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FOREWORD

I am pleased to put into the hands of readers Volume-8; Issue-3: May-June 2023 of **"International Journal of Environment, Agriculture and Biotechnology (IJEAB) (ISSN: 2456-1878)",** an international journal which publishes peer reviewed quality research papers on a wide variety of topics related to **Environment, Agriculture and Biotechnology**. Looking to the keen interest shown by the authors and readers, the editorial board has decided to release issue with DOI (Digital Object Identifier) from CrossRef also, now using DOI paper of the author is available to the many libraries. This will motivate authors for quick publication of their research papers. Even with these changes our objective remains the same, that is, to encourage young researchers and academicians to think innovatively and share their research findings with others for the betterment of mankind.

I thank all the authors of the research papers for contributing their scholarly articles. Despite many challenges, the entire editorial board has worked tirelessly and helped me to bring out this issue of the journal well in time. They all deserve my heartfelt thanks.

Finally, I hope the readers will make good use of this valuable research material and continue to contribute their research finding for publication in this journal. Constructive comments and suggestions from our readers are welcome for further improvement of the quality and usefulness of the journal.

With warm regards.

Editor-in-Chief
Date: July, 2023

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Vulnerability and adaptative capacity to climate change in five localities riparating the wetlands of the Oti Plain in the north du of Togo

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Abstract— *In the National Development Plan (PND) 2018-2022, particularly in point 1.5, in connection with environmental management, taking into account the fight against climate change has been clearly defined as crucial for the development of Togo based on the National Climate Change Adaptation Plan (PNACC). With this in mind, we have assessed the vulnerability and adaptive capacities to climate variability and change in five localities bordering the wetlands of the Oti Plain. The work consisted of conducting surveys in a participatory manner with the target groups. These surveys focused on the perception of populations and producers of climate change, the shocks experienced, and adaptation measures. Risk indices were calculated. Then we proceeded to calculate the vulnerability or severity indices. The results highlight the irregularity of rains, poverty in general, the poverty of agricultural soils, pockets of drought, the drop in agricultural yields, diseases, and deforestation as the main shocks emanating from climate change. The observation of the populations indicates a clear increase in temperatures and an irregularity in rainfall. The adaptive capacities developed by producers to cope with these multifaceted shocks have been identified and depend on the production sector. Given these results, future investigations should make it possible to deepen the understanding of climate change in all vulnerable sectors. This information will be used to better establish adaptation strategies to climate change, particularly in vulnerable areas.*

Keywords— ***Adaptation, climate change, perception, Togo, wetland.***

I. INTRODUCTION

Climate change has already caused widespread damage to nature and humans, beyond natural climate variability. It is responsible for a widespread deterioration of the functions and structures of ecosystems (terrestrial, freshwater, marine). The increase in the frequency and intensity of several types of extreme weather events (heat waves, heavy rainfall, droughts, etc.) cause irreversible impacts by pushing natural and human systems beyond their adaptation limit. They also cause increasing population displacements. These events expose millions of humans to food insecurity and lack of water, to which children, the elderly, and pregnant women are particularly susceptible (IPCC, 2022).

Aware that the fight against the adverse effects of climate change must be collective, Togo joined the dynamics of the international community in this area, by ratifying the United Nations Framework Convention on Climate Change (UNFCCC) on March 8, 1995 and the Kyoto Protocol on July 2, 2004. Among the actions, and in the direction of the fight against this scourge, in 2009, Togo proposed a National Action Plan for Adaptation responding to questions relating to natural disasters, agriculture, flooding, and coastal erosion (MANATIONTOGO, 2015).

Despite the government's efforts, the vulnerability of populations to climate change has increased in recent years due to the security context coupled with the health context of the Covid-19 pandemic.

Throughout the country and especially in the savanna region, the effects of climate change are more noticeable. Chronic drought resulting from climate variability and change plays an accelerating role in deforestation, poverty, famine, and the cruel lack of drinking water for the population, especially in rural areas. Rainfall variability is therefore the main handicap to the development of survival and income-generating activities (agriculture, livestock, fishing, trade, etc.).

Togo has experienced drought events (1972, 1980, 2000-2004, 2008, and 2016) and flood episodes (2009-2011), which affected a large number of people, particularly in the savannah region, the most vulnerable and most exposed to the effects of climate change. Farmers face great threats and struggle to maintain their livelihoods (Fiankan-Bokongo, 2009). The vulnerability of the agricultural sector is measured in terms of impacts on the profitability or viability of farming systems exposed to hydro-meteorological hazards and water control problems. Other sectors of activity such as livestock and fishing are also affected by this scourge. Rising temperatures accentuate the mortality of livestock, the transmission of diseases via food and water, the lack of pasture, and the drying up of fishing grounds.

There is a general consensus that climate change threatens food security, mainly due to the increase in extreme events and spatiotemporal lags. The continent is already experiencing a major deficit in food production in many regions and the potential decline in soil moisture and energy will be an additional pressure (Diop et al., 1999; Louvel and Gromard, 2006). Countries that lack food are more vulnerable to the adverse effects of climate change according to IPCC (2001). This vulnerability of ecosystems and human societies varies greatly depending on the region. It strongly depends on the level of development, the unsustainable use of oceans and soils, the level of inequity and marginalization, contemporary and past unjust societal models (such as colonialism), as well as governance (IPCC, 2022).

The mostly rural local populations of northern Togo have their own way of appreciating the effects and manifestations of climate change. The surveys carried out in five localities bordering the wetlands of the Oti Plain as part of our study made it possible to determine the shocks, impacts, and severity of climate change in the area.

II. MATERIALS AND METHODS

2.1 Study area

This study is carried out in North-Togo between latitudes N 9°30' and N 11°00' and longitudes E 0°15' and E 0°55' corresponding to the northern plains covered mainly with dry savannas with Leguminoseae and Combretaceae, home to significant biological diversity (Koumantiga et al., 2018; Badabaté et al., 2012) and a hydrographic network drained by the Oti River and its tributaries. This area straddles the savanna region and the Kara region. It includes five (05) localities, three of which are in the Oti prefecture: Poporkou, Tchanaga, and Sadori, and two in the Kéran prefecture: Atalotè and Pessidè (Fig 1). The, dry savanna enjoys a Sudanian-type climate with a dry season and a rainy season. The annual rainfall is 1,201.69 mm and the average annual temperature is 27.7°C (Badjaré, 2012). Extreme temperatures vary between 39°C and 17°C in the dry season and between 34°C and 22°C in the rainy season (Agboh & Badjaré, 2007). The population, which is largely rural, was 30,476 in 2010 (INSEED, 2011). The localities in this area have experienced strong urbanization and demographic pressure in recent years in connection with the intense pressure on wetlands accentuated by the effects of climate change.

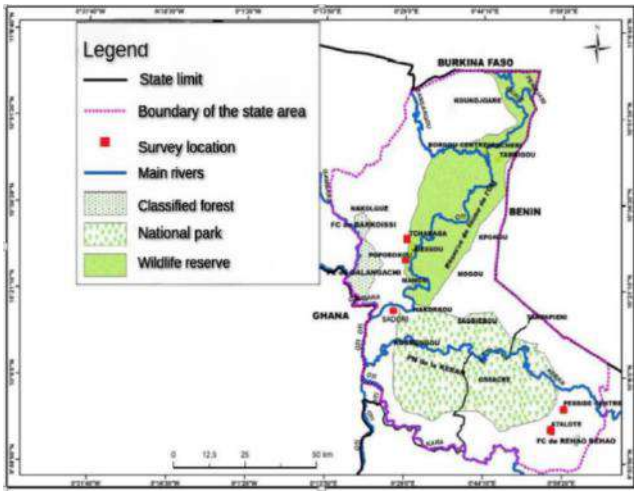

Fig.1. Map of the study area

Source: DGSCN, 2010, Authors: Lamboni L.

2.2 Data collection methods

2.2.1 Choice of survey localities and constitution of the sample

The choice of the localities prospected during the study is guided by three criteria: the proximity of the localities in relation to the wetlands, the geographical accessibility of the localities, and the production sectors (activities) which can directly or indirectly influence the important wetlands of the Oti basin. The target population concerned by the survey is made up of people who are direct users of wetlands, mainly farmers, fishermen, breeders, and hunters.

2.2.2 Investigations

The socio-anthropological surveys aim, on the one hand, to understand the perceptions of the populations on the

wetlands, the anthropic activities carried out around these zones, and the socioeconomic importance of these ecosystems in their well-being and development. On the other hand, to also understand their perceptions of climate change and their capacities to adapt to current and future adverse effects of climate change and variability. These surveys should make it possible to highlight the vulnerable populations in each locality, prioritize the main shocks due to climate change and variability, and take stock of the technological, organizational, and/or socioeconomic adaptation capacities.

This method ultimately enabled us to measure the severity of the change in the production sectors and the lives of the populations, taking gender into account. To achieve this, the method adopted consisted of questioning, in a semi-structured way, target groups according to the production sectors on their perception of climate change, the manifestations, the effects, the shocks feelings, and coping strategies. Questionnaires and interview guides have been designed for this purpose.

In this approach, the Q method and the method for calculating the risk of climate change in the production sectors were used.

2.3 Data management

2.3.1 The Severity of climate change

After listing the shocks in each group, the producers themselves ranked them. The village survey data made it possible to analyze the severity of climate change in each village according to the production sectors. Once the shocks were listed, the terms were harmonized. For example, “lack of rain” has been harmonized with “irregular rain”. The data were then used to calculate the incidence I, the severity S and the risk index. From the incidence and the severity, the severity map of the villages or of a target group such as men and women was established. In the analysis of the map, a high value indicates a high impact. However, high severity is associated with low value.

2.3.2 Impact, vulnerability risk indices

The risk indices were calculated according to the method of Smith et al. (2000) and Quinn et al. (2003). We first proceeded to the calculation of the impact **I** of climate change in each locality, then to the calculation of the Severity index, and finally we ended up with the calculation of the climate risk index.

The severity indices allowed us to produce graphs of shocks for each locality or vulnerability indices from the following equations:

(1) Severity index Sj = 1 + (r-1) / (n-1)

With: r = threat rank (in order of importance according to the participant);

n = total number of threats listed by the participant;

We then calculate the average for all participants who listed a certain threat

$$(2)\text{Incidence(Ij)} = \frac{\textbf{Type of threat X number of times listed}}{\textbf{Number of participants}}$$

(3) **Indice de risque (0-1) : Rj = Ij/Sj**

2.4. Data processing and analysis

Climate data and data from field surveys and interviews were processed using Excel 2013 and Kobocollete software.

III. RESULTS

3.1 People's Perception of climate change

3.1.1 Parameters and Indicators of climate change

In the five localities surveyed, climatic parameters such as rainfall, temperature, wind, and insolation were cited as the most determining climatic variables. The indicators of changes in climatic parameters that are perceived by the peasant populations are 8 in number for rainfall, 3 for temperature, 2 for wind, and 2 also for insolation (Table 1).

Table 1: Climate parameters and change indicators cited by the populations

Climatic parameters	Indicators of change
Rainfall	- Irregularity of rains; - Decline in rainfall; - Shortening of the duration of the rainy season; - Existence of pockets of drought; - Early agricultural season; - Early cessation of the rains; - Delay of rains; - Frequent flooding
Temperature	- Increasingly high temperatures; - Decrease in freshness during harmattan periods; -Increased minimum temperatures
Wind	- Increasingly violent winds; - Increased whirlwinds
Insolation	- Increase in the number of sunny days; - Decrease in the number of cloudy days

3.1.2 Perceptions by the local populations of the wetlands of the Oti Plain of climate parameters and indicators of change

The climatic phenomena are perceived by the rural populations in a sensory way starting from the variation of the factors of the climate such as the temperature, the pluviometry, the winds and the insolation; but also psychically under the influence of functional factors. The declarations of the mostly peasant populations are inspired by local knowledge, and which reveal their perception of the phenomenon of climate change.

- **Rainfall**

The populations, regardless of their sectors of activity, have noticed an upheaval with regard to the normal course, as known in the past, of the rainy events. The elderly situates these climate changes in the 70s and 80s following the drop in rainfall and the droughts that hit the populations hard at that time (Fig 1). The youngest, given their short existence in time, perceive climate change less well but remember recent climatic manifestations, in particular, the famines of 2005 and 2007 and recent flood episodes (2009 and 2010). The main upheavals perceived by the population's concern: the late start and/or poor distribution of the rains during the rainy season, the shortening of the duration of the rainy season, the reduction in rainfall heights, the reduction in the number of rainy days, the existence of pockets of drought, the occurrence of very heavy rains.

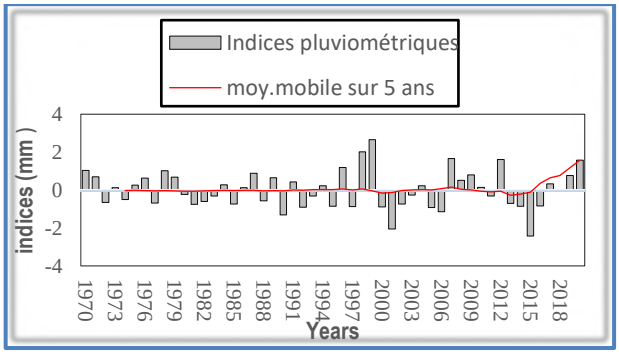

Fig.1: Rainfall index of the Mango synoptic station from 1970-2020

- **Temperature**

More than 80% of respondents found that it is getting hotter and hotter. The two other indicators of temperature changes such as "decrease in coolness during the harmattan period and increase in minimum temperatures" were reported by less than 20% of those surveyed (Fig 2).

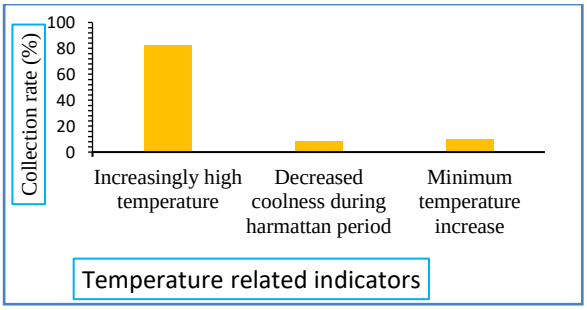

Fig.2. Perception of temperature changes

- **Wind**

More than 70% of the populations questioned perceived the indicator "increasingly violent winds" in our survey localities. 27% reported "increased eddies" especially during the harmattan (Fig 3).

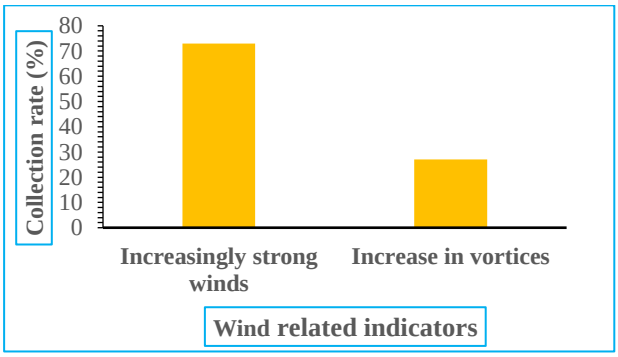

Fig.3. Perception of wind changes

- **Sunstroke**

According to the histogram (Fig 4), more than 90% of farmers claim "an increase in the number of sunny days" compared to the 1980s. This change resulted in "a decrease in the number of cloudy days"; a finding corroborated by more than 60% of respondents.

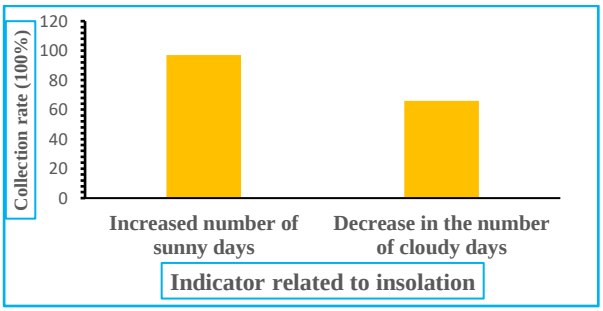

Fig.4: Perception of changes in insolation

3.2 Vulnerability of populations living near wetlands in the Oti Plain to climate change

3.2.1. The incidence and severity in all the localities

bordering the wetlands of the plain of the Oti

Table 2 shows 30 shocks listed by all populations. These shocks were identified taking into account gender and sector of activity. Among these shocks, the irregularity of rains, deforestation, poor agricultural soils, and low agricultural yield are the most important with an incidence of 1, followed by the invasion and resistance of weeds and the lack of firewood. heats 0.8. Medium-impact shocks include difficult access to land, an increase in temperature, a drop in income, the existence of pockets of drought, short agricultural season, distance from health centers, drought, insufficient drinking water points and poverty with a value of 0.6. Low-impact shocks include pastoralist/farmer conflicts, the disappearance of certain fish species, the reduction of fodder species, soil erosion, flooding of agricultural fields, famine, diseases, poultry diseases, lack of grazing, livestock mortality, scarcity of fish in rivers, a parasite of crops and strong winds with a value of 0.4. Two shocks with very low incidence were given: the drying up of watering points and conflicts between fishermen 0.2.

In terms of severity, poverty; irregular rainfall, poor agricultural soils, deforestation, and low agricultural yield are the most severe with respectively 1 and 1.1. Five shocks have a fairly high severity and range from 1.2 to 1.3: the existence of pockets of drought and the invasion and resistance of weeds (1.2); difficult access to land, a decline in income, and flooding of agricultural fields (1.3). Six medium-severity shocks (1.4 and 1.5) respectively disease, short agricultural sea, son and strong winds (1.4); distance from health centers insufficient drinking water points, and soil erosion (1.5). The low-severity shocks include respectively conflicts between fishermen and the drying up of watering points (2), the disappearance of certain fish species, famine and reduction of fodder species (1.9), three shocks with severe =1.8: lack of pasture, livestock mortality and scarcity of fish in the rivers; two shocks with severity = 1.7: poultry disease, breeder/farmer conflicts and crop parasite; three shocks with severity =1.6: increase in temperature, drought and lack of firewood. Of all this, it is the irregularity of the rains and the existence of pockets of drought which seem to be the shocks most indicative of climate change.

Table 2: Incidence and severity values in all five study localities bordering the wetlands of the Oti Plain

Order number	Shocks of all men and women according to the sector of activity (agriculture, livestock, and fishing)	Impact	Severity
1	Difficult access to land	0.6	1.3
2	Drying up of drinking water points	0.2	2.0
3	Temperature increase	0.6	1.6
4	Income drop	0.6	1.3
5	Breeder/farmer conflicts	0.4	1.7
6	Fisherman conflicts	0.2	2.0
7	Deforestation	1	1.1
8	The disappearance of certain species of fish	0.4	1.9
9	Decrease in forage species	0.4	1.9
10	Distance from a health center	0.6	1.5
11	Weed invasion and resistance	0.8	1.2
12	Existence of pockets of drought	0.6	1.2
13	Soil erosion	0.4	1.5
14	Low agricultural yield	1	1.1
15	Famine	0.4	1.9
16	Flooding of agricultural fields	0.4	1.3
17	Irregularity of rains	1	1.0
18	Lack of water points	0.6	1.5
19	Disease	0.4	1.4
20	poultry disease	0.4	1.7
21	Lack of firewood	0.8	1.6
22	Lack of pasture	0.4	1.8
23	Livestock mortality	0.4	1.8
24	Scarcity of fish in rivers	0.4	1.8
25	Short agricultural season	0.6	1.4
26	Drought	0.6	1.6
27	Agricultural soil poverty	1	1.1
28	Poverty	0.6	1.0
29	crop pest	0.4	1.7
30	strong winds	0.4	1.4

3.2.2 Incidence and severity in all localities of riparian studies of the wetlands of the Oti Plain according to gender

- **According to women**

The data in Table 3 shows that 14 shocks were identified by women. The strongest incidences (1) are given by poverty, the irregularity of rains, the drop in agricultural yields, poor soils, and deforestation. Five shocks have a fairly high incidence (0.8): difficult access to land, insufficient drinking water points, illnesses, drop in income, and lack of firewood. Three shocks have an incidence = 0.6: distance from health centers, pockets of drought and crop pests, and a single shock with low incidence (0.4): famine.

In terms of the severity of each of these fourteen shocks, the difficult access to land is of maximum severity (1). Then come successively poverty (1.1), the irregularity of the rains (1.2); deforestation, and insufficient drinking water points (1.3). Two shocks have an average severity (1.4; 1.5) respectively: diseases, the drop in agricultural yields, and soil poverty. The least severe shocks are represented by the drop in income (1.6); starvation (1.7); remoteness from health centers, pockets of drought (1.8); lack of firewood (1.9); and culture pests (2.0).

Table 3: Incidence and severity values in all five study localities bordering the wetlands of the Oti Plain according to women.

