Thus, its botany has positive adaptive and microclimatic implications; and that direct relationship exists between the microclimatic potentials of Azadirachta indica plantation and its canopy density which varied with stages of growth. As the tree of the 21st century, *Azadirachta indica* proved to be a desert fighter as it significantly counteracted the excesses of extreme high winds and temperature which are the driving engines for both droughts and desertification in the area.

Recommendations

Proper assessment of any tree species for large scale utilization should find answers to the three universal questions of plantation forestry – Which species? Where? and Why? Critical answers to the above queries could provide useful direction in the selection and utilization of desirable species that can be harnessed to tackle both physical and socioeconomic problems.

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