Order number	Women shocks	Impact	Severity
1	Difficult access to land	0.8	1.0
2	Falling agricultural yields	1	1.5
3	Income drop	0.8	1.6
4	Deforestation	1	1.3
5	Famine	0.4	1.7
6	Insufficient drinking water points	0.8	1.2
7	Irregularity of rains	1	1.2
8	Distance from a health center	0.6	1.8
9	Lack of firewood	0.8	1.9
10	Diseases	0.8	1.4
11	Poverty	1	1.1
12	Soil poverty	1	1.5
13	pocket of drought	0.6	1.8
14	Culture parasite	0.6	2.0

- **According to men**

Out of a total of 26 given shocks (Table 4), deforestation, erratic rainfall and low agricultural yield and poor agricultural soils emerge as the high-impact shocks (1.0). These shocks are followed by weed invasion and resistance and poverty (0.8). Six shocks have an impact of (0.6): increase in temperature, drop in income, existence of pockets of drought, short agricultural season, crop pests, and drought. Low incidence shocks are represented by: livestock breeder/farmer conflicts, the disappearance of certain fish species, the reduction of fodder species, soil erosion, starvation, disease, poultry disease, lack of pasture, livestock disease, scarcity of fish in rivers, and strong winds (0.4); the drying up of watering points and conflicts between fishermen (0.2).

With regard to the severities of the shocks, the irregularity of the rains, the increase in temperature, the deforestation is the shocks with maximum severity (1); followed by the low yield and poverty of agricultural soils (1.1), the existence of pockets of drought (1.2); invasion and resistance of weeds, short agricultural season and drought (1.3); flooding of agricultural fields, poverty and crop pests (1.4); declining income, starvation and strong winds, soil erosion and disease (1.6), poultry disease and lack of pasture (1.7); the decrease in fodder species, livestock mortality and the scarcity of fish in rivers (1.8); the drying up of drinking water points (1.9); the disappearance of certain species of fish (2).

Table 4: Incidence and severity values in all of the five study localities bordering the wetlands of the Oti Plain according to men.

Order number	men shocks	Impact	Severity
1	Drying up of drinking water points	0.2	1.9
2	Temperature increase	0.6	1.0
3	Income drop	0.6	1.5
4	Breeder/farmer conflicts	0.4	1.9
5	Fisherman conflicts	0.2	2.0
6	Deforestation	1.0	1.0
7	The disappearance of certain species of fish	0.4	2.0
8	Decrease in forage species	0.4	1.8
9	Weed invasion and resistance	0.8	1.3

10	Existence of pockets of drought	0.6	1.2
11	Soil erosion	0.4	1.6
12	Low agricultural yield	1.0	1.1
13	Famine	0.4	1.5
14	Flooding of agricultural fields	0.4	1.4
15	Irregularity of rains	1.0	1.0
16	Disease	0.4	1.6
17	poultry disease	0.4	1.7
18	Lack of pasture	0.4	1.7
19	Livestock mortality	0.4	1.8
20	Scarcity of fish in rivers	0.4	1.8
21	Short agricultural season	0.6	1.3
22	Drought	0.6	1.3
23	Agricultural soil poverty	1.0	1.1
24	Poverty	0.8	1.4
25	crop pest	0.6	1.4
26	strong winds	0.4	1.5

3.2.3. **The incidence and severity of each locality of riparian studies of the wetlands of the Oti Plain according to the sectors of activity and gender**

3.2.3.1 Incidence and severity according to Farmers

❖ **Locality of Poporkou**

- **Shocks given by women**

The analysis of the severity map S of the women of Poporkou (Fig 5) shows that poverty, disease, difficult access to land, and irregular rainfall stand out as high-impact shocks. In terms of severity, disease, and poverty are the most severe shocks, followed by difficult access to land, deforestation, and remoteness from health centers. These shocks are medium even if their impact is low.

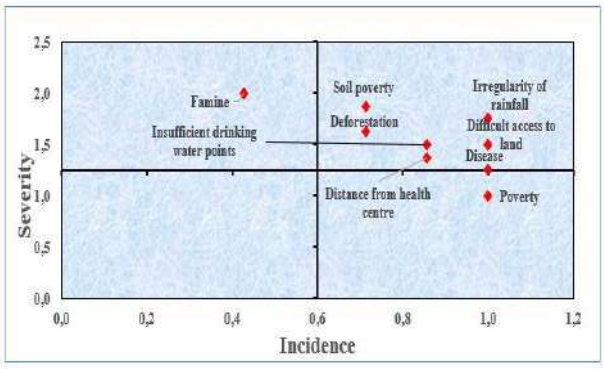

Fig.5: Severity S map of Poporkou women

- **Shocks given by the male farmers of Poporkou**

For male farmers, the trend that emerges at the level of the severity map is that the irregularity of rains and the low agricultural yield are of high incidence and of respectively high and medium severity, while the poverty of agricultural soils, crop pests, and the short agricultural season are of medium incidence and severity (Fig 6).

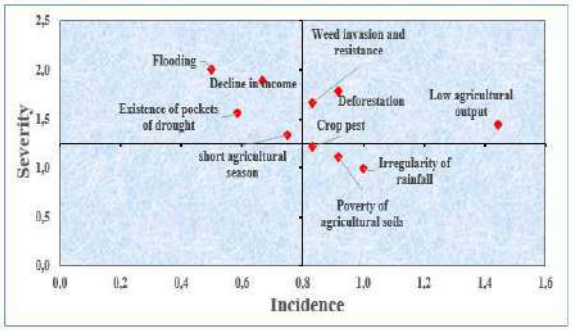

Fig.6: Severity S map of Poporkou Farmers

❖ **Locality of Tchanaga: a group of farmers**

- **Shocks given by women**

The analysis of the severity map of the women of Tchanaga shows that poverty, the irregularity of rains, and the decline in agricultural yields are shocks with high incidence and high severity in terms of poverty and the irregularity of rains. Soil poverty also emerges as a shock with high severity but medium incidence (Fig7).

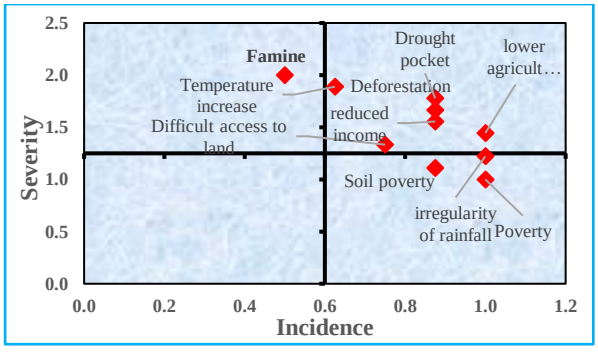

Fig.7: Severity S map of Tchanaga women

- **Shocks given by male farmers**

The men's severity map shown in Figure 8 reveals 5 groups of shocks: the group of shocks with high incidence and severity (poverty of agricultural soils and irregular rainfall), the group of shocks with medium incidence and high severity (low agricultural yield), the group of shocks with medium incidence and medium severity (invasion and resistance of weeds and diseases), the group of shocks with medium incidence and low severity (deforestation and poverty) and the group of shocks with low incidence and severity (drop in income, existence of pockets of drought, crop pests, short agricultural season, farmer/herder conflicts and increase in temperature).

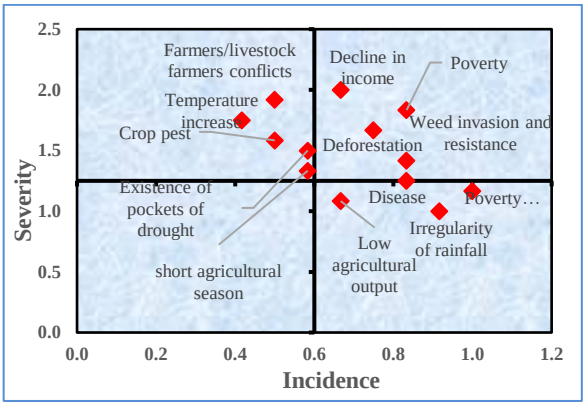

Fig.8: Severity S map of male farmers in Tchanaga

❖ **Locality of Sadori**

- **Shocks given by women**

The severity map of the shocks listed by the women of Sadori shows that groups of shocks emerge as follows (Fig 9): shock with high incidence and severity (poverty, irregular rainfall, and deforestation), shock with high incidence and severity medium (soil poverty and drop in agricultural yields), shock with high incidence and low severity (diseases, drop in income and lack of firewood), shock with low incidence and fairly high severity (invasion and resistance of weeds), low incidence and moderate severity (difficult access to land and pockets of drought). The rest of the shocks are divided into groups of shocks with low incidence and severity (flooding of agricultural fields and crop pests).

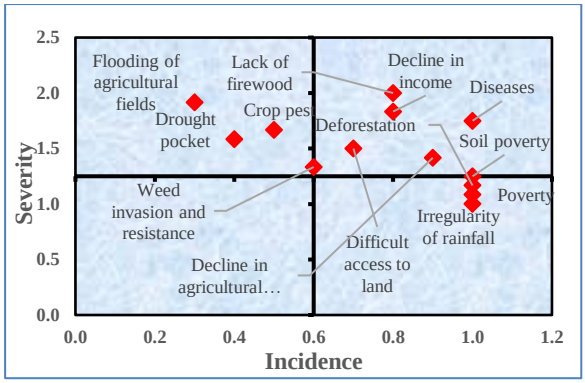

Fig.9: Severity S map of women in Sadori

- **Shocks given by men**

The severity map of the men of Sadori presents 7 groups of shocks (Fig 10): shock with maximum incidence and high severity (diseases and poor agricultural soils), shock with high incidence and high severity (invasion and resistance of weeds, low agricultural yield, and erratic rains), shock with medium incidence and medium severity (short agricultural season and flooding of agricultural fields), shock with medium incidence and low severity (deforestation), shock with low incidence and high severity (existence of pockets of drought), shock with low incidence and medium severity (crop pests and poverty). The rest is made up of low-impact and low-severity shocks (low income, farmer/herder conflicts, and temperature rise).

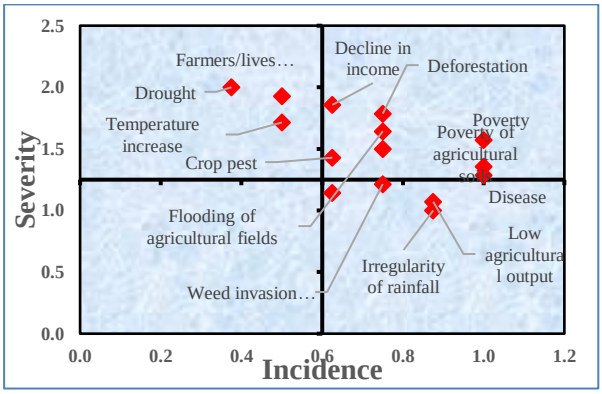

Fig.10: Severity map of male farmers in Sadori

❖ **Locality of Pessidè**

- **Shocks given by women**

According to Figure 11, the various shocks listed by the women of Péssidè could be divided into 9 groups: the group of shocks with high incidence and severity (poverty), the group of shocks with high incidence and medium severity (deforestation and soil poverty), the group of shocks with medium incidence and fairly high severity (lower agricultural yields, distance from water points, irregular rainfall), the group of shocks with medium incidence and

low severity (lower income), the medium incidence and severity shock group (high winds and diseases), high incidence and low severity shock group (weed invasion and resistance), low incidence and high severity shock group (pests crop), the group of shocks with low incidence and medium severity (pocket of drought) and the group of shocks with low incidence and severity (rise in temperature and lack of firewood).

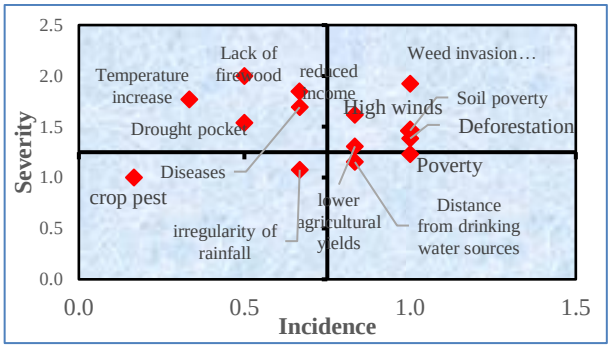

Fig.11: Severity map of the women of Péssidè

- **Shocks given by men**

Analysis of the map of the severity of the shocks listed by the men of Péssidè makes it possible to identify the following groups of shocks (Fig 12): shocks with high incidence and severity (poverty and irregular rainfall), shocks with high incidence and medium severity (invasion and resistance of weeds, poor agricultural soils, and low agricultural yield), shock with high incidence and low severity (strong winds and soil erosion), shock with medium incidence and high severity (diseases), shock with medium incidence and severity (crop pests), low incidence and medium severity shock (short agricultural season). The rest of the shocks are divided into groups of shocks with low incidence and severity (reduction of income, deforestation, existence of pockets of drought, farmer/herder conflicts, and temperature increase).

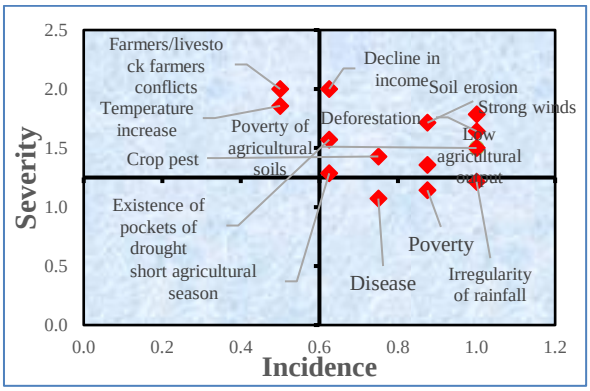

Fig.12: Map of severity S of the men of Péssidè

❖ **Locality Ataloté**

- **Shocks given by women**

The Atalotè women's severity map presents a breakdown of shocks into several sub-groups (Fig 13): shock with maximum incidence and severity (diseases), shock with high incidence and severity (poverty, irregular rainfall, and poor agricultural soils), shock with high incidence and low severity (deforestation, drop in income, soil erosion and strong winds), shocks with medium incidence and severity (difficult access to land, drop in agricultural yields and lack of firewood), shocks with low incidence and medium severity (invasion and resistance of weeds), shock with low incidence and severity (crop pests and pockets of drought).

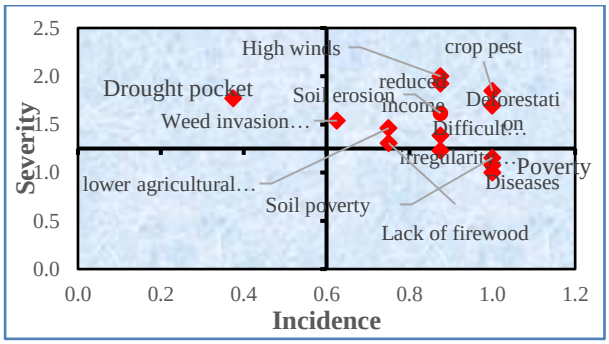

Fig.13: S Severity map of Atalote women

- **Shocks given by men**

Examination of the Atalote severity map (Fig 14) shows that the various shocks are distributed as follows: shocks with high incidence and severity (diseases, irregular rainfall, and poverty), shocks with high incidence and medium severity (invasion and resistance of weeds and poor agricultural soils), shocks with high incidence and low severity (strong winds, soil erosion and farmer/herder conflicts), shocks with medium incidence and severity (existence of pockets of drought , short agricultural season, crop parasite and low agricultural yield), and shocks with low incidence and severity (reduction of income, deforestation, increase in temperature and drought).

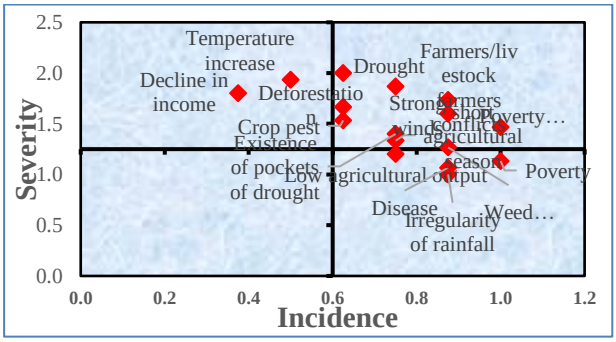

Fig.14: S severity map of Atalote men

3.2.3.2 Incidence and severity according to breeders

- **Shocks of breeders in the localities of Tchanaga, Sadori and Péssidè.**

Breeders in the localities of Tchanaga, Sadori, and Pessidè suffer the same shocks, with the only difference being the watering points for animals, which are lacking during the dry period in Péssidè. Thus, the shocks are divided into (Fig 15): shocks with high incidence, and severity (livestock mortality and poultry diseases), shocks with high incidence, and medium severity (breeder/farmer conflicts), shocks with high incidence and low severity (poverty and reduction of fodder species), shocks with medium incidence and high severity (drying up of watering points and irregular rainfall), shocks with medium incidence and severity (increase in temperature and lack of grazing), low incidence and medium severity shock (drought) and medium incidence to low severity shocks (low income, deforestation, disease , and insufficient drinking water points).

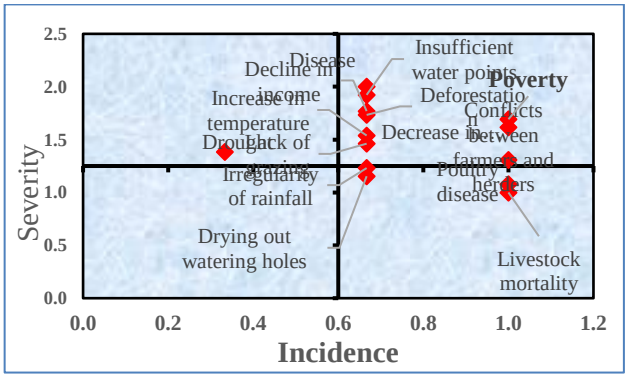

Fig.15: Severity map of breeders

3.2.3.3 Incidence and severity according to fishermen

- **Shocks of the fishermen of the localities of Poporkou, Tchanaga and Sadori**

Fishermen from the localities of Poporkou, Tchanaga and Sadori mentioned the same shocks. Analysis of the severity map shows a breakdown of shocks by group (Fig 16): shocks with high incidence, and severity (scarcity of fish and poverty), shocks with high incidence and high severity (silting of the river bed, bank erosion and water pollution), shocks with high incidences, and medium severity (disappearance of certain species of fish, drop in income and flooding), shock with high incidence, and low severity (low agricultural yield), shocks with low incidence and medium severity (conflicts between fishermen). The rest is made up of shocks with low incidence, and severity (irregular rains, poor agricultural soils and diseases).

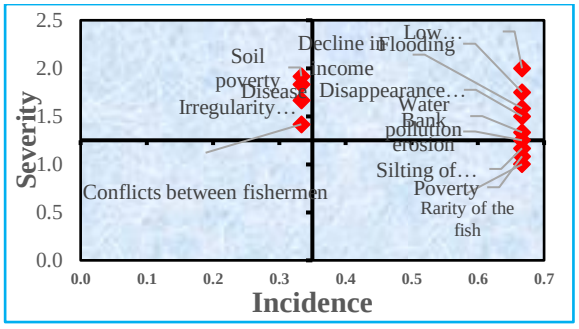

Fig.16: Severity S map of fishermen

3.3 Population adaptation to climate change

Aware of the various changes that occur in climatic rhythms and their perverse effects on life itself and on activities, local populations have initiated a set of readjustments or adaptations in farming systems. These identified local strategies for adaptation to climate change depend on the sectors of activity.

3.3.1 Farmers' adaptation strategies to climate change

The shocks with high incidence and severity that farmers experience are, among others, the irregularity of rains, the poverty of agricultural soils, the invasion and resistance of weeds, and pockets of drought. To mitigate the shocks due to the effects of climate change, the producers listed adaptation strategies. These new strategies, inspired by those implemented in the other regions of the country, are essentially based on the self-promotion and organizational capacities of local communities. The table below presents all the strategies encountered during our surveys.

Table 5: Farmers' coping strategies

Adaptation of the cropping calendar in relation to the climatic conditions of the year (modification of sowing dates)
Off-season cultivation to compensate for the poor agricultural campaign
Abandonment of certain crops such as cotton in favor of food and cash crops (soya, sesame).
Use of agricultural fertilizer (NPK fertilizer and manure) to improve soil fertility
Use of herbicides against weeds and insecticides against crop pests
Crop rotation for soil fertility management
Income-generating activities to cope with the high cost of living and declines in agricultural productivity
Use of short cycle seeds against the shortening of the rainy season

Increase in agricultural land to deal with low agricultural yields
Diversification of crops such as: soybeans, rice, yams, sesame, corn, sorghum, etc.
Youth investment in agribusiness: growing sesame and soybeans for sale
Exploitation of lowlands for market gardening and rice growing
Manufacture and trade of charcoal against monetary poverty
Trade
Breeding
Income Generating Activity
Exodus

Some strategies prove to be ineffective against certain shocks, in particular the exploitation of lowlands and the surroundings of watercourses for crops because of the richness of these soils. However, crop fields established on these soils are frequently victims of flooding. Also, the charcoal making activities encountered in all the localities of the study area, particularly in the Oti- kéran - Mandouri protected areas, contribute to the destruction of the vegetation cover. In addition, the use of herbicides are sources of degradation of plant cover, soil and water pollution and the destruction of soil fauna (earthworms and others, etc.). Moreover, after the harvest, it is market gardening activities that relieve the deficits of low harvest yields.

Illustration of some coping strategies

Photo1: Empty insecticide packaging at the edge of a sesame field

Photo 2: exploitation of the banks of watercourses for crops

Photo 3: onion cultivation near the backwaters of the Oti

Source: LAMBONI, August, 2022.

3.3.2 Livestock farmers' adaptation strategies to climate change

The coping strategies observed among breeders in the face of climate change are part of a logic that has existed for a long time in the study area and elsewhere. We can cite a bibliographic study by Boubacar Saïdou who put forward the notion of resilience to analyze the forms of adaptation of the Fulani to climate change in the Sahel (Saïdou, 2015, quoted by Bouju, 2016, p. 399-401). Other more recent studies in sub-Saharan Africa point in the same direction: we can cite Kabore et al. (2019) for Burkina Faso or Tidjani et al. (2016) for Niger, who showed how, historically, rural societies had to take into consideration the natural risks that prevailed in their territory. To respond immediately to problems, each breeder opts for management and operation that allows him to achieve his production objectives without departing from the characteristics of his traditional system. The table below summarizes the choices made by farmers to deal with the effects of climate change:

Table 6: Adaptation strategies of farmers

Use of veterinary care against poultry epidemics and livestock diseases
Construction of watering points for animals
Limitation of animal straying
Collection and storage of fodder in times of abundance for future use
Departure for transhumance for large breeders and grazing on the outskirts within a radius of 5km for small and medium breeders
Agriculture (grain farming) to cope with drought and food deficit
Storage of stubble transformed into bales for livestock feed
Diversification of activities
Sale of animals to avoid losses by disease
Exploitation of lowlands, source of green fodder
Exploitation of wetlands source of green fodder and water for watering

Illustration of some coping strategies of breeders

Photo 4: Animal watering well

Photo 5: exploitation of lowland fodder

Photo 6: exploitation of wetlands

Source: LAMBONI, August, 2022.

3.3.3 Fishermen's adaptation strategies to climate change

The shocks suffered by fishermen are, among others, the scarcity of fish, poverty, the silting up of riverbeds, the drying up of fishing water points (ponds, ponds, etc.), the pollution of water, disappearance of certain species of fish, erosion of the banks of waterways, etc. Strategies for adapting to climate change are based on seasonal subsistence agriculture (rice, maize, millet, sorghum, etc.), market gardening (onions, tomatoes, cabbage, etc.), trade. The adaptation strategies adopted by the fishermen are based on a capital of traditional knowledge, given the still rudimentary nature of this sector. The inventory of traditional knowledge available for the adaptation of fishers to climate change are:

- **Depositing bait in the water (nets, traps, etc.**): fishermen operate mainly in ponds, backwaters and the Oti River and its tributaries. These baits are used to attract fish.

Photo 7: fishing net

Photo 8: making traps in Poporkou

Photo 9: depositing nets as bait on the Oti River around Tchanaga**.**

Source: LAMBONI, September, 2022.

Depending on the climatic conditions, the weather may or may not be favorable for fishing. And fishermen generally use their traditional knowledge in case the climatic conditions are unfavorable to fishing.

- **The construction of micro-dams**

Fishermen build small dams in the water using branches, clods of earth or wood to prevent fish from moving away from their fishing area. Also during floods, shallower ravines and pits near watercourses fill up. During the floods the fish are trapped in these ravines and pits, a godsend for the fishermen who exploit them thoroughly.

- **Night fishing**

According to the opinion of a fisherman in Sadori, the night is one of the best times to fish because of the calm, because no noise will scare the fish away. In addition, it is during the night that we make big catches because the fish resume the course of their lives at this moment.

- **Decrease in collective fishing campaigns**

Once developed in the past, the decline in fishing yield has led to a decrease in the frequency of collective fishing.

- **Diversification of income sources**

Because of the decline in fishing yields and to cope with the high cost of living, fishermen have diversified their source of income, particularly agriculture (cultivation of cotton, sesame, soy; food crops such as corn, millet, sorghum,

cowpea), trade (marketing of charcoal, wood, small shops, etc.) which represent some of the income-generating activities.

IV. DISCUSSION

People's perception of climate change

With regard to climatic parameters, rainfall, temperature, wind and insolation were cited as the most determining climatic variables. This perception of producers, whether they are farmers, breeders, or fishermen, is explained by the fact that these four climatic variables have a direct influence on the three sectors of activity.

These factors determine the good or bad agricultural season for the farmers, the availability of water and fodder for the animals (breeders), and a good yield of fishing activity for the fishermen. Indeed, the following facts are at the origin of these perceptions: (i) the irregularity of the rains has as a consequence, among other things, the poor development of crops, the lack of water for domestic needs and for livestock (ii); the increase in temperature causes the burning of crops, the early drying of fishing areas, agricultural land and watering points for animals, high livestock mortality (iii); the increase in the frequency and intensity of the winds cause the erosion of agricultural land, the lodging of crops, the uprooting of trees, the uncovering of the roofs of houses and public works (schools, market sheds), etc.

The work of Adjonou, 2009; Badjana, 2010; Badabate et al. 2012 noted similar perceptions in a study on the agricultural exploitation of the banks of the Oti Plain as a strategy for adapting to climate change. This work has shown that the progressive drying of the land and its degradation linked to climatic variability (reduction in rainfall and increase in temperature) cause the agricultural front to progress towards the edges of waterways in search of moist and fertile land. This adaptation strategy has led to the destruction of the gallery forests of the Oti Plain. Moreover, the results of our study are more or less consistent with those of Guibert et al. (2010) cited by Bambara et al. (2013) on peasant perceptions in responses to a survey conducted in the cotton-growing area of northern Benin.

The work of Ouédraogo et al. (2010), relating to a study on the perceptions and strategies of adaptation to changes in rainfall conducted in the Sahelian, Sudano-Sahelian, and Sudanian zones of Burkina Faso, noted indicators such as the drop in rainfall, the disruption of the season, erratic rainfall, pockets of drought, heavy rains and floods. Our results compared to those of Ouédraogo et al. (2010) point in the same direction.

Vulnerability of populations bordering the wetlands of the Oti Plain to climate change

The study of vulnerability to climate change, generally and particularly in Togo, cannot be dissociated from the effects linked to variability and climate change from those linked to anthropogenic factors. In fact, over the last few decades, extreme climatic phenomena (drought, decline in soil fertility, increase in animal diseases, floods, pockets of drought, violent winds, rise in temperature) have become more and more frequent with increasing intensity. increasing and therefore constitute real catalysts for the degradation of the biophysical environment (Belem et al. 2007, Vissoh et al., 2012). Several local concepts, adages and proverbs are used by rural communities to account for these observed shocks. The peasant world, in particular farmers, has a close link with its environment and its dependence on the climate (FAO, 2007). Recent Afrobarometer data (Afi and Ekoutiamé, 2019), show that Togolese believe that climatic conditions, with regard to agricultural production, especially drought, have deteriorated over the past ten years. This thought is more advanced among farmers in the Savannah region, the region where climate change is most severe.

With regard to the shocks of climate change, the work of Belem and Sanon (2006) carried out in the central plateau of Burkina Faso, identified famine and drought as the shocks having the greatest impact. In terms of severity, lack of plant species, drought, and famine represent the most severe shocks. In the southwestern area of Burkina Faso, Ouattara et *al* (2006) found that insufficient rainfall had the highest incidence. As for severity, these same authors identified poor seed quality and wandering animals as the most severe shocks. We also noted in our study, similar shocks which make vulnerable the populations and the various sectors of activity (agriculture, breeding and fishing). Indeed, through this study we have observed that climate change has a negative impact on vulnerable sectors (agriculture, livestock and fishing). So:

- at the agricultural level, the shocks with incidence and severity are poverty; the irregularity of the rains which affects the dates of the start of crops and, as a result, the shift in the agricultural seasons; the poverty of agricultural soils which leads to a drop in agricultural yields, the use of chemical fertilizers and the agricultural exploitation of the banks of watercourses; the existence of pockets of drought in the middle of the agricultural season which damage crops; invasiveness and weed resistance that encourage the use of chemical pesticides; the increase in temperature which explains the long dry seasons and the premature

drying up of water points; deforestation which leads to the degradation of plant cover, the erosion of biodiversity and soils, the degradation of gallery forests along watercourses; strong winds that destroy tall trees and homes.

- at the level of breeders, we noted shocks with high incidence and severity, degradation of pastures (decline in fodder species), poultry and livestock diseases, early drying up of water points, recurring conflicts with farmers;
- for fishermen, the shocks noted are the scarcity of fish, water pollution, the silting up of waterways, the disappearance of certain species of fish, the drying up of fishing areas.

This vulnerability is also felt differently at the gender level. For women, the shocks with the greatest incidence and severity are poverty, famine, difficult access to land, insufficient drinking water points, disease, and distance from health centres.

Even if our results do not allow us to conclude on the effects of climate change, it is clear that these various shocks negatively affect the populations, mostly rural, who see their living conditions deteriorate. And this vulnerability has increased lately due to covid, armed conflicts, terrorism affecting West African countries (Mali, Burkina-Faso, Niger, Benin, Togo, etc.).

To cope with these multifaceted shocks, the adaptive capacities developed by producers have been identified. The populations are disarmed in the face of water stress. For the other shocks, limited means are implemented and deserve to be improved by advisory support, better communication on the evolution of climatic parameters in rural areas, granting of credits to vulnerable groups, and awareness-raising on protections. natural ecosystems.

V. CONCLUSION

This study provided varied knowledge on the adaptive capacities developed by the populations bordering the wetlands of the Oti Plain and their vulnerabilities in the face of the adverse effects of climate change. The shocks suffered by the populations are, among other things, irregular rainfall, general poverty, poor agricultural soils, pockets of drought, declining agricultural yields, disease, and deforestation. Faced with the incidence and severity of these shocks, populations have had to develop multifaceted adaptation strategies that vary according to the production sectors. In addition, it also emerges from this study, on the one hand, that the most vulnerable production sector is the agricultural sector dependent on climatic parameters and, on the other hand, that the most vulnerable group among the rural poor is the group of women. In view of these results, future investigations should make it possible to deepen the understanding of climate change in all vulnerable sectors. This information will be used to better establish climate change adaptation strategies, particularly in vulnerable areas.

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Goat Farming for the Economic Upliftment of Resource Poor Farmers of Maharashtra

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Abstract— *Survey of farmer was done to record the farmer's profile, livestock production system, socio - economic condition in pre constructed preforms for the selection of farmers. Survey revealed that average annual income of farmers at the beginning of intervention at Traimbakeshwar and Ambegaon taluka was Rs. 25,270/- and Rs. 26,530/-respectively. So, based on survey, 14 SC and 20 ST, altogether 34 resource poor farmers were selected randomly. Necessary training was imparted to the farmers on goat farming. Farmers were given one unit of adult Osmanabadi goat i.e. one male and four female goats, 200 kg pelleted goat feed, 2 kg mineral mixture, feeder, waterer and turpolin sheet. Goats were maintained in semi intensive system of management. Farmers renovated the existing goat shed with low cost locally available materials. Farmers were feeding maize, marvel grass, guinea grass, hybrid napier etc. as green fodder. Supplied pelleted feed was also provided @ 100 g twice daily to each goat. Routine deworming and vaccination was done. Animals were monitored regularly. The data on performance, mortality, disposal of goats were collected. Average weight of male and female adult Osmanabadi goats was recorded to be 23.470 ± 0.872 kg and 25.216 ± 0.691 kg respectively. Average birth weight was recorded to be 2.580 ± 0.234 kg. Average daily gain of kids was recorded to be 108.45 ± 10.21 g / day. So, far 48 kids were born from 27 kiddings and average kidding per cent was triplet 7.41 %, twinning 62.96 % and single 29.63 %.*

Keywords— ***Goat farming, Economic Upliftment, Farmer, Maharashtra***

I. INTRODUCTION

In rural area livestock is basically considered as complementary enterprises and every household rear livestock, mainly to meet the demand of meat and as a cash crop to manage the household economy under small scale production system. Goats play an important role in the food and nutritional security of the rural poor especially in the rain fed regions where crop production is uncertain, and rearing large ruminants is restricted by acute scarcity of feed and fodder. Goat occupies a unique place among domestic livestock in India due to high population ie 148.88 m. As per 20th livestock census (1) population of goat in Maharashtra is 10.60 million, which is 7.12% of the national population. There are 37 recognized breeds of goat in India and in Maharashtra 4 recognized breeds of goat i.e. Osmanabadi, Sangamnari, Berari and Konkan Kanyal are prevalent. The Osmanabadi goat is native dual purpose breed of Marathwada region of Maharashtra, but the breed is reared, bred and well adapted throughout the Maharashtra state and it is popular for higher twinning percent (7).

The package of practices for goat production is low cost and handy technology, so it is suitable to the landless labourers, resource poor farmers for the adoption and self – employment. The small ruminants especially goat contribute to the livelihoods of millions of rural poor in most of the developing countries of the Asia and Africa, where ninety five percent of the world's goat population is concentrated. In a study it was found that the socio – economic status of the goat farmers mostly women farmers could be uplifted through goat husbandry (5). Similarly, in India about 70 % landless labours, marginal and small farmers are associated with goat farming for livelihood improvement (6). So, an effort was made for the study of performances of goat at farmer's field with their

participation to improve socio-economic condition of resource poor farmers of Maharashtra by way of adopting package of practices for goat farming.

II. MATERIALS AND METHODS

Benchmark survey of 65 ST farmers at Traimbakeshwar taluka, Nashik district and 40 SC farmers at Ambegaon taluka, Pune district, altogether 105 resource poor farmers was done to record the farmer's profile, livestock production system, experience of the farmer, socio - economic condition etc. in pre constructed proforma for the selection of farmers. Necessary training was imparted to the farmers on "Goat farming for livelihood improvement" before distributing the animals. After training of farmers field visit was arranged for buildup of confidence. Each and every farmer beneficiary was given one unit of adult Osmanabadi goat i.e. one male and four female goats, 200 kg pelleted goat feed, 2 kg mineral mixture, feeder, waterer, turpolin sheet etc. as roofing material of goat shed. On the day of distribution animals were checked for health condition, insured by insurance company, documents were verified and afterwards MOU was signed by the farmers for proper care and management of goats.

Goats were being maintained in semi intensive system of Management. Farmers renovated the existing goat shed with low cost locally available materials. Most of the sheds were of bamboo or wood or shed net or wire mesh with GI sheet or thatched roof and earthen or wooden floor. Goats were allowed for grazing 3 - 4 hrs. daily in fallow / forest land. Farmers were feeding maize, marvel grass, guinea grass, hybrid napier etc. as green fodder. Leaves of banyan, jackfrut, mango, jamun, acacia pod, weeds etc. were also provided by farmers. Supplied pelleted feed was also provided @ 100 g twice daily to each goat. After exhaustion of supplied feed they were informed about feed formula for preparing concentrate mash feed consisting of maize crust (purchased), rice bran / wheat bran, ground nut cake (purchased), cotton seed cake (purchased), mineral mixture and common salt.

Routine deworming by broad spectrum anthelmentics and vaccination against PPR and Enterotoxaemia were done to prevent morbidity and mortality. Mineral & vitamin mixture was provided for overcoming deficiency, improving health and production. In case of illness of goat, facilities for diagnosis, treatment and medicine was provided by local LDO mostly and ourselves during our visit. Diagnosis was done on the basis of history, clinical symptoms and PM findings in case death of animal. Follow up visit to farmer's goat unit was made at two months interval for interaction, recording data, checking health of goats, deworming, distributing mineral mixture for weak & debilitated goats and to solve the problems of farmers if any. Data on live weight, birth weight, milk yield, kidding %, mortality and disposal of goat were recorded as per standard procedure. We have supplied pan balance and graduated plastic container to the farmers for recording birth weight of kid and milk yield of doe. Live weight of adult goats and average daily gain of kids were recorded by us. Afterwards data were analysed statistically as per Snedechor and Cochran (8).

III. RESULTS

Survey of 105 resource poor farmers revealed that most of the farmers in Traimbakeshwar taluka were ST (100 %) and female (88 %) whereas most of the farmers in Ambegaon taluka were SC (100 %) and male (90 %). Average age of farmers in Traimbakeshwar and Ambegaon taluka was 37.1 and 49.1 years. Most of the farmers have secondary level education in both Traimbakeshwar (45 %) and Ambegaon taluka (50 %). Average family size in both the talukas was 6 and 4 respectively. Main profession of the farmers were agriculture in both the talukas ie Traimbakeshwar (96 %) & Ambegaon (60 %). Secondary profession of the farmers was daily wage in both the talukas ie Traimbakeshwar (58.34 %) & Ambegaon (30 %). Average land size of farmers in Traimbakeshwar and Ambegaon taluka was 2.34 and 1.10 acre. 30% farmers in Ambegaon taluka informed that theyhad no land. Hence, 45.46 % farmers of Ambegaon taluka reported that they do not produce any crop. Main crop cultivated was rice and main livestock reared in both the talukas were cattle. 24.14 % farmers in Traimbakeshwar taluka and 57.13 % farmers in Ambegaon taluka do not keep any livestock. Most of the farmers of both the talukas expressed interest about goat training, 49.95 % in Traimbakeshwar taluks and 40.28 % in Ambegaon taluka. Average annual income of farmers at the beginning of intervention at Traimbakeshwar and Ambegaon taluka was Rs 25,270/- and Rs 26,530/- respectively.

Based on survey, seven SC farmers at Valati & Thorandle villages, Ambegaon taluka, Pune on 7.1.21, five ST farmers at Zharwad village, Traimbakeshwar taluka, Nashik on 5.3.21, five ST farmers at Vinyaknagar village, Traimbakeshwar taluka of Nashik district on 25.8.21, seven SC farmers at Nagapur villages, Ambegaon taluka, Pune on 14.12.21 and ten ST farmers at Vinyaknagar village, Traimbakeshwar taluka of Nashik district on 30.3.22, so in total 34 resource poor farmers were selected randomly. Four trainings were conducted during this period physically at farmer's field. 398 farmers including 259 farm women were trained.

Average adult weight of male and female Osmanabadi goats was 23.470 ± 0.872 kg and 25.216 ± 0.691 kg respectively. So, far 48 kids were born from 27 kidding and average kidding per cent was triplet 7.41 %, twining 62.96 % and single 29.63 % respectively. Average birth weight of kid was recorded to be 2.580 ± 0.234 kg.

Average daily gain of kids was observed to be 108.45 ± 10.21 g / day. Average daily milk yield was found to be 475.60 ± 12.45 ml / day which was utilised for household consumption. So far 17 goats died during the reporting period due to PPR (6), pneumonia (5), enteritis (5) and abortion (1) with mortality rate of 7.80 %. So far six farmers sold ten goats and earned Rs. 58,500/-.

Fig-1 Deliberation of lecture by one resource person during training on 24.2.21

Fig-2:Input distribution programme

Fig-3:Farmer feeding maize fodder to her goats

Fig-4: Goats allowed for grazing in fallow land

Fig-5: Goats maintained in low cost shed

Table – 1: Monitoring of goat units, Advocacy Service & Interaction:-

Sl. No.	Year	Date of visit	Name of villages	Number of goat units visited	Amount of mineral mixture distributed	Amount of anthelmentics distributed	Number of farmers benefitted
1	2020-21	19.11.20	Zharwad	5	10 Kg	5 strips	8
2	2020-21	28.12.20	Valati, Thorandle	5	10 Kg	6 strips	9
3	2020-21	5.2.21	Vinyaknagar	10	24 Kg	9 strips	24
4	2020-21	23.2.21	Zharwad	5	10 Kg	5 strips	9
5	2021-22	10.8.21	Zharwad	10	17 Kg	8 strips	16
6	2021-22	11.8.21	Vinyaknagar	10	23 Kg	11 strips	26
7	2021-22	22.10.21	Valati, Thorandle	14	20 Kg	10 strips	18
8	2021-22	22.12.21	Vinyaknagar	15	30 Kg	13 strips	27
9	2021-22	9.3.22	Valati, Thorandle, Nagapur	14	30 Kg	15 strips	28
10	2021-22	31.3.22	Zharwad	10	24 kg	15 strips	20
	GT			98	198	97	185

The table indicated that the scientists visited farmer's field frequently even in Covid pandemic period, interacted with the farmers to solve the problems. They visited 98 goat units, distributed 198 kg mineral and vitamin mixture to the farmers for their weak, debilitated and pregnant goats. Even 97 strips of anthelmentics were distributed for deworming of goats.

IV. DISCUSSION

It was revealed from the survey that most of the farmers in Traimbakeshwar taluka were tribal women farmers in contrast to farmers in Ambegaon taluka who were SC and male mostly. Age wise it was observed that most of the farmers are younger in Traimbakeshwar taluka of Nashik district than the Ambegaon taluka of Pune district. Survey revealed that number of family members of the beneficiaries in Traimbakeshwar taluka was higher than that of farmers in Ambegaon taluka. It was observed that more land was available to the farmers at Traimbakeshwar taluka than that of Ambegaon taluka. Farmers in both the talukas were interested to undergo training on goat farming. It was also found that average annual income of farmers in Ambegaon taluka, Pune district (Rs 26,530/-) from all sources was slightly higher than that of farmers of Traimbakeshwar taluka, Nashik district (Rs 25,270/-) in Maharashtra.

Thirty four resource poor farmers consisting of 14 SC and 20 ST farmers were adopted for the study. The productive performance of goat in the farmer's field was that the average weight of female was higher than that of male. Twinning % was recorded to be very high ie 62.96 %. In contradiction to present findings it was reported (4) that triplet, twining and single per cent in Osmanabadi goat at Peint taluka of Nashik district were 4.85 %, 53.40 % and 41.75 % respectively. The twining percentage in Osmanabadi goat in Vidarbha region was reported to be 10.52 % ranging from 0 – 26.31 % (7) which was much lower than the present findings.

Similar to present study birth weight of Osmanabadi kids was reported to be 2.20 to 2.38 kg in different housing systems in Konkan region of Maharashtra (2). Similarly it was reported (3) that birth weight of Osmanabadi goat in RCC semi open housing was recorded to be 2.445 ± 0.084 kg in coastal climate in Konkan region of Goa.

In the present study growth was found to be lower. However, growth of Osmanabadi goat in semi open housing in semi intensive system of management in organized farm in coastal climate of Goa was higher (122. 86 ± 14.58 g / day) than the present findings (108.45 ± 10.21 g / day) in

farmer's field (3) . Average daily milk yield (475.60 ± 12.45 ml / day) in the present study was reported to be higher than that of earlier study in Osmanabadi goat at Peint taluka of Nashik district (4).

In respect of mortality of goat in the present findings (7.80 %) which was lower than that of earlier findings (11.62 %) in Osmanabadi goat in Peint taluka of Nashik district under optimum housing, feeding and management condition of contradiction (4). The lower mortality in the present study was due to better adaptability of goat. The lesser amount of income was due to short duration of 1 year 5 months after initiation of project. Earnings of at least 50 % farmers will be expected more than double in next year. Monitoring was done once in every month and through ten follow up visits 185 farmers were benefitted by way of advocacy service and getting different inputs for the improvement of health of goats.

V. CONCLUSION

So, performance of Osmanabadi goat was moderate to good under optimum housing, feeding and management condition of farmers with almost zero input by them. Even farmers earned a good amount of money through selling of goats which helped them for livelihood improvement. It is expected that around 60 % farmers will attain doubling of income in next year. So, goat farming plays an important role for enhancing income of rural socio economically backward resource poor farmers particularly women farmers of Maharashtra.

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Inventory of Arthropods on the Soil Surface in Chili Plant Ecosystems Cultivated by IPM

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Abstract— *Chili (Capsicum sp.) is a strategic commodity with high economic value in Indonesia. Pest control on chili plants generally uses synthetic chemical insecticides which can reduce the diversity of arthropods. Reduced diversity of food sources for natural enemies can increase pest populations. The objectives of this study were to determine the abundance and diversity of arthropods in the chili plant ecosystem with integrated pest management (IPM). The observation area was 6 acres. Sampling was carried out in August-October 2020 in Jagaraga Village, West Lombok District, Indonesia, on chili fields using the IPM technique, namely a combination of the use of pheromone and botanical insecticides and non-IPM cultivation techniques using chemical insecticides, and carried out using the Yellow Pan Trap and Pitfall Trap. Observations were conducted on the generative growth stages of the chili plants. Results indicated that 612 ground surface arthropods were recorded in chili plots using the IPM technique representing 41 species, 24 families and 10 orders. The order Collembola, which acts as a decomposer was the most abundant (42.81% of the total collected arthropods), followed by Hymenoptera (28.92%), and Diplopoda (12.25%). Analysis of functional groups showed that the species richness of arthropods in IPM plots was higher than that of non-IPM. On IPM plot, almost all functional groups were found, namely predators (18 species), decomposers (11 species), parasitoids (1), and pest of 11 species. The high number of predator species in IPM chili fields indicates the large number of niches available and the abundance of prey for predators to colonize. The order Hymenoptera is the most abundant predator group collected from the chili field with IPM system. The Shannon index value of arthropods on the IPM plot of 2,887 indicates that the chili ecosystem with IPM was a fairly stable habitat, the natural control mechanism was going well. Every agronomic action carried out should be able to preserve and increase the carrying capacity of the environment so that it can support the development of organisms for sustainable stability.*

Keywords— ***Chili plant, ecosystem, arthropods, diversity, IPM***

I. INTRODUCTION

Chili (*Capsicum* sp.) is one of the horticultural commodities which is included in Indonesia's three strategic commodities along with shallots [1]. Chili production for the West Nusa Tenggara region in 2019 has decreased, the total production of cayenne pepper in 2019 was 164.77 thousand tons, a decrease of 21.73% compared to 2018 which reached 210.53 thousand tons. The same thing happened to the production of large chilies, where total production was 17,679 thousand tons in 2019, down 26.33% compared to 2018 which reached 23,998 thousand tons [1].

Constraints to chili production are usually caused by weather factors that often change and attacks from plant pests and diseases. Pest attacks on chili plants cannot be avoided, which are generally quite high intensity, both in the vegetative and generative phases of chili plants. Important pests on chili plants include fruit flies, whitefly (*Planococcus citri*), aphids (*Myzus percisae*), armyworm (*Spodoptera litura*), and ground caterpillar (*Agrotis ipsilon*) [2]. The level of attack caused by these pests is often the cause of decreased chili production and it is necessary to control it to reduce the level of damage to prevent a decrease in chili production [3].

Pest attacks on chili plants cannot be avoided, both in the vegetative and generative phases. Pest attacks on chili plants are quite high. Important pests on chili plants include fruit flies, whitefly (*Planococcus citri*), aphids (*Myzus percisae*), armyworm (*Spodoptera litura*), ground caterpillar (*Agrotis ipsilon*) [2]. The level of attack caused by these pests is often the cause of decreased chili production and it is necessary to control it to reduce the level of damage and be able to prevent a decrease in chili production [3].

The excessive use of insecticides to control pest populations has a direct detrimental impact on the biodiversity of insects and other arthropods, causing resurgence and does not rule out the possibility that other insects that have important ecological functions such as pollinating insects will also die, especially the use of broad-spectrum insecticides [4]. Currently, the application of chemical pesticides is still mostly carried out by farmers by spraying and spreading which allows most of the pesticide deposits or residues to fall on the soil surface [5].

Arthtropoda is the largest phylum of animalia in the ecosystem, which is characterized by its segmented body, encased in chitin, bilaterally symmetrical, with joints on the limbs and other body parts [6]. Its existence can be found anywhere. Insects, spiders, ticks, centipedes and collembolans are included in the Arthropoda group. In ecosystems, arthropods can act as pests, predators, decomposers, pollinators, parasitoids, and parasites [7]. Based on the sub phylum Arthropoda is divided into 3 namely Trilobites, Mandibulata and Chelicerata. The class Insecta (Hexapoda) belongs to the sub-phylum Mnadibulata which is further divided into sub-classes Apterygota and Pterygota. The distribution of orders and families in Arthropods that are commonly found in the field is as follows: Order Lepidoptera (77 families), Order Coleoptera (124 families), Order Orthoptera (16 families), Order Ispottera (4 families), Order Homoptera (32 families), Order Hemiptera (38 families), Order Collembola (5 families), Order Diptera (104 families), Order Hymenoptera (71 families), Order Demaptera (4 families) and Order Thysanoptera (5 families) [8].

The main groups of soil and litter arthropods include Acarina, Collembola, Myriapoda as well as various other Insecta class orders which have an important role in terrestrial ecosystems, including playing an active role in the decomposition of organic matter, nutrient cycling, agricultural productivity, plant growth and improving physical, chemical and environmental conditions. soil biology [9].

The role of arthropods in ecosystems is divided based on their trophic level, namely herbivorous arthropods, carnivorous arthropods and decomposer arthropods. Herbivore arthropods fall into the category of pests because they cause damage to plants by eating all parts of the plant. Carnivorous arthropods are natural enemies of arthropods, including predators and parasitoids that prey on or weaken other organisms. Then decomposer arthropods are a group of decomposer arthropods that help microorganisms break down litter or the remains of dead plants and animals, then the decomposition results are very useful because they can increase fertility [10, 11].

The presence of several types of ground surface arthropods is often used as a parameter of soil quality, whether polluted or not, whether the pH is acidic or neutral and whether the mineral content such as C-organic in the land is high or low and also the presence of ground surface arthropods is used as a bioindicator of environmental quality and land fertility. In addition, the interaction between ground surface arthropods and abiotic factors results in a continuous exchange of substances and energy so that the ecosystem on the land becomes stable. In accordance with the statement [12] that the activities of the surface fauna that sometimes enter the soil affect the number of soil pores that are formed.

The application of IPM in cultivation is not only an effort to increase crop productivity but also directly affects the presence of arthropods, especially ground-level arthropods. Many biological agents are found in soil such as spiders, ants or groups of microorganisms such as fungi and bacteria. In an agro-ecosystem, the presence of pests will attract predators to come and live in that place, followed by an increase in the predator's ability to prey. Different pests allow the availability of various natural enemies in an ecosystem [7]. In addition, the abundance and diversity of soil arthropods can be used as indicators in assessing the state of an ecosystem, such as whether or not the land is fertile. Fertile soil where there are lots of organic matter, chemical components and soil minerals that are optimum will be favored by soil insects or soil arthropods [13].

Diversity is an indicator in measuring community stability (the ability of a community to maintain itself stable despite disturbances to its components) [14]. High diversity indicates that a community has high complexity because the community also has high species interactions. High diversity of organisms in an ecosystem, longer food chains and also more symbioses that produce positive feedback that can reduce disturbances in the ecosystem so as to create a balanced ecosystem. Not much is known about the existence of ground-level arthropods, especially those found in chili fields in the Lombok area, so this research was conducted to obtain information related to the diversity of ground-level arthropods in chili fields in the area and to complete information about their ecological

role with the aim of knowing the diversity ground-level arthropods in chili plant ecosystems, especially in chili fields that apply the IPM concept.

II. MATERIALS AND METHODS

The research was carried out on 600 m2 of farmer's chili planting land in Jagaraga Village, Kediri District, West Lombok Regency, West Nusa Tenggara from August - October 2020. The research was conducted on chili plants that were 40 HST old or had entered the generative phase. divided into two plots, namely the first plot planted and maintained with the IPM concept and the second plot in plants and maintained by farmers. The research implementation began with land observation and plotting areas, setting traps, sampling and identification of ground-level arthropods in the laboratory.

2.1. IPM treatment

In the IPM nursery plots the seeds were planted in polybags with a size of 4x6 cm filled and sown with a mixture of soil, manure with a ratio of 2:1 with the addition of 80 g NPK + 75 g carbofuran one planting medium containing 1 chili seed. Tillage in the IPM plots was carried out once before planting the seeds by means of a tractor and hoeing to a depth of 30-40 cm with the aim of clearing the remaining weeds and maximizing soil loosening. Then given basic fertilizer in the form of a mixture of manure as much as 20-30 tons/Ha, 500 g Urea/ZA, 300 g SP-36, 200 g KCl, sprinkle every one meter with 100g of fertilizer mixture. The beds were made in both IPM and non-IPM plots with a length of 500 cm, a width of 110 cm, a height of 30-40 cm and the distance between one bed and another was 60 cm.

In the IPM plots, the chili seeds used were chili seeds that were 21 days old. Planting is done the day after the bed is watered and the planting hole is formed and planting is done in the afternoon. Maintenance of chili plants includes replanting, watering, fertilizing and controlling pests and diseases. Stitching was done in the morning or evening and is done in the first and second week after planting. Irrigation is carried out using a lab system and is carried out every two weeks with the aim that the roots of the chili plants get sufficient water intake. When it comes to the rainy season, irrigation is done once a week during the rainy season. Control with the IPM technique is a combination of the use of pheromone, furadan insecticides only given during the vegetative phase. Clove extract botanical insecticides are given when entering the fertilization phase.

2.2. Non-IPM treatment

Seedlings are carried out by sowing the chili seeds on the irrigated beds and then covering them with banana leaves or straw, after seven days they are transferred to polybags. The process of transplanting is carried out when the seedlings are 21 days old. Tillage is carried out by tractor once before planting the seeds, hoeing as deep as 30-40 cm to clear the remaining weeds and maximize soil loosening. Loose soil is given basic fertilizer in the form of SP-36 300. The chili seeds used are chili seeds that are 21 days old. Planting is done the day after the bed is watered and the planting hole is formed and planting is done in the afternoon. Stitching and embroidering were done when needed; watering was done every two weeks to once a month depending on the weather.

Control of pests and diseases in non-IPM plots was carried out using the chemical insecticides chlorantraniliprole, chlorpyrifos and cypermethrin, application by mixing the three types of insecticides every week starting when the plants were 15 days old until just before harvest.

2.3. Trap installation

The installation of pitfall traps was carried out by digging the soil in the chili plant beds to form a hole with a depth of ± 10 cm. The holes were made at five points in both IPM and non-IPM plots. Traps were set at the five predetermined points on the IPM plots and farmer plots. Each pitfall trap is filled with ± 100 ml of detergent solution with the aim of making it difficult for the trapped arthropods to rise to the surface. Traps are set every five days.

2.4. Sampling

Samples were collected from pitfall traps that had been installed for 1x24 hours, samples were isolated from pitfall traps using a filter and spraying water on a filter containing arthropods to remove dirt carried, after which samples were taken using a brush carefully on the filter and put into a collection bottle which contains 70% alcohol. Sampling was carried out 10 times during the generative phase. Parameters observed in this study included: The total number of ground surface arthropods trapped, Number of ground surface arthropod species per ecological function, Diversity and abundance of ground surface arthropods at the study site. The data resulting from the identification of arthropods was tabulated into a database in Excel format to obtain the number of species, number of families, orders, and abundance of collected arthropods.

2.5. Data and analysis

Data included Shannon-Wiener index and Relative Abundance index, which were calculated as follows.

Shannon-Wiener (H') = - Σ pi.ln pi [15];

in which H' = Shannon-Wiener diversity index; pi = s/N; s = number of individuals of one species; N = total number of individuals; ln = logarithm of all individual totals.

The diversity index criteria (H') used were: H' value ≤ 1 = low diversity; Value of H' 1 < H' ≤ 3 = Moderate diversity; H' value ≥ 3 = high diversity.

Relative Abundance Index (Kr) = Ki/ΣK x 100%;

in which Kr = relative abundance of species i; Ki = Abundance for species i; ΣK = Total abundance of all species

III. RESULTS AND DISCUSSION

3.1. Collected Surface Arthropods

There were 1,231 individuals representing 42 species belonging to 23 families and 10 orders recorded in this study. Based on the identification results in the IPM plots, 612 individual arthropods were included in 10 arthropod orders including the Coleoptera Order, the Hymenoptera Order, the Aranae Order, the Collembola Order, the Diptera Order, the Hemiptera Order, the Orthoptera Order, the Dermaptera Order, the Diplopoda Order and the Spirobilida Order, 23 families and 42 ground-level arthropod species. In non-IPM plots (farmer method) there were 619 individuals representing 21 species, 13 families and 8 orders. The number of arthropod orders found in this study is relatively more than that of the research conducted by Latoantja et al. [16] in Palu, where 6 orders representing 11 families and 111 individual ground-level arthropods were found in chili cultivation. Arsi et al. [17] reported 8 orders of ground-level arthropods with a total of 546 individual arthropods found in cayenne pepper fields and 9 orders with a total of 599 individuals in cayenne pepper plants in Aceh. The number of species and the number of families of ground-level arthropods on chili IPM land was twice as high as the number of species and families on non-IPM land. Between the two there was no significant difference in the diversity of arthropods (H = 2.89 in IPM and H = 2.560), but the index of diversity in IPM land was slightly higher than in non-IPM land.

The Order group with the highest abundance and the most species is Collembola. The existence of Collembolla is needed in the ecosystem because of its role as a decomposer. The existence of Collembola is closely related to soil properties. Rice straw used as mulch is a macromolecule containing lignin and cellulose which has long and stiff fiber components that attract Collembola to carry out decomposition activities into elements which are returned to the soil [18].

Furthermore, the second highest number of individuals was from the Hymenoptera order, which in this study were found to all act as predators. The number of species and individuals of hymenoptera is more found in IPM land. The Hymenoptera order has a habit of colonizing, the use of pitfall traps as traps is entered by many ants that walk on the ground and can live in various places. *Paratrechina longicornis* was the most abundant species in both IPM and non-IPM plots, but the population was much more numerous in IPM land.

3.2. Arthropod Composition and Abundance According to Taxonomy

Based on the results of observations, it was found that the composition of the ground surface arthropods in the IPM plots was more diverse. Arthropods found on IPM land were 42 species from 23 families, while in non-IPM plots (farmer's method) ground surface arthropods were found only 21 species from 13 families. Data on the composition and abundance of ground-level arthropods according to their taxonomy is presented in Table 2.

The composition of the aboveground arthropods in the IPM plot consisted of 23 families with a total of 612 individuals, while in the non-IPM plot there were 13 families with a total of 619 individuals. The highest abundance in the IPM plot was the Collembola Order where the number of families found was 4 families and 9 species or species with a population of 262 individuals and an abundance of 42.81%. In non-IPM plots, collembola abundance reached 49.11% from 2 families and 6 species. According to Amir [19], the distribution of Collembola is very wide, it can be found in various habitats such as arctic, desert, sub-tropical and tropical. The distribution of Collembola can occur with the help of soil particles and organic matter, wind and water.

Table 1. Collected ground surface arthropods in IPM plots and non-IPM plots

No	Order	Family	Species	IPM	Non-IPM	Ecological Role
1	Coleoptera	Tenebrionidae	*Gonocephalum depressum*	29	26	hama

2			*Gonocephalumpygmeum*	6	-	hama
3			*Alphitobius diaperinus*	10	9	hama dan vektor
4		Carabidae	*Brachinus* sp.	1	-	predator
5			*Carabus* sp.	1	-	predator
6		Cicindelidae	*Calomera angulata*	1	-	predator
7		Chrysomelidae	*Epitrix* sp.	1	-	hama
8		Hydropilidae	*Hydrophilus toiangularis*	2	-	dekomposer
9	Hymenoptera	Formicidae	*Prenolepis* sp.	2	44	predator
10			*Diacamma* sp.	4	-	predator
11			*Nylanderia fulva*	30	36	predator
12			*Paratrechina longicornis*	119	78	predator
13			*Camponotus consobrinus*	2	-	predator
14			*Monomorium pharaonis*	21	-	predator
15			*Componotus* sp.	6	-	predator
16			*Solenopsis* sp	2	-	predator
17	Orthoptera	Gryllidae	*Taleogryllus* sp.	1	-	predator
18			*metioche vittaticollis*	-	2	predator
19		Acrididae	*Calliptamus* sp.	3	3	hama
20			*Trimerotropis thalassica*	1	-	Hama
21		Blattidae	*Shelfordella lateralis*	2	-	dekomposer
22		Pyrgomorphidae	*Pyrgomorpha conica*	2	-	hama
23	Hemiptera	Alydidae	*Leptocorisa* sp.	1	1	Hama
24		Pentatomidae	*Nezara viridula*	-	1	Hama
25	Dermaptera	Anisolabididae	*Euborellia arcanum*	1	-	predator
26	Diptera	Drosophilidae	*Drosophila tetrachaeta*	2	4	hama
27			*Colocasiomyia* sp	1	-	hama
28		Dolichopododae	*Dolichopus* sp.	3	-	parasitoid
29	Diplopoda	Paradoxosomatidae	*Oxidusgracilis* sp.	75	76	hama
30	Dpirirobilida	Trigoniulidae	*Trigoniulus corallinus*	6	-	predator & detrivor
31	Araneae	Oxyopidae	*Oxyopes* sp.	3	1	Predator
32		Lycosidae	*Pardosa pseudoannulata*	12	13	predator
33			*Lycosa pseudoannulata*	7	20	predator
34		Zodariidae	*Mallinella* sp.	2	1	predator
35	Collembola	Oncopoduridae	*Oncopodura* sp	30	-	dekomposer
36		Isotomidae	*Folsomia candida*	17	-	dekomposer
37		Entomobryidae	*Entomobrya multifasciata*	35	56	dekomposer
38			*Dicrarocentrus bicolor*	12	34	dekomposer
39			*Acrocyrtus* sp	61	93	dekomposer
40		Neanuridae	*Neanura muscorum*	13	62	dekomposer
41			*Bilobella braunerae*	29	-	dekomposer

42	*Anurida maratima*	30	33	dekomposer
43	*Sensillanura barberi*	35	26	dekomposer
Total		**612**	**619**	

Table 2. Composition and abundance of ground surface arthropods in IPM and non-IPM plots

Order	IPM land				Non-IPM land			
	Family number	Species number	Population	Abundance (%)	Family number	Species number	Population	Abundance (%)
Coleoptera	5	8	51	8.33	1	2	35	5.65
Diplopoda	1	1	75	12.25	1	1	76	12.28
Hymenoptera	1	8	177	28.92	1	3	158	25.52
Diptera	2	3	6	0.98	1	1	4	0.65
Orthoptera	4	6	9	1.47	2	2	5	0.82
Hemiptera	1	1	1	0.16	2	2	2	0.32
Dermaptera	1	1	1	0.16	-	-	-	0
Collembola	4	9	262	42.81	2	6	304	49.11
Aranae	3	4	24	3.92	3	4	35	5.65
Spirilobilida	1	1	6	0.98	-	-	-	0
10 ordo	23	42	612	100	13	21	619	100

3.3. Soil Surface Arthropod Composition According to Ecological Function

In the IPM plots, ground surface arthropods were found which had more diverse ecological functions, namely as pests, predators, parasitoids, decomposers, vectors and detritivors with the following composition: 129 pests, 212 predators, 265 decomposers, 6 parasitoids, 1 vector and 6 individuals playing a role as a detritivor. Based on their function, the decomposer group is the largest group found in IPM land consisting of 9 species of Collembola, 1 species of Coleoptera and 1 species of Orthoptera. Predators are the second largest group consisting of Coleoptera, Hymenoptera, Aranae, Orthoptera, Dermaptera and Spirirobilida. The majority of arthropod species caught on non-IPM land are Collembola Hymenoptera which is the second largest dominant order, next Diplopoda followed by Coleoptera (Table 3).

Table 3. Composition of ground surface arthropods in IPM plots according to ecological function

Order	Hama	Preda-tor	Dekom-poser	Para-sitoid	Vektor	Detri-tivor
Coleoptera	46	3	2	-	1	-
Diplopoda	76	-	-	-	-	-
Hymenoptera	-	177	-	-	-	-
Diptera	3	-	-	3	-	-
Aranae	-	24	-	-	-	-
Orthoptera	3	1	1	-	-	-
Collembola	-	-	262	-	-	-
Dermaptera	-	1	-	-	-	-
Hemiptera	1	-	-	-	-	-
Spirirobilida	-	6	-	-	-	6
Total	129	212	265	3	1	6

The results of the abundance analysis showed that the most common predators and parasitoids were found in the IPM plots. *Paratrechina longicornis* was the most abundant predator found in 119 individuals, followed by Perdosa pseudoannulata with 12 individuals and *Trigoniulus corallinus* with 6 individuals. The most common parasitoid in the IPM plots was *Dolichopus* sp. as many as 3 individuals.

Based on its function, the detrivore group is the largest group found in non-IPM land which only comes from the Order Collembola with 6 species. The second largest group is predators from the order Hymenoptera 3 species, Aranae 4 species, and Othoptera 1 species. The results showed that in the non-IPM plots of arthropods that acted as pests, there were 120 individuals, 195 predators, 304 decomposers, and 9 vectors. No ground surface arthropods were found that acted as detriphores. There were no parasitoids in the non-IPM plots, but 78 individuals of *Paratrechina longicornis* predators and 20 individuals of *Lycosa pseudoanulata* (Table 4).

Table 4. Composition of ground surface arthropods according to the ecological function of the Non IPM plots

Order	Pest	Predator	Decomposer	Vektor
Coleoptera	35	-	-	9
Hymenoptera	-	158	-	-
Collembola	-	-	304	-
Araneae	-	35	-	-
Diplopoda	76	-	-	-
Orthoptera	3	2	-	-
Hemiptera	2	-	-	-
Diptera	4	-	-	-
Total	120	195	304	9

The population of ground-level arthropods that act as natural enemies is lower in non-IPM land compared to IPM land. This is due to the use of chemical insecticides on non-IPM land which affects the presence of less natural enemies.

Paratrechina longicornis is a predator found in abundance in IPM land with 119 individuals having an abundance value of 19.44 percent followed by *Pardosa pseudoannulata* with 12 individuals with an abundance of 1.96 percent and *Trigoniulus corallinus* with 6 individuals with an abundance of 0.98 percent.

The parasitoid found most in the IPM plots was Dolichopus sp. as many as 3 individuals, while in the non-IPM plot no parasitoids were found, only 78 individuals of Paratrechina longicornis predators and 78 individuals of Lycosa pseudoanulata were found. Putra and Utami [20] found the same thing in a study on chili plants in Bantul, Yogyakarta, where the most common natural enemy species was *Paratrechina longicornis*. *Paratrechina longicornis* has the ability to survive in very dry and rather humid areas, consuming both live and dead insects (Bolton, 1971 cited in [21]). The parasitoid group found was the species Dolichopus sp. which amounted to 3 individuals with a relative abundance of 0.49%. According to Brooks [22] most of the genus Dolichopus is found in agricultural fields, meadows, under bark, in tree hollow debris and in plant tissues. Dolichopus sp. become natural enemies for plant seed fly pests such as Hydrelia sp. which attacks rice and *Ophiomyia phaseoli* pests of bean seedlings.

In the non-IPM plots (farmer method) only predators were found, namely *Paratrechina longicornis* as many as 78 individuals with a relative abundance of 12.60% and *Lycosa pseudoannulata* as many as 20 individuals with a relative abundance of 3.23%. No parasitoids were found in the non-IPM plots (farmer method), making *Paratrechina longicornis* the dominant natural enemy in this area.

3.4. Ratio of Natural Enemies and Pests

To understand the ecological condition of a land, it can be done by looking at the dynamics of the role composition of the individuals collected at each observation time. Observations showed that the number of pests was higher than the number of natural enemies in both experimental fields. However, at the beginning of the observation (40 days after planting) it showed that the abundance of pests was higher than the abundance of natural enemies, as indicated by the ratio of natural enemies: pests on IPM land 1:5.2 and 1:4 on non-IPM land then the population of natural enemies increased very sharply (more than 100% of the population at the beginning of the observation) in IPM fields, as well as in non-IPM chili fields. The ratio of populations of natural enemies and pests on chili plants by HDI at 45 dap, 50 dap, 55 dap respectively was 1:0.34; 1:0.35 and 1:0.45 while on non-IPM land the ratio of natural enemy populations to pests at 45 dap, 50 dap and 55 dap was 1:0.45 ; 1:0,56 and 1:1. This shows that natural enemies are able to find prey quickly so that they can balance the pest population. Allegedly because natural enemies, especially existing predators, are generalist predators, especially spiders Pardosa and Lycosa which do not depend on their main prey, but can take advantage of existing alternative prey. Herlinda [23] stated that spiders can also eat reshuffling insects if there is no main prey.

Comparison of populations of natural enemies and pests and IPM during observations appears to be more stable where natural enemy populations are almost always higher than pest populations. This indicates an increase in pest populations followed by an increase in natural enemy populations. According to Wackers et al. [24], an increase in natural enemies is also determined by the availability of food sources, because with an increase in plant diversity there is also an increase in feed sources in the form of pollen, nectar, extra-floral nectar, and honey dew. Around the chili land with IPM, there were corn and peanut plants, so it can be said that the intercropping technique is one of the techniques that can be used in integrated pest management (IPM) activities which is one way of conserving natural enemies.

The use of synthetic chemical insecticides on a regular basis on non-IPM land results in a decrease in the abundance of pests and natural enemies, but the abundance of pests increases faster than natural enemies. This can be seen when the plants were 55, 60 and 65 days after planting, the rations of natural enemies to pests were 1:1; 1:2.55 and 1:2.56.

3.5. Index of Diversity and Abundance of Ground Arthropods

The diversity index of surface arthropods in the HDI plot was 2.887, while the index value of surface arthropod diversity in the non-IPM plot (farmer method) was 2.559. This means that the diversity of ground-level arthropods is in the moderate category. According to Chalid [25], moderate diversity is defined as the distribution of moderate numbers of individuals, not low and not high and the waters and soil are slightly polluted. The research location is land that is often cultivated and planted every year so that agricultural activities such as tillage, fertilizing and applying pesticides make the ecosystem on the land quite stable but there is little pollution. Changes in land use cause changes in the living space of an organism, the microclimate in ecosystem areas, and competition between residents of related ecosystems.

The most abundant ground-level arthropods in the IPM chili field were the formicidae family, the *Paratrechina longicornis* species, which had the highest abundance value of 19.44%. *Paratrechina longicornis* is an ant species that has a very wide distribution, its habitat is everywhere and is very tolerant of extreme environments and belongs to the generalist predators. The research location is a cultivation center area and is very close to residential areas so that these ants can live and find food anywhere and in the ecosystem most of them act as predators, the rest are vectors that cause disease. In line with Haneda and Yuniar's statement [26], that the Formicidae family is a group of arthropods that are commonly found and have a wide distribution, they have diverse eating habits.

The highest abundance of ground-level arthropods on non-IPM land was collembola, the Entomobryidae family, namely Acrocyrtus sp. with an abundance of 15.02% Acrocyrtus sp. usually found in places that have high humidity, under litter that starts to rot and mold. According to Ramel et al. [27], the collembola family Entomobryidae has behavior as a eater of fungi, lichen, bacteria, pollen of certain plants and as a decomposer of organic litter. Applying straw to the soil surface in the IPM and non-IPM plots is believed to increase soil organic matter in the land. It is known that straw contains organic matter which is a source of energy for the soil biological community and a source of plant nutrients. One of the soil fauna on the surface of the soil that utilizes organic matter as an energy source is the collembola, so that in the IPM and non-IPM plots there is an abundance of collembola. This is also in line with the statement of Suhardjono et al. [28] that one of the factors that influence the presence of collembola is the presence of decaying plant materials and the presence of litter because when active, collembola utilizes organic matter as a source of energy.

IV. CONCLUSION

The ground-surface arthropods in the IPM plot consisted of 10 orders, 24 families, 42 species and 612 individuals, more diverse than the ground-surface arthropods in the non-IPM plot which consisted of 8 orders, 13 families, 21 species and 619 individuals. The diversity index of ground surface arthropods in IPM land was moderate, with H'= 2,887 higher than the non-IPM plot H'= 2,559. The ground surface arthropods found in the IPM plots that acted as pests were 129 individuals, 212 individual predators, 265 individual decomposers, 3 individual parasitoids, 1 individual vector and 6 individual detritivores. While the ground surface arthropods found in the non-IPM plots (farmer's method) that acted as pests were 120 individuals, 195 individuals as predators, 304 individuals as decomposers and 9 individuals as vectors. *Paratrechina longicornis* which acts as a predator was found to be abundant with a K value = 19.44% in the IPM plots, whereas in the non IPM plots Acrocyrtus sp. which acts as a decomposer was found abundant with a value of K = 15.02%.

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Impact of Growing Media and Nutrition on Growth and Yield of Broccoli Microgreens (*Brassica oleracea*)

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Abstract *—Microgreens are a new class of vegetables that are harvested within 7-21 days after sowing, have a lot of nutritional potential and are a new trend in the food industry. One type of microgreens that is grown commercially is broccoli. The nutrients in broccoli microgreens are 4-6 times more than mature plants, contain good vitamin C, and contain antioxidants that can help protect the body from the harmful effects of free radicals. Cultivating microgreens requires the right planting medium and nutrients to support plant growth. The research objective was to obtain the interaction between the types of growing media and the nutrients used to increase the growth and yield of broccoli microgreens. This research was carried out from October to November 2022 at the Greenhouse of the Faculty of Agriculture, Andalas University. The study* was a two-factorial experiment in a completely randomized design (CRD) *with 3 replications. The first factor is several types of planting media, namely soil, cocopeat, and rock wool. The second factor consisted of several types of nutrition, namely AB mix and young coconut water. Observational data were analyzed using statistical analysis of variance test F. If F Count treatment is greater than F Table 5% then it will be continued with the DNMRT test at 5% level. The results showed that there was an interaction between the type of growing media and the nutrition given to the growth of broccoli microgreens. The use of rock wool growing media and AB mix nutrition gave the best response for the observed parameters of seedling height, number of leaves, fresh weight, and chlorophyll content. The results of the antioxidant analysis carried out when harvesting broccoli microgreens gave a red color change when given HCl, whereas if NaOH was added drop by drop there was no blue color change. So it can be concluded that broccoli microgreens contain betacyanin.*

Keywords *—**Microgreens, Broccoli, Cocopeat, Rockwool, Nutrition.***

I. INTRODUCTION

Microgreens are vegetables that are harvested at a young age, harvesting is done when the cotyledon leaves and a pair of young leaves have appeared. Microgreens are a new class of vegetables that are harvested within 7-21 days after sowing, have a lot of nutritional potential and are a new trend in the food industry (Kyriacou et al., 2016). Nutrients in microgreens are 4-6 times more than mature plants, contain good vitamin C, and contain antioxidants that can help protect the body from the harmful effects of free radicals (Xiao et al., 2012).

There are many types of microgreens that aregrown commercially around the world, one of which is broccoli. The product from the broccoli plant that we know so far and is often sold in the market isonly the end product in the form of broccoli vegetables. The length of time it takes to harvest broccoli encourages farmers to carry out various innovations, one of the innovations made is by planting broccoli microgreens (Widiwurjani, 2019).

According to Sriwahyuni (2021), topsoil-growing media can be used in the cultivation of microgreens. However, the use of topsoil still has some drawbacks such as high organic matter content little and lack of availability of certain nutrients for plants, so certain nutrients are needed for plants to increase the availability of nutrients, one of which is organic matter. Several types of organic materials that can be used as planting media include

cocopeat and rockwool. Cocopeat is obtained from the extraction ofcoco fiber which has the advantage of being a plantingmedium, namely the ability to bind water (Pratiwi et al., 2017). Based on previous research (Ramadhan, 2018) the use of 25% and 50% cocopeat combined with soil as a planting medium is the best composition for the growth of ground merbau seedlings.

Besides that, rock wool planting media also has advantages that not many other planting media have, especially in terms of the ratio of the composition of water and air that can be stored by rockwool growing media. Additional nutrients are also needed to increase the production of broccoli microgreens. In meeting these needs, one alternative that can be done is to add AB Mix and young coconut water as nutrients for the growth of broccoli microgreens. AB Mix nutrients are nutrients that are commonly used in plant growth. The results of Hidayanti's research (2019), explained that the treatment of giving AB Mix nutrition had a significant effect on plant height, number of leaves, and fresh weight of red spinach.

The young coconut water given to the plants as a nutrient is expected to increase the growth and yield of broccoli microgreens. According to Amsar in Sari (2021), the hormones contained in coconut water are auxinns an cytokinins. Both of these hormones functon as plant growth stimulants, auxin can affect stem elongation and root branching. Meanwhile, cytokinins can influence growth and differentiation, encourge cell division and promote germination. Based on this, its is necessary to conduct research to further study the effects of Several Kinds of Growing Media and Different Nutrients in the Growth and Yield of Broccoli Microgreens (*Brassic oleracea*).

II. MATERIALS AND METHODS

This research was carried out in October 2022 which is located in the Greenhouse and Seed Technology Laboratory, Faculty of Agriculture, Andalas University. The materials used are broccoli seeds, water, soil, tissue, cocopeat, rockwool, AB Mix nutrition and young coconut water. Tools that used include plastic seedling trays, meters, digital scales, microscopes, calipers, color charts, scissors, sprayers, documentation tools, and stationery, millimeter blocks, chlorophyll meters.

The experiment was carried out using a completely randomized design with 2-factor factors and consisted of 3 replications. The first factor consisted of several types of planting media, namely soil, cocopeat, and rockwool. The second factor consisted of several types of nutrition, namely AB Mix and young coconut water. Observational data were analyzed using the analysis of variance F test. If F calculated treatment is greater than F table 5% then it will be continued with the DNMRT test at 5% level.

The implementation study started with a selection of broccoli microgreens seeds, preparation of planting media, planting, treatment, maintenance, observation, and harvesting. The parameters observed consisted of sprout height, number of leaves, fresh weight, chlorophyll content, and antioxidant content.

III. RESULTS AND DISCUSSION

3.1 Sprout Height

The results of variance showed that in the sprout height variable, there was an interaction between the planting medium and the nutrition given to the broccoli microgreens.

Table 1. Height of Broccoli Microgreens Sprouts at 21HST treated with different types of growing media and nutrients.

Growing Media (M)	Nutrition (N)	
	AB Mix	Coconut Water
---------- cm ----------		
Land	4,6133 a A	3,2033 b B
Cocopeat	3,1567 b A	3,0567 b A
Rockwool	4,7133 a A	3,7400 a B
KK = 7,34%		

Note: Numbers followed by different lowercase letters in the same column and numbers followed by different uppercase letters in the same row are significantly different according to DNMRT at a level of 5%.

Treatment of rockwool growing media and AB mix nutrients can increase the height growth of broccoli microgreens sprouts, this is because the nutrients from AB Mix received by plants contain macro elements Nitrogen (N) and Phosphate (P), microelements Boron (B) and Zinc Zn) which can help plant growth. Zhang et al. (2020) explained that the hypocotyl is one of the main parts of sprouts and green vegetables, it is located below the

cotyledons and just above the roots. Hypocotyl development is an important character for prospective plants because it will then develop into plant stems.

In addition, rockwool's growing media is media that is able to absorb and transmit water well so that it has a high water-holding capacity. With these advantages, Rockwool planting media can optimize the role of nutrients to be absorbed by plants in meeting their needs and supporting plant growth and development (Miranda, 2017).

3.2 Number of Leaves

The results of variance on the number of leaves variable for broccoli microgreens showed that therewas an interaction between the growing media and the nutrition given to the broccoli microgreens.

Table 2. Number of Broccoli Microgreens Leaves atAge 21 HST treated with different types of growing media and nutrients

Growing Media (M)	Nutrition (N)	
	AB Mix	Coconut Water
---------- sheet----------		
Land	3,20 a A	2,00 b B
Cocopeat	2,30 b A	2,00 b B
Rockwool	3,20 a A	2,30 a B
KK = 3,85%		

Note: Numbers followed by different lowercase letters in the same column and numbers followed by different uppercase letters in the same row are significantly different according to DNMRT at a level of 5%.

At the age of 21 HST, the treatment of rockwool growing media with AB mix nutrients and soil planting media with AB mix nutrients had the highest number of leaves, and the lowest number of leaves was found in soil growing media with young coconut water nutrients and cocopeat growing media with young coconut water nutrients.

Rockwool planting media has environmentally friendly properties because it is made from a combination of rocks, such as basalt, coal, and limestone which are heated at 16000C until they melt to resemble lava which then turns into fibers. After it cools, the fiber bundle will be cut according to the needs and the rockwool also has sufficient nutrient availability (Nurdiana et al, 2013). This is supported by the results of a study (Valupi, 2021) concerning the effect of using rockwool growing media on pakcoy microgreens showing the highest number of leaves found in rockwool growing media.

3.3 Fresh Weight

The fresh weight of broccoli microgreens at 21 HST depends on the use of different growing media and nutrients. This can be seen in table 3, there is an interaction between the treatments given.

Table 3. Fresh Weight of Broccoli Microgreens at Age21 HST treated with different types of growing media and nutrients.

Growing Media (M)	Nutrition (N)	
	AB Mix	Coconut Water
---------- g ----------		
Land	8,9371 b A	6,2563 b B
Cocopeat	7,7665 b A	7,2901 b A
Rockwool	15,0277 a A	10,3625 a B
KK = 10,38%		

Note: Numbers followed by different lowercase letters in the same column and numbers followed by different uppercase letters in the same row are significantly different according to DNMRT at a level of 5%.

Based on Table 3, it can be seen that the treatment of rockwool growing media with AB mix nutrition gave the highest fresh weight yield of broccoli microgreens with a value of 15.0277 g. Broccoli microgreens grown using rockwool growing media have a heavier weight presumably because the rockwool media is able to absorb

water well so that the absorption of macro and micronutrients needed by plants can run optimally. Fresh weight is the result of plant metabolism. Fresh weight is influenced by the state of nutrients that can be absorbed by the roots (Maharani, 2021).

Treatment media plant and nutrition have a very significant effect on the chlorophyll content of broccoli microgreens based on Table 4. The type of rockwool growing media with AB mix nutrition produced the highest chlorophyll content value of 0.3253 compared to other treatments. As for the lowest chlorophyll content, it was found in the treatment of soil planting media with young coconut water nutrition, which was 0.2403.

3.4 Chlorophyll Levels

Table 4. Microgreens Broccoli Chlorophyll Levels atAge 21 HST treated with different types of growing media and nutrients.

Growing Media (M)	Nutrition (N)	
	AB Mix	Coconut Water
Land	0,2807 b A	0,2403 c B
Cocopeat	0,2620 c B	0,2757 a A
Rockwool	0,3253 a A	0,2643 b B
KK = 1,38%		

Note: Numbers followed by different lowercase letters in the same column and numbers followed by different uppercase letters in the same row are significantly different according to DNMRT at a level of 5%.

The content of chlorophyll in is one of vegetables the important criteria for determining the content of nutrients. Chlorophyll is known acts as an antioxidant for the body. The high availabilityof chlorophyll in nature and its biological properties are an opportunity to be developed as a food supplement or functional food ingredient (Rahmawati, 2007).

One of the factors that affect the production of chlorophyll pigment is nutrients. Cocopeat has a high water absorption capacity, capable of storing water properly, contains the nutrients needed by plants, and loosens the soil.

3.5 Antioxidant Analysis

Antioxidant analysis was carried out 1 time at harvest, when the plants were 21 HST and the following results were obtained:

Table 5. Antioxidant Analysis of Broccoli Microgreens at 21 HST treated with several types of growing mediaand different nutrients.

Sample	HCl (a red color change occurs)	NaOH (appear blue green)	Conclusion
Land + AB Mix	+	-	Betacyanin
Land + Coconut Water	+	-	Betacyanin
Cocopeat + AB Mix	+	-	Betacyanin
Cocopeat + Coconut Water	+	-	Betacyanin
Rockwool + AB Mix	+	-	Betacyanin
Rockwool + Coconut Water	+	-	Betacyanin

In Table 5 the qualitative test results for the antioxidant content show that the broccoli microgreensget a red color change when given HCl, whereas if NaOH is added drop by drop there is no blue color change. So it can be concluded that broccoli microgreens contain betacyanin.

Betacyanin is a pigment that can be used as a natural dye and can be extracted from plants. Betacyanin has the property of being easily soluble in water solvents, so Betacyanin is very well developedas a natural dye. In plants, betacyanin is found in flowers, fruits and leaves which have a purplish-red color (Strack, et.al., 2003).

IV. CONCLUSION

1. The interaction between growing media and nutrients has influenced this research for the parameters of

observation of sprout height, number of leaves, fresh weight, and chlorophyll content.

2. The results of the qualitative test for the antioxidant content showed that the broccoli microgreens had a red color change when given HCl, whereas if NaOH was added drop by drop there was no blue color change. So it can be concluded that broccoli microgreens contain betacyanin.

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Study of Small-Scale Capture Fisheries in West Sulawesi Waters "Case Study of Large Pelagic Fishing Rod in Mamuju Regency"

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Abstract— *Mamuju Regency, West Sulawesi Province, has the potential for pelagic fish, especially large pelagic fish, namely tuna, skipjack and cob, which are very prospective. The majority of fishermen in Mamuju Regency use fishing rods to catch large pelagic fish. Fishing rod fishermen with a large pelagic catch target are in Mamuju Regency, Simboro District, precisely in Sumare Village but currently it is known that there has been a decrease in the number of fishing rod fishermen in Mamuju Regency since the last 5 years experiencing a decrease in production. This study aims to determine the status of small-scale capture fisheries in a sustainability perspective according to ecological, technological, social and economic dimensions for small-scale fisheries in Mamuju Regency, and recommendations for sustainable capture fisheries. The study was conducted using qualitative methods using Rapfish analysis to determine the sustainability of fishing efforts. The results showed the highest dimensions in fish resources (70.13) and fishing technology (50.06) which means quite sustainable (good) while in the social dimension (38.47) and economic dimension (28.75) in the bad category which means there needs to be special attention in handling.*

Keywords— ***Sustainability Status, Small-scale capture fisheries, Rapfish Analysis***

I. INTRODUCTION

Geographically, Mamuju Regency is located on the western edge of Sulawesi Island. In the north of Mamuju Regency there is Mamuju Bay and in the south there is Lebani Bay. The resources of coastal areas and small islands of West Sulawesi Province, are assets to be developed on the basis of economic activities on the aim of prospering coastal communities and increasing local native income generation (BPS Sulbar, 2022).

According to (Halim et al, 2020) said that small-scale fisheries are defined as fishing activities that occur within the scope of households and vessel sizes ≤ 5 GT. This type of fishing vessel is dominated by fishing gear, fishing rods, and gill nets. Hand Line is one type of fishing gear used by fishermen of Mamuju Regency to catch large pelagic fish.

The rate of production in capture fisheries activities is determined by how much fishing effort in utilizing fish resources. Fishing effort is determined based on the dimensions of the fishing gear, vessel, number of days of operation, and fishing technology used. Thus fishing efforts will determine the amount of fish production in a fishery area, so that fishing efforts will affect the biological conditions of fish resources (Nelwan et al, 2015).

When the rate of fishing effort is lower than the available fish stock, the remaining fish stock can still grow and develop. However, if the level of fishing effort exceeds the availability of fish stocks, then the availability

of fish for fisheries will decrease. Thus fish production will increase proportional to fishing efforts.

Small-scale capture fisheries in Mamuju Regency need to be studied considering the decline in production of large pelagic fish catches in various areas in Mamuju Regency. Based on data from the Marine and Fisheries Service of West Sulawesi Province, it was recorded that capture fisheries production in Mamuju Regency decreased in 2019 (21,468 tons), then decreased in 2020 (19,333 tons) and increased only 167 tons in 2021 (19,500 tons). The decrease in the production of large pelagic fish catches has resulted in a shift in fishing areas, considering the smaller size of the fish and the farther fishing ground so that some large pelagic fish fishermen switch to catching bottom fish and switch fishing bases.

Problems faced in the sustainability of small-scale capture fisheries in the waters of Mamuju Regency include various things including the condition of densely fished waters so that fish resources (SDI) are increasingly limited, fishing efforts continue to increase but productivity decreases so that fishermen's income decreases, conflicts over the use of SDI are increasing which results in an increase in the intensity of social conflicts between fishermen.

The majority of fishermen in Mamuju Regency use fishing rods to catch large pelagic fish such as tuna, skipjack and cob. However, some fishermen use tonda fishing gear to catch swordfish. Fishing rod fishermen with a large pelagic catch target are in Mamuju Regency, Simboro District, precisely in Sumare Village but currently it is known that there has been a decrease in the number of fishing rod fishermen in Mamuju Regency since the last 5 years experiencing a decrease in production. The data is confirmed by data from DKP Mamuju Regency.

Based on the background described above, the objectives of this study are: (1). Determining the status of small-scale capture fisheries in a sustainability perspective according to ecological, technological, social and economic dimensions for small-scale fisheries in Mamuju Regency, (2). Recommendations for sustainable capture fisheries.

II. METHODOLOGY

2.1. Location and Time of Research

This research was conducted from September 2021 to February 2022, with the research location in Sumare Village, Simboro District, Mamuju Regency, West Sulawesi Province. The selection of the research site was carried out purposively with the consideration that Mamuju Regency is one of the areas in West Sulawesi Province that has the prospect of large pelagic fishing, namely tuna, skipjack, and cob using fishing gear. Mamuju Regency is also one of the areas with the most pelagic fish catches in West Sulawesi Province.

2.2 Sampling Method

The population in this study is all fishing rod fishermen in Sumare Village with large pelagic fish catches namely tuna, skipjack and cob. The information on the number of fishermen obtained from Fisheries Extension in Sumare Village in 2021, namely with a total of 710 fishermen with each criterion including 300 mixed fishermen and 410 pure fishermen. Of the 410 genuine fishermen, 160 of them are large pelagic fishing rods (DKP Mamuju Regency, 2021).

Sampling for research according to Masri Singarimbun (2014), if the subject is less than 100 people then all should be taken, and if the subject is large or more than 100 people should be taken 10-15% or 20-25% depending on the size of the risk borne by the researcher. The total number of fishing rods in Sumare Village is 160 people, which is more than 100 samples, so the researchers took 15% of the population, so the number of samples in this study was 24 fishermen. In addition to sampling, researchers used a snowball sampling system in determining informants, namely interviews with the Head of DKP, Fisheries Extension of Mamuju Regency and interviews with the manager of the TPI cooperative in Sumare Village.

2.3 Data Retrieval Method

This research uses the case study method by interviewing fishermen who use fishing rods with the criteria of having 10 years of experience using fishing gear located in Simboro District, Sumare Village. However, in addition, data collection was also carried out by filling out questionnaires on 24 respondents by Selected Experts with the aim of obtaining professional consideration from the expertise of the respondents in determining the level of importance of several variables in formulating priority programs for the development of integrated capture fisheries resource management.

The relatively same size of fishing rods and boats provide the same fishing opportunities, so that fishing units with the aim of catching large pelagic fish species found in Sumare Village will provide the same fishing opportunities. In addition, the entire fishing unit uses rumpon as tool technology Help arrest. Clearly the source and type of data used in this study are presented in the table below:

Table 1. Needs and Data Sources Used

Dimension	Required data	Data Sources
Fish Resource Dimension Data	· Production of Yellowfin Tuna, Skipjack, Tongkol, 2017-2021 · Caught species	· DKP Mamuju Regency · DKP Mamuju Regency
Ecological Dimensions	· Fish size · Fishing season · Fish production in each rumpon	Primary data from interviews/questionnaires
Dimensions of Fishing Technology	· The amount of fishing effort in Sumare Village · Personal data of fishermen, fishing rods and boats in Sumare Village	Fisherman's logbook fishing rod
Social Dimension	· Stakeholder participation	Primary data from interviews/questionnaires
Economic Dimension	· Asset ownership · Fishermen's household income	Secondary data

2.4. Data Analysis

The management and analysis of data used in this study consists of several analyses that refer to solving the problem formulation in this study. The following data analysis is used:

2.4.1. Cacth Analysis Per Unit Effort (CPUE)

CPUE analysis is used in assessing the domain of large pelagic fish resources on the Standard CPUE indicator. In determining the optimum effort for large pelagic fishing in Sumare Village, Mamuju Regency uses the Catch per Unit Effort (CPUE) analysis which is a value reflecting the productivity of fishing gear used to capture large pelagic fish resources, namely tuna, skipjack and cob. The CPUE value is obtained by adjusting the production value and *effort* for 2017-2021. The CPUE value can be formulated as follows (Fauzi and Anna, 2005).

$$\mathbf{CPUE_t} = \frac{Catch_1}{Effort_1}$$

1. t = 1,2,...n

Where :

$CPUE_t$ = catch per catch $in_{t\text{-year}}$

Catch1 = catch in the t-year

2.4.2. Data Analysis Method (Rapfish Analysis)

Each fisher has different preferences about the use of resources, depending on personal goals or the intended target group. Rapfish is one method in analyzing fisheries sustainability and is new in application in the field of fisheries. The procedure for analyzing rapfish techniques applied in this study as explained by Fauzi and Anna (2005) is through stages:

1. Analysis of fisheries data of the study location through statistical data.

2. Analysis of field observation data and literature studies.

3. Fisheries Resources Assessment.

The Rapfish method basically uses a Multi Dimentional Scaling (MDS) approach. All attributes obtained from the results of this study were analyzed in a multidimensional manner. This multidimensional analysis is to determine the points in the Rapfish studied relative to the two points of reference. The reference points are good and bad in the interval 0 - 100, where there are good extremes and bad extremes. The sustainability index intervals are intervals 0-25 in bad status, hoses 26-50 in less status, hoses 51-75 in sufficient status and lapses 76-100 in good status.

In the assessment of fishery resources, the most important thing to know is the estimated value of catches from fish stocks. To determine the status of small-scale capture fisheries in a sustainability perspective according to ecological, technological, social and economic dimensions for small-scale fisheries in Mamuju Regency, the estimated value of the catch first needs to know the productivity of fish stocks, which is usually estimated with quantitative models. In this study the technique for estimating biological parameters of surplus production models is through estimating coefficients developed by Clarke, Yoshimoto, and Polley (1992) or often known as the CYP method. With this analysis, the value of r, q, K, MSY, JTB (Number of Catches allowed) and exploitation rate are obtained.

The general criterion for determining the attributes of each dimension is the ease with which it can be objectively scored, and the extreme point of its sustainability can be simply expressed as good or bad. The scoring criteria for each attribute are determined using the Likert scale. The following dimensional indicators are used in this study in the table below:

Table 2. EAFM Indicators

No.	Dimensions	Indicator	Criteria	Data analysis
1.	Dimensions of Fish Resources	Raw CPUE	1. Sharp decline (> 20%/year) 2.Slightly decreased (<20%/year)	CPUE analysis (secondary data)
		Fish Size Trends	1. The size of the tuna is getting smaller (<15kg) 2. Fixed relative size (15-45kg)	Fish weight measurement (Primary data)
		Catch Species Composition	1. Lower proportion of target fish (<50%) 2. The proportion of target fish is the same as non target	Frequency Analysis (Primary data)
		Range Collapse	1. Fishing ground fixed distance 2. Far fishing grounds 3. Fishing ground very far	Descriptive analysis based on interview results
2	Dimensions of Fishing Technology	Gear selectivity	1. Not Environmentally Friendly 2. Environmentally friendly	Descriptive data analysis
		Vessel Capacity and Arrest Efforts	1. R < 1 2. R = 1 3. R > 1	CPUE analysis (secondary data)
		Certification of fishing boat crew in accordance with regulations	1. Low < 50% 2. Moderate 50-75% 3. High >75%	Class Range Interval Analysis (secondary data)
		The size of the fishing vessel	1. There are changes to increase production capacity 2. There is no change in ship size	Descriptive data analysis
3	Social Dimension	Stakeholder participation	1. Low (<3 stakeholders involved) 2. Moderate (3-5 stakeholders involved) 3. High (>5 stakeholders involved)	Class Range Interval Analysis (Primary data)
		Fishermen's working relationship	1. Semimodern 2. Traditional	Class Range Interval Analysis (Primary data)
		Stakeholder interaction	1. Stakeholder meeting (> 10x in 1 year) 2. Stakeholder meetings (5 – 10 times in 1 year) 3. Stakeholder meetings (< 5 times)	Class Range Interval Analysis (Primary data)
		Fisheries Conflict	1. >5 times/year 2. 2-5 times/year	Class Range Interval Analysis (Primary data)
4	Economic Dimension	Asset ownership	1. Asset value reduced, <50% 2. Fixed asset value, 50%	Class Range Interval Analysis (secondary data)

No.	Dimensions	Indicator	Criteria	Data analysis
		Working capital	1. Personal 2. Others 3. Personal and other people	Class Range Interval Analysis (secondary data)
		Profit-sharing system	1. Traditional 2. wage system 3. Salary system	
		Fisherman Household Income	1. < average UMR 2. = average UMR 3. > average UMR	Revenue Analysis (secondary data)

III. RESULTS AND DISCUSSION

Mamuju Regency, West Sulawesi Province, has the potential for pelagic fish, especially large pelagic fish, namely tuna, skipjack and cob, which are very prospective. The production of capture fisheries in Mamuju Regency fluctuates every year. Based on data from the Marine and Fisheries Service of Mamuju Regency, the highest production value between 2017-2021 experienced peak production in 2019, which was 21,468 tons (BPS Sulbar, 2022) for tuna, skipjack and cob catches.

Capture fisheries production in Mamuju Regency from 2017 to 2019 always increased, but there was a decrease in catches in 2020. In 2019, capture fisheries products for large pelagic fish were 21,468 tons but decreased in 2020 by 19,333 tons or decreased by 2,135 tons in 1 year.

The most dominating types of fish in the sea of Mamuju Regency are Tongkol fish, skipjack fish and the lowest number of tuna catches. This can be seen in the catch in 2021 based on data from West Sulawesi Province in Numbers (2022) with a total catch of 4,222 tons of swordfish, 1,997 tons of skipjack fish and 727 tons of tuna catch.

In order to determine the status of small-scale capture fisheries in Mamuju Regency in a sustainability perspective, it is very important to conduct an analysis of four dimensions such as resource, technological, social and economic dimensions using Rapfish analysis as follows:

3.1 Dimensions of Fish Resources

Sustainable capture fisheries management requires information and patterns of distribution of fish resources that are utilized. Large pelagic fish resources are related to efforts that are allowed for sustainable fishing management. The data used is data on the production of large pelagic fish in Mamuju Regency using hand line fishing gear for a vulnerable time of 5 years 2017-2021.

The CPUE value of large pelagic fish in Mamuju Regency has fluctuated in the five years 2017-2021. The highest CPUE value was found in 2019 with a value of 0.22 tons/trip while the lowest CPUE value in 2017 only reached 0.11 tons/trip. The relationship between CPUE and Effort values is presented in Figure 12. The equation is:$Y = -0.000001x + 0.3816$with $R^2 = 0.7333$, which means that if the effort increases by 1 trip, CPUE will decrease by 0.000001 ton/trip. In the research results of Novitasari, F., et al (2022) stated that the catch per unit effort (CPUE) reflects the comparison between the catch and the unit effort devoted.

The number of attributes used in the dimensions of fish resources in this study consisted of (1) CPUE, (2) Fish Size Trend, (3) Fish Composition, (4) Range Collapse. The following is the value of the rapfish analysis in the Figure.1.

Based on Figure 1 it shows that the value of the dimension of fish resources in the management of large pelagic fish in Mamuju District, Sumare Village is at a value of 70.13% or in the good category (good). In the analysis of each attribute used in the fish resource indicator that has the highest sensitivity (leverage) is the trend attribute of fish size. In fishing activities for large pelagic fish by fishermen in Sumare Village, fish sizes are still below average. This is because the location of the fishing ground is not too far (fixed) which causes the size of the catch to be relatively small. The fishermen of Sumare Village are included in the small-scale capture fisheries group using hand line fishing gear and a fleet of vessels with a size of <10 m. This is what makes the fish size trend attribute the highest attribute.

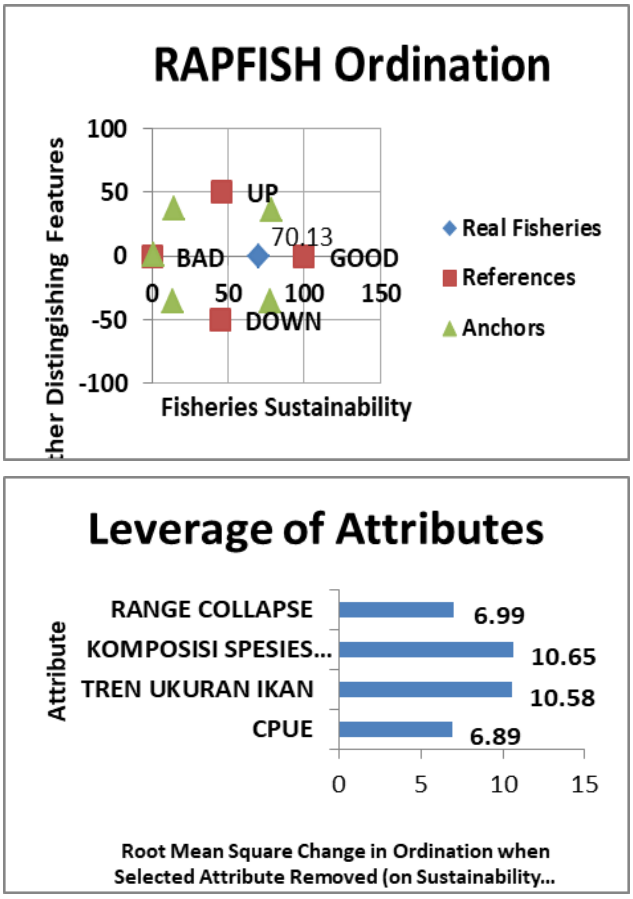

Fig.1. RapFish Analysis of Fish Resource Dimensions and Leverage of Attributes Analysis of Fish Resource Dimensions

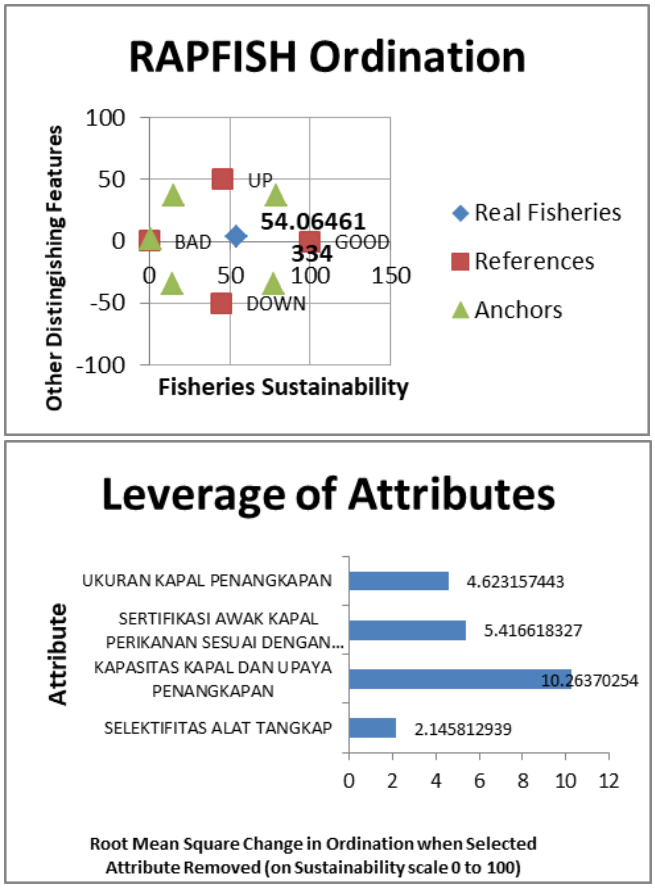

Fig.2. Analysis of Leverages Attributes D imence of Fishing Technology and Analysis of RapFish Dimence of Fishing Technology

3.2 Dimensions of Fishing Technology

Fishermen in Sumare Village, Mamuju Regency target large pelagic fish in their fishing production by working in groups. Most of the fishermen in Sumare Village use handline fishing gear in the fishing process and are carried out in a semi-modern manner. This can be seen from the use of technology which is combined with traditional knowledge patterns of fishermen with the use of technology such as GPS or ecosonder in determining a better fishing ground.

The number of attribute uses on the dimensions of fishing technology in this study consists of (1). Gear selectivity, (2). Fisheries Capacity and Catching Effort, (3). Certification of Fishing Vessel Crew in Accordance with Regulations, (4). Catching Vessel Size. The following are the rapfish analysis values in the table below:

Based on Figure 2 shows that the dimension of fishing technology is at a value of 54.06 or is in the good category. The sensitivity analysis (leverages) on each attribute shows that the highest value is in the capacity of the vessel and the fishing effort with a value of 10.26. The use of fishing gear used by Sumare village fishermen, namely fishing rods, is included in traditional fishing gear so that the fishing results are more selective but the results are not optimal. Technological limitations in the fishing process using fishing rods make maximum fishing efforts but catches are still relatively minimal. This needs special attention for fishermen so that small-scale fisheries of large pelagic fish types can produce maximum catches and are economically and ecologically sustainable.

3.3 Social Dimension

The social aspect is part of guaranteeing the social welfare of fishermen or coastal communities in improving the economy and fishing productivity of these fishery commodities. Some things that are included in the benchmark of social aspects in fishing communities are working relationships between fishermen, stakeholder

participation, interactions between stakeholders, and conflicts between fishermen.

Sumare Village, Simboro District, Mamuju Regency is a coastal area where the majority of the population is a fishing community. The social construction of people in coastal areas is these fishermen, although not all villages in coastal areas have residents who make a living as fishermen. The real life of fishing communities that can be done by means or through business that can be influenced by the fishing season (Hasmah, 2018).

Residents in Sumare Village who work as fishermen partly have good-looking houses with adequate facilities, they are boat owners or commonly referred to as ponggawa. In these conditions it has been shown that there is one system that makes fishermen increasingly economically marginalized. This situation requires the role of the government and stakeholders in helping the fishermen's economy, especially mustard fishermen. Mustard fishermen are fishermen who do not have fishing gear such as boats and other equipment.

Mustard fishermen only participate in helping the fishing process.

The role of the government at both the district and provincial levels has not had a real impact on small-scale fishing fishermen in Sumare Village. The existence of a government program regarding fishermen insurance premium assistance carried out by the Director of Fish Resources Management has not been carried out evenly. Fishermen in Sumare Village do not get real assistance from the government. Supposedly, the assistance provided by the government must be right on target by providing assistance to villagers who are left behind and still use simple (traditional) fishing gear.

The number of uses of attributes in the social dimension in this study consists of (1). Stakeholder participation, (2). Working relations between fishermen, (3) Stakeholder interaction, (4) Conflict between fishermen.

Based on Figure 3 in rapfish analysis shows that the social dimension in the management of small-scale fisheries of large pelagic fish in Sumare Village is at a value of 38.47 or in the bad category. The sensitivity analysis (leverages) on each attribute shows that the highest value is in the attribute of modification of fishermen's labor relations with a value of 20.58. This indicates that fishing activities that work in groups and are still traditional in nature are the most important aspects that need to be considered in the management of small-scale businesses in large pelagic fish in Sumare Village.

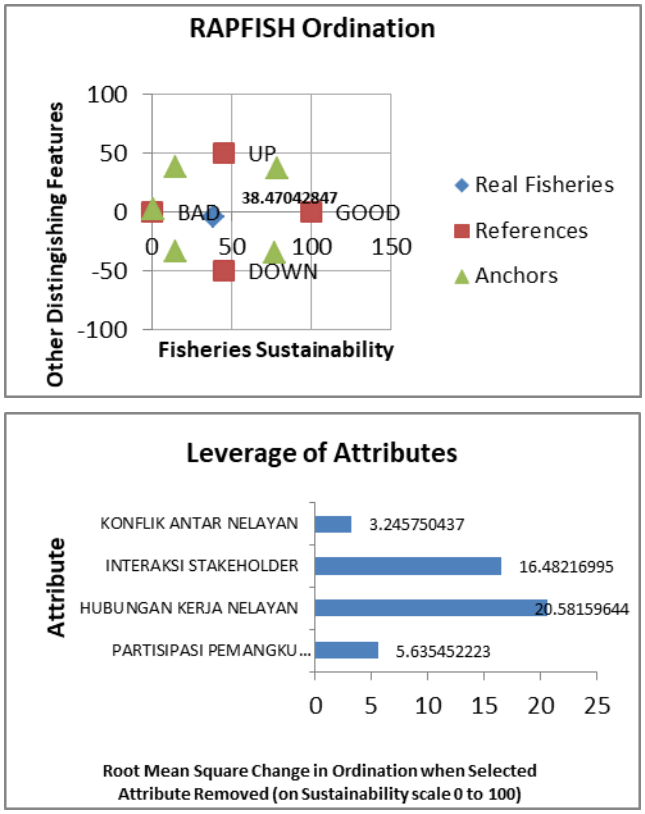

Fig.3. Leverage Analysis of Social Dimension Attributes and Rapfish Analysis Social Dimension Ordination

3.4 Economic Dimension

The small-scale capture fisheries business in Sumare Village that catches large pelagic fish, namely tuna, skipjack and tuna, provides distinct benefits for fishermen. Fishing activities in Sumare Village are carried out in groups. This directly has an impact on the ownership of production assets owned by these fishermen. Some fishermen serve as retainers, namely owners of boats and fishing gear, some become mustard fishermen or crew members who assist in the fishing process.

Fishing equipment such as boats and other supporting tools cannot be owned by small fishermen like mustard greens because some of them do not have enough capital to start a business. The average value of investment in small-scale fishing for large pelagic fish in Sumare Village is in the range of Rp. 50,000,000, and only collectors or retainers own the fishing production assets. The catch sharing system by boat owners is usually a percent distribution of 40% for owners and 15% each for crew members who assist in the process of catching large pelagic fish in Sumare Village.

Fishing production activities for large pelagic fish using handline fishing gear have an average total cost of Rp. 137,947,550 per year for fixed costs and variable costs with a total cost of IDR 11,495,629 per month. The

revenue value that can be generated in large pelagic fishing activities can reach an average of Rp. 201,729,375 per year or as much as IDR 16,810,781 per month. The amount of net income received by fishermen with an average of Rp. 63,781,825 per year or as much as IDR 5,315,152 per month.

The profit-sharing system is based on one of the fishermen respondents who own large pelagic fishing boats in Sumare Village. If it is based on the number of crew members used in fishing activities, it can be concluded that the wages received by those who are members of the fishermen working group are at an average level below the standard minimum wage for the province of West Sulawesi. In table 9 it can be seen the results of the distribution of pelagic fishing, where the retainer gets a share of 40% or Rp. 5,283,100 while the crew only get 15% of each income or Rp. 1,981,162, which is below the standard minimum wage of Rp. 2,678,863 in West Sulawesi Province.

The number of attributes used in the economic dimension in this study consists of (1) Asset Ownership, (2) Working Capital, (3) Profit Sharing System, (4) Fisherman Household Income, can be seen in the picture below:

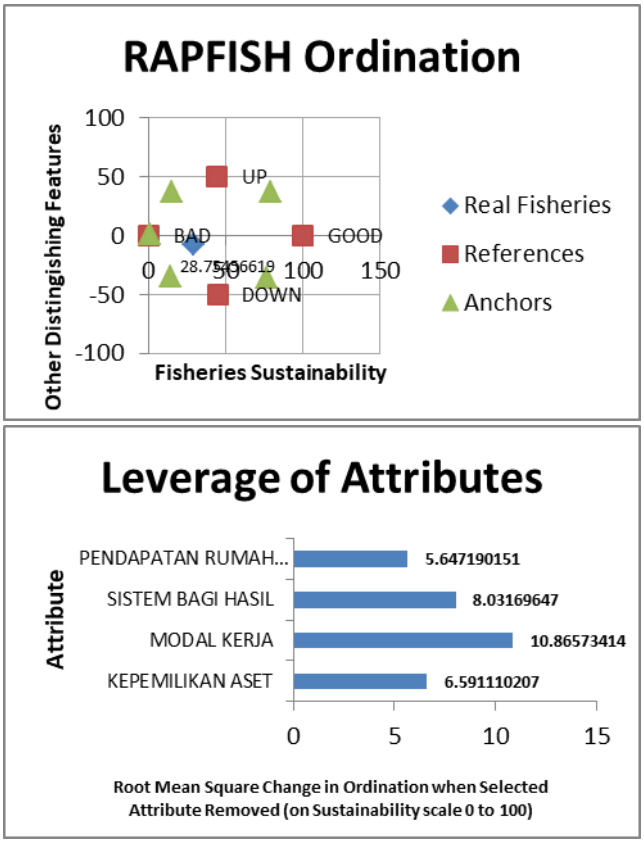

Fig.4. Leverage Analysis of Economic Dimensions Attributes and Economic Dimension Rapfish Ordination Analysis

Based on Figure 3 in rapfish analysis shows that the social dimension in the management of small-scale fisheries of large pelagic fish in Sumare Village is at a value of 38.47 or in the bad category. The sensitivity analysis (leverages) on each attribute shows that the highest value is in the attribute of modification of fishermen's labor relations with a value of 20.58. This indicates that fishing activities that work in groups and are still traditional in nature are the most important aspects that need to be considered in the management of small-scale businesses in large pelagic fish in Sumare Village.

3.5 Status of Management of Large Pelagic Fish Resources in Mamuju Regency

Management of fish resources, especially large pelagic fish, namely tuna, skipjack and cob in Mamuju Regency is a very important aspect in the fisheries sector as a determinant of the sustainability of large pelagic fishing activities. The following is a laying diagram for each dimension used in the management of large pelagic fish in Mamuju Regency, Sumare Village according to the results of this study:

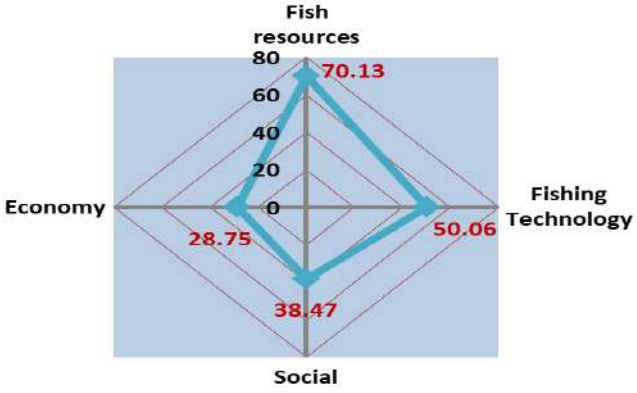

Fig.5. Overlay diagram of all EAFM dimensions in the management of large pelagic fish

Figure 5 shows a flyover diagram that illustrates the interrelationships between the four dimensions at once. The fly chart depicts a score of 0% -100% with an interval of 25%, namely bad, poor, adequate and good. The more the index goes out, the better the sustainability status and vice versa. In the flyover diagram, it can be seen that overall the index of small-scale fisheries for large pelagic fish in Sumare Village, Mamuju Regency is in the range of 28% -70%, the sustainability of fishing effort is in the status of less and quite sustainable. The dimensions of fish resources and fishing technology are in a fairly sustainable status with values of 70.13 and 50.06, this can be used as an alternative by looking at the sustainability value in the rapfish analysis which is quite high. The use of more selective fishing gear can have an impact on the

sustainability status of small-scale fishing activities from a technological dimension. In addition, it is necessary to increase the selectivity of fishing gear because by using selective fishing gear, fish sizes will be obtained according to market needs.

The social and economic dimensions are in a less sustainable status with a social dimension value of 38.47 and an economic dimension value of 28.75 which are in the bad category (bad). In this case, there needs to be special attention from the local government of Mamuju Regency as well as the provincial and central levels in raising the economic level of small-scale fishing communities. Small-scale fishermen dominate capture fisheries in Sumare Village, but this business does not provide much profit and is not sufficient for decent needs because fishermen's income is still below the regional minimum wage (UMR). The main problem for small-scale fishing businesses is meeting operational costs, inadequate marketing and TPI systems, these factors have triggered the ineffectiveness of the government's role in fishing businesses in Sumare Village.

The role of the government is very important in establishing policies and providing innovation and assistance or providing alternative livelihoods and managing fish catches which can have a significant impact on improving the welfare of fishing communities in Mamuju Regency.

In the dimensions that have been analyzed based on the EAFM approach, it shows that the fish resources available in the waters of Sumare Village based on CPUE analysis show that there is no exploitation. One of the causes of no exploitation in the waters around Sumare Village is because fishermen still use traditional fishing gear, namely hand lines which are classified as environmentally friendly. However, this cannot help fishermen in increasing their business, especially for small fishermen (sawi) due to limited capital. There is a need to strengthen capacity in the institutional aspect in assisting and guiding small fishermen to develop their business so that it is sustainable and economically profitable.

Based on the results of research conducted by (Andi Eka Ratu, 2019), namely measuring the sustainability index using rapfish analysis of each dimension of tuna management in Bulukumba Regency, the results of the fishing technology dimension and the economic dimension are in the bad category (bad). This requires special attention from the regional government of Bulukumba Regency, as well as at the provincial and central levels in raising the economic level of fishing communities who work in tuna fishing. There is a need for government policies and innovations in providing assistance and providing alternative livelihoods and processing tuna which can have a significant impact on improving the welfare of fishing communities in Bulukumba Regency.

IV. CONCLUSION

A. Conclusion

1. Rapfish analysis is used as an initial analysis in obtaining a general and comprehensive picture of the sustainability status of small-scale capture fisheries businesses in Sumare Village, Mamuju Regency. Based on the sustainability index of each dimension, the highest index on the dimension of fish resources and fishing technology is in the good category so that fishing effort can be continued and improved in its management, while the lowest index is on the economic and social dimensions which are in the bad category so that it is necessary to improve the system to create ecologically and economically sustainable management.
2. Based on the assessment of the four dimensions, important attributes that have high sensitivity values can be used to identify efforts (recommendations) that can be made to improve the sustainability of fisheries at the research location, where the attributes with the highest values are trends in fish size, vessel capacity and fishing effort, fishermen's working relationship and working capital.

B. Suggestion

1. The results of the analysis on the economic and social dimensions that are in the bad category need to be improved through synchronization of the system for each small-scale fisheries management actor for large pelagic fish consisting of fishermen as fishing actors, government officials and private parties in developing their businesses. fishermen to get capital so that small fishermen (sawi) are no longer dependent on retainers, so they can maintain business continuity and improve the welfare of large pelagic fish fishermen in Sumare Village, Mamuju Regency.
2. Family participation in the utilization of SDI needs to be carried out by the family so that fishermen do not only rely on family income sources from catching fish but from other forms such as added value from catch products, this can be done in various ways including efforts to improve skills and insight in processing the catch, namely tuna, skipjack and tuna so that fishermen's families are able to be competent in finding other alternatives in improving their welfare.

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Guso (*Eucheuma sp.)* Ice Cream Enhanced with Blue ternate

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Abstract— *The main thrust of this study was to determine the profile of Guso (Eucheuma sp.) Ice Cream enhanced with Blue ternate in terms of ingredients and costing, tools and equipment, procedure, shelf life, nutritive value, sensory qualities and level of preferences in three different treatments in the aspect of appearance, taste, aroma, and texture. The study utilized experimental design with the aid of a descriptive questionnaire which determined the sensory preferences of the respondents towards the three treatments of the Ice cream in terms of appearance, taste, aroma, and texture. This study was conducted at Bohol Island State University in the six campuses with thirty (30) purposively selected participants who tasted and rated the Ice cream. To obtain the nutritive content samples were sent to the First Analytical Service and Technical Cooperative Laboratories for nutritional content and microbial analysis. After the data were retrieved, these were tabulated and interpreted using the Average Weighted Mean. The Friedman Test was used to obtain the difference in the participants' sensory preferences for the three treatments. Findings revealed that the ingredients and tools in making the Guso (Eucheuma sp.) Ice Cream enhanced with Blue ternate were minimal, less expensive, and available in the local market. The nutritive content of the Guso (Eucheuma sp.) is Iron, Sodium, Calcium, Fats, Calories, Dietary fiber, Vitamin A, Vitamin C, and Vitamin D3 is within the range of recommended daily intake for Filipinos. Shelf life ranged from 2 to 3 months stored at the standard temperature of ice cream, which is 0°F (-18°C) or colder. All treatments of Guso (Eucheuma sp.) Ice Cream enhanced with Blue ternate was liked by the participants in all four attributes. Generally, the result of the study showed that there was a significant difference in the respondents' preferences for Guso (Eucheuma sp.) Ice Cream enhanced with Blue ternate in terms of taste, and texture. Thus, the null hypothesis is rejected. However, data reveals that there is no significant difference in the respondents' preference for Guso (Eucheuma sp.) Ice Cream enhanced with Blue ternate in terms of appearance and aroma. Research findings showed that was a feasible nutritious Ice Cream safe for human consumption. Hence, a proposed technology guide is offered for the dissemination of the research output.*

Keywords— **dessert, creamy, organic, ice cream**

I. INTRODUCTION

Most Filipinos have a sweet tooth. For special occasions, something sweet must always be on the table, be it desserts or dishes. Ice cream is one of the best desserts that Filipinos are fond of eating. It is consumed mainly by many because of its sweet taste. Ice cream is a popularly known sweet dessert in the world. Ice cream is a frozen dessert made by freezing a pasteurized mix of milk solids, sugar, corn syrup, flavoring, stabilizer, and emulsifier, with or without eggs. In the Philippines, artificially flavored ice cream production became popular because of its appearance and availability. It is in great demand, especially during the summer season. People tend to buy ice cream made with artificial flavorings.

Eucheuma is a species of Seaweed known to be low in calories and high in dietary fiber, antioxidants, vitamins, and minerals such as calcium and potassium. Scientific studies have shown that regular consumption of Eucheuma helps improve bodily functions, including lowering blood pressure, cholesterol, and blood sugar,

preventing cardiovascular diseases, colon cancer, and breast cancer, and promoting anti-aging, brain development, and tissue repair.

Furthermore, Blue ternate *(Clitoria ternatea) is* commonly known as "telang" in the Philippines because of its combined health benefits and its unique aesthetic value. Blue ternate flower received considerable attention from people as potentially valuable sources because it is popular among the communities and more information about the nutrients of the flower. Blue ternate is native and abundant in the Philippines. It provides health advantages and foreseen demands for drinks with helpful benefits. Blueternate flower has the power to heal and offer beneficial enzymes needed by the body that other plants cannot provide (George, 2003).

Today's population increasingly demands and consumes healthy products (Rozycki et al., 2011). The researcher has observed that numerous ice creams with artificial flavorings was known and people are fond of eating not knowing the side effects. The researcher finds possible sources of food that are abundant in the environment and can be made into a nutritious ice cream that can benefit consumers and Guso seaweed farmers. Hence, the researchers will produce ice cream from Guso (Eucheuma sp.) puree enhanced with Blueternate, abundant in the Philippines, specifically in Bohol. Furthermore, the researcher aimed to promote the Guso Ice Cream product if found acceptable.

II. LITERATURE BACKGROUND

This study is based on existing and prevailing laws, theories, and concepts that emphasize technology development for the benefit of all.

Eucheuma is a species of Seaweed known to be low in calories and high in dietary fiber, antioxidants, vitamins, and minerals such as calcium and potassium. Scientific studies have shown that regular consumption of eucheuma helps improve bodily functions, including lowering blood pressure, cholesterol, and blood sugar, preventing cardiovascular diseases, colon cancer, and breast cancer, and promoting anti-aging, brain development, and tissue repair.

Bohol is a major producer of the Eucheuma spinosum variety, commonly known as Eucheuma cottonii, with about 80 percent of the country's supply coming from the farms. (Garcia-Yap,2014) In 1973, Seaweed's farming started in Hingotanan with only a family-sized culturing. Guso farming is known in Bien Unido Bohol. Presently, more than 2,000 families are benefiting from seaweed farming. Out of the total area of 618,315 hectares potential for seaweed development in the whole province of Bohol, 6,215 hectares or 34 percent are located in Bien Unido. 2,482 hectares or 57 percent out of the total 4,340 hectares that are fully developed, are in Bien Unido. Production-wise, Bien Unido is producing 118,744,539 kilos or 118,744 tons of dried seaweeds per annum.

Through industrial processing of the Seaweed cultivated, many edible and non-edible items can be made. In terms of industrial use, the essential component of Seaweed is a substance called Carrageenan, also commonly known as seaweed flour. From your dried Seaweed, about 25% of the weight is Carrageenan. This can be extracted through a complicated industrial process. In its semi-refined or refined form, Carrageenan is used to manufacture food items, both for human and animal consumption. (Roberto, 1990)

In recent years, with the development of food processing technology and the in-depth study of marine algae resources, researches on food processing technology of eucheuma have been carried out in the country, and the characteristics of soft-elasticity of taste and taste are achieved through acid and alkali treatment, and sodium hypochlorite is used for soaking. Sterilization achieves the purpose of food safety. This processing method can significantly increase the flexibility of Eucheuma.

Ice cream is made from dairy milk or cream and is flavored with a sweetener, either sugar or an alternative, and spice, such as cocoa or vanilla, or with fruit such as strawberries or peaches. It can also be made by whisking a flavored cream base and liquid together. Colorings are sometimes added, in addition to stabilizers. The mixture is cooled below the freezing point of water and stirred to incorporate air spaces and to prevent detectable ice crystals from forming. The result is a smooth, semi-solid foam solid at very low temperatures (below 2 °C or 35 °F). It becomes more malleable as its temperature increases.

Blue ternate *(Clitoria ternatea)* commonly known as "telang" in the Philippines because of its combined health benefits and its unique aesthetic value. The utilization of blue ternate has been limited to herbal tea types, pastry flavoring and food coloring. Matured blue ternate flowers falling from the plant are neglected leaving the flower to get rotten. Blue ternate flower received considerable attention to people as potentially valuable sources because it is popular among the communities and more of information about the nutrients of the flower. Most macaroon products in the market are coconut macaroons, so the researchers decided to utilize blue ternate flower as macaroons since there is no existing blue ternate flower product like Macaroon in the market (Rabeta, 2019).

Blue ternate is native and abundant in the Philippines. It provides health advantages and foreseen demands for drinks with helpful benefits. Blue ternate flower has the power to heal and offer beneficial enzymes needed by the body that other plants cannot provide (George, 2003). The flowers of CT, or the Blue ternate flower, widely used as a natural colorant ranging from drink to food (Patras et al., 2010) industries and it is sensitive to temperature and pH changes. Besides, it was used to color the nasi kerabu blue which is a famous dish in Kelantan. Usually, nasi kerabu (blue-colored rice) is eaten with grilled chicken or fried fish coated with flour, fish crackers, salted egg and other local herbs. The flowers are most famously used to make a traditional welcome tea known as dokanchan, which hotels there frequently serve to travelers upon their arrival (Baird, 2015).

Blue ternate has found its application in baked products, violet cakes, gelatins, ice creams, tea, tarts, bakery and savory products (Rabeta, 2018). Since the macaroons is a popular pastry of most people in different ages, it is best to innovate a new flavor in macaroons with natural flavors and ingredients such as blue ternate. The flower of blueternate contains Nitrogen, Phosphorous, potassium, calcium, magnesium, sodium and ash content.

The Theory of Food Choice Development states that learning starts even before birth and carries until the latest stages of life (Koster & Mojet,2006) It takes many forms, from completely unconscious conditioning and simple imitation to cognitive learning based on reasoned argumentation.

This means that food choice is a dynamic behavior subject to almost continuous change that can be influenced at very different levels. It varies not only from person to person and from situation to situation but also depends on the type of food products. Condiments or spices vary much more between and varies depending on the eating situation and the frequency of the individual's exposure to the products. Like these could gain preferences among street food eaters available as one street food option in the market.

Accordingly, the Theory of Innovation by Schumpeter (2007) states that innovation has the capacity and imagination to handle the old system and be able to transform theory into reality. When implemented, innovation is a new idea that leads to a more effective process, product, service, or technology. It provides better solutions that meet advanced, unaddressed or existing market needs.

The Philippine Institute of traditional and Alternative Health Care, P.I.T.A.H.C. accelerates the development of traditional and alternative health care fund for other purposes. The law on Traditional and Alternative Medicine of 1997 is also known as the Republic Act 8423 which states that the quality and delivery of health care services to the Filipino people should be improved through the development of traditional and alternative health care delivery system and a legally workable basis should be sought by which indigenous societies would own their knowledge of traditional medicine.

This research study is anchored on Article XIV Section 10 of the 1987 Philippine Constitution which states that:

> Science and Technology is essential for national development and progress. The state shall give priority to research and development, invention, innovation, and their utilization; and to science and technology education, training and services. It shall support indigenous, appropriate, and self-reliant scientific and technological capabilities, and their application to the country's productive system and national life.

Further, Republic Act No. 8659 Sec. 2 states that the college shall primarily provide higher professional, technical and special instruction and promote research extension services, advance studies and progressive leadership in agriculture, fisheries, forestry, industrial Technology, engineering, arts and sciences, and other fields as may be relevant. It shall also give primary consideration to the integration of research/studies for the development of the province of Bohol.

In relation to the above statement, these articles served as a keystone for the researcher to use indigenous materials to invent something new. With the help of technology, the researcher enhances her ingenuity, skills, and abilities by utilizing available natural resources such as Echeuma sp. Through critical, creative thinking, scientific and technological knowledge, it can yield a product that could help boost the country's progress through performing experiments and discoveries.

Objectives of the Study

The primary purpose of this study was to determine the profile, level of sensory preferences, and significant difference of Guso Ice Cream. The study will be conducted at Bohol Island State University Clarin Campus, the Municipality of Clarin Public Market, and the TESDA Provincial Training Center of Bohol, Tubigon.

Specifically, it aimed to answer the following questions:

1. What is the profile of Guso (Eucheuma sp.) Ice Cream in three treatments in terms of:

    1.1 ingredients and costing;

    1.2 tools and equipment;

1.3 procedures;

1.4 nutritional value;

1.5 shelf- life?

2. What are the respondents' sensory qualities and level of preferences on the Guso (Eucheuma sp.) Ice Cream in three treatments in terms of appearance, taste, aroma, and texture.

3. Is there a significant difference in the sensory preferences of the respondents of the Guso (Eucheuma sp.) Ice Cream in three different treatments?

III. METHODOLOGY

An experimental design will be used in this study. It involved a single variable of three treatment groups in determining the sensory preferences of Guso Ice Cream.

The locale of the study was conducted in Bohol Island State University Clarin Campus. The latter environment provides an appropriate avenue for the researcher to field the food samples to gather data on the innovative food's sensory qualities and preference level since it is near the researcher's location. There were 120 respondents who evaluated the product through sensory evaluation, broken down as follows: 50 people of different ages in Bohol Island State University, Clarin, Campus. Faculty members in B.I.S.U. Clarin with Food Technology NCII in Bohol Island State University, as a target consumer and 10 TESDA Cookery assessor from Provincial Training Center of Bohol, Tubigon, will evaluate the product's sensory qualities and product preference level in the aspects of color, flavor, aroma, and texture of the innovated food. The shelf life of Guso Ice cream will be observed and will be rated by the researchers themselves.

Purposive sampling will be utilized in determining the respondents. They will be chosen according to their ability and knowledge to assess the product quality since they are experts in food preparation. On the other hand, the varied age group of respondents will be utilized as participants who rated the product's preference level.

This study used a self-made questionnaire in obtaining the respondents' assessment of the sensory preference of the Guso Ice Cream. This includes the Ice Cream sensory qualities and the level of preference of the product in terms of color, flavor, aroma, and texture. The questionnaire was based on the Hedonic Scale sheet of Gatchalian, where some modifications were made to fit the present study. As a result, the following scoring system is observed: (9)- like Extremely, (8)-like very much, (7)-like moderately, (6)-like slightly, (5)-neither like nor a dislike, (4)-dislike slightly, (3)-dislike moderately, (2)-dislike very much, (1)-dislike extremely.

The respondents will check the Likert Scale corresponding to their perceptions to get the sensory qualities in terms of color, flavor, aroma, and texture.

In gathering the data on shelf life, an observation guide will be used to keep on track of the changes of the product property at room temperature in 1 month. The product samples will be sent to F.A.S.T Laboratories, Cebu City, for product testing on the aspect of nutrition and microbial analysis.

To determine the ice Guso Ice Cream marketability the researcher will display the product at the Municipality of Clarin Public Market.

To ensure the accuracy and substance of each item in the questionnaire, the researcher will seek advice from the research coordinator and submit the draft to the RDE Team.

IV. RESULTS AND DISCUSSION

1.1 Ingredients and Costing

The Guso (*Eucheuma sp.)* ice cream Enhanced with Blue ternate has a cheaper price per serving than the organic ice cream available in the market. It shows viability for consumption since it is cheaper and the ingredients are available in the local market. Moreover, adding *Eucheuma spinosum* as the main ingredient and Blue ternate flower extract flavoring ingredients increases the product cost.

Ingredients	**Quantity**			**Percentage**			**Unit**	**Unit Cost**	**Total Amount per Treatment**		
	T1	T2	T3	T1	T2	T3			T1	T2	T3
Blue Ternate;	19.7	19.7	19.7	1.45%	1.40%	1.36%	g	200.00/1000 g	3.94	3.94	3.94
Eucheuma sp. Puree	50	100	150	3.89%	7.15%	10.35%	g	100.00/ 1000g	5.00	10.00	15.00

All-purpose Cream	500	500	500	37.25%	35.73%	34.49%	g	60.00 /250g	120	120	120.00
condensed milk	300	300	300	21.55%	21.44%	20.70%	g	250.00/ 1000g	37.50	37.50	37.50
Evaporated milk	370	370	370	27.52%	26.44%	25.53%	g	38.00/ 370ml	38.00	38.00	38.00
Refined Sugar; and	100	100	100	7.55%	7.41%	6.90%	g	100.00/1000g	10.00	10.00	10.00
Vanilla	9.8	9.8	9.8	0.79%	0.70%	0.68%	g	16.00/120 ml	1.30	1.30	1.30
Total Grams per treatment	1349.5	1399.5	1449.5	100 %	100%	100%					
Total Cost									215.74	220.74	225.74
Yield:	40	42	45								
Size/ serving	100 g	100 g.	100 g.								
Cost/serving									5.39	5.25	5.00

The tools used in making *Eucheuma spinosum* ice cream comprise a mortar and pestle, a strainer flower, a measuring cup, a measuring spoon, a rubber spatula, and a blender. All tools used in preparing the bilimbi fruit juice are essential kitchen tools and handy to work on. The equipment involved, like a blender and weighing scale, is less expensive.

1.4 Nutritional Value

Samples of the product were sent to the First Analytical Service and Technical Cooperative Laboratories in Cebu City to determine the nutrient content of the Guso(*Eucheuma sp.)* Ice cream Enhanced with Blue ternate.

Analysis	Result	Test Method
Iron, mg/Kg	23.3 (5.29 mg per serving)	Flame AAS
Sodium mg/Kg	1649	
Calcium mg/Kg	3644	
Fat, g/100g	9.71	Maojonnier Extraction
Calories, g/100g	222	By Calculation
Cholesterol, mg/100g	30.08	Gas Chromatography
Dietary Fiber, g/100 g	1.57	Enzymatic – Gravimetry
Vitamin A, µg RE/100g	Less than 25**	High Performance Liquid Chromatography
Vitamin C, mg/100g	Less than 0.8**	
Vitamin D3 (as Cholecalciferol),mg/100g	Less than 0.42**	

Samples of the product were sent to the First Analytical Service and Technical Cooperative Laboratories in Cebu City to determine the nutrient content of the Guso Ice Cream enhanced with Blue ternate . Laboratory results reveal that the product has a content of Iron 23.3 mg/kg. Iron is a mineral that is naturally present in many foods, added to some food products, and available as a dietary supplement. Iron is an essential component of hemoglobin, an erythrocyte (red blood cell) protein that transfers oxygen from the lungs to the tissues. The amount of iron you need is 8.7mg a day for men over 18. 14.8mg a day for women aged 19 to 50. 8.7mg a day for women over 50. The grams

per serving of the product was 100 grams, hence the iron present in the product per serving is 2.33 mg. It implies that the inclusion of this innovative ice cream is a good contributor to intake to satisfy the RDA for Iron in one's diet.

In the aspect of Sodium content, result shows that the product has 1649 mg/ kilogram. The Daily Values are reference amounts of nutrients to consume or not to exceed each day. The Daily Value for sodium is less than 2,300 milligrams (mg) per day.The product has 100 grams per serving, thus the sodium present in the product was 164 mg. One of sodium's main functions is to balance the amount and distribution of water in our bodies, playing a key role in the control of our blood pressure.

Calcium is a mineral and is important for building strong bones and teeth, especially during childhood and adolescence. It is also important for many body processes, such as blood clotting, hormone secretion, muscle contraction, and nervous system function. In the aspect of the Calcium content of the product, laboratory results revealed 3644 mg of calcium content per kilogram. The grams per serving of the product as indicated in the ingredients and cost was 100 g., thus the calcium content of the products is 364.4 mg per serving. Children should eat a variety of foods that are good sources of calcium. The Daily Value for calcium is 700 milligrams (mg) per day for children 1 through 3 years of age and 1,300 milligrams (mg) per day for adults and children 4 years of age and older. Thus, the calcium present in the product is within the Recommended dietary intake developed by FDA.

The product fat content is 9.71 g/100 grams. Men should not consume more than 30g of saturated fat per day, while women should consume no more than 20g. Children should consume less. As a result, the product's fat content is within the recommended dietary allowance. Fat helps the body absorb vitamin A, vitamin D and vitamin E. These vitamins are fat-soluble, which means they can only be absorbed with the help of fats.

Moreover, the amount of Vitamin A present in the product was less than 25 µg RE/100g. The amount of vitamin A adults aged 19 to 64 need is 700 µg a day for men 600 µg a day for women. Vitamin A is important for normal vision, the immune system, reproduction, and growth and development. Vitamin A also helps your heart, lungs, and other organs work properly.

Percent of the recommended amount (%DV) for an average 2,000-calorie diet based on 60 percent energy from carbohydrates, 10 percent from protein, and 30 percent from fats. The Calorie amount of the product was 222 g/100 grams. The product has 100 grams per serving. The product's calorie content is within the Recommended dietary allowance.

The Dietary Fiber Content of Guso Ice Cream Enhanced with Blue ternate 1.57 g/100 grams. In the 2016 ruling, the FDA increased the daily reference value (DRV) for dietary fiber from 25 grams per day to 28 grams per day.

Moreover, the amount of Vitamin A present in the product was less than 25 µg RE/100g. The amount of vitamin A adults aged 19 to 64 need is 700 µg a day for men 600 µg a day for women. Vitamin A is important for normal vision, the immune system, reproduction, and growth and development. Vitamin A also helps your heart, lungs, and other organs work properly.

The Vitamin C content of the product is less than 0.8 mg/100 grams. The recommended daily amount for vitamin C is 75 milligrams (mg) a day for women and 90 mg a day for men. During pregnancy, 120 mg a day is recommended. The upper limit for all adults is 2,000 mg a day.

Lastly, the Vitamin D3 content of the product is less than 0.42 mg/100g.

The data above signify that all the nutritive contents of "Guso (Euchema sp.) Ice Cream Enhanced with Blue Ternate" in the three treatments are within the recommended dietary allowance for Filipinos. 31 Hence it is a good fruit juice drink substitute for existing product in the market.

1.6 The Shelf-life of Guso *(Eucheuma sp.)* Ice cream Enhanced with Blue ternate

Sensory Qualities	Treatments	Desirable Quality	W1	W 2	W 3	W4	W 5	W 6	W 7	W 8
Color	T1	Light Blue green	**No Changes**							
	T2	Medium Blue green								
	T3	Bue green								
Aroma	T1	No Odor	**No Changes**							
	T2	No Odor								
	T3	No Odor								

Taste	T1	Sweet and Creamy	**No Changes**
	T2	Moderately Sweet and Creamy	
	T3	Slighlty Sweet and Creamy	
Texture	T1	Smooth	**No Changes**
	T2	Slightly Smooth	
	T3	Crystallized	

Shelf life is the period for which food will remain safe and fit for use, provided that it is kept in defined storage condition (Dominic Man,2015). It is interrelated to food safety since the freshness of the food is essential in making 31 a good quality product. Good product quality ensures customer satisfaction and good sale in return. Raw fruit/ or vegetable juice will keep well in the freezer for two to three months (Sindhu, R.,2018). Shelf-life of Guso (*Eucheuma sp.)* in ice cream all treatments were observed within the span of 2 months. Observation data showed that at the onset of 2 months, the color, flavor, aroma, and texture of the three treatments remained the same. Therefore, the shelf life of the Eucheuma ice cream expires more than 2 months after being stored at the standard temperature of ice cream, which is 0°F (-18°C) or colder.

Acceptability Level of Guso Ice Cream in terms of Color, Taste, Aroma and Texture

Treatments	SENSORY ATTRIBUTES	WM	DV	Rank	SENSORY ATTRIBUTES	WM	DV	Rank	SENSORY ATTRIBUTES	WM	DV	Rank	SENSORY ATTRIBUTES	WM	DV	Rank
Treatment 1		7.56	LVM	2		7.76	LVM	2		7.76	LVM	2		7.36	LVM	3
Treatment 2	APPEARANCE	7.83	LVM	1	TASTE	7.96	LVM	1	AROMA	8.06	LVM	1	TEXTURE	8.03	LVM	1
Treatment 3		7.56	LMV	2		7.23	LVM	3		7.60	LVM	3		7.40	LVM	2

The table shows that the three treatments are acceptable in terms of color, taste, aroma, and texture, with respondents describing them as "like very much." In terms of appearance, taste, aroma, and texture, the respondents prefer all of the Guso(*Eucheuma sp.)* Ice Cream Enhanced with Blueternate. In terms of numbers, all treatments achieve the highest average weighted mean. As a result, Guso Ice Cream Enhanced with Blueternate will be the market's alternative ice cream.

The difference in the sensory preference of the respondents on the three treatments of Guso *(Eucheuma spinosum)* Ice Cream Enhanced with Blueternate

Variables	*df*	*α*	Friedman Chi-Squared Test	*p-value*	Result	Decision
Treatments & Appearance	2	0.05	1.5556	0.45	Not Significant	Accepted
Treatments & Taste	2	0.05	8.3333	0.01	Significant	Rejected
Treatments & Aroma	2	0.05	2.0769	0.35	Not Significant	Accepted
Treatments & Texture	2	0.05	8.4902	0.01	Significant	Rejected

There is no significant difference on the appearance of the three treatments, $F_r(2) = 1.56, p = .459$.There is no significant difference on the aroma of the three treatments, $F_r(2) = 2.08, p = .354$.There is a

significant difference on texture among the three treatments, $F_r(2) = 8.49,\ p = .014$. The pairwise comparisons using Wilcoxon signed rank test with Bonferonni correction of $\alpha = \frac{0.05}{3} = 0.017$ showed that t1 & t2 and t2 & t3 are statistically significant with $p = .004$ and $p = .006$, respectively. There is a significant difference on texture among the three treatments, $F_r(2) = 8.33,\ p = .016$. The pairwise comparisons using Wilcoxon signed rank test with Bonferonni correction of $\alpha = \frac{0.05}{3} = 0.017$ showed that t1 & t2 and t2 & t3 are statistically significant with $p = .004$ and $p = .006$, respectively.

V. CONCLUSION

Based on the findings of the study, the Guso *(Eucheuma sp.)* Ice Cream Enhanced with Blue ternate in different treatments is acceptable. It contains food nutrients that are within the recommended dietary value. Treatment 2 was most preferred among the three Variants. Hence, Guso *(Eucheuma sp.)* Ice Cream Enhanced with Blueternate is a feasible nutritious organic Ice Cream produced for consumption and commercialization.

VI. RECOMMENDATIONS

1. The researcher may improve the appearance and aroma to make it more distinctive and appealing to smell.

2. The administration may provide financial assistance for further production of ice cream as an Income Generating Enterprise of the university.

3. Community immersionists may adopt this Organic Ice Cream for innovation to augment the Ice Cream market value in the community.

4. Entrepreneurs may consider this Guso (*Eucheuma sp.)* Ice Cream Enhanced with Blueternate production as one of their business ventures.

5. The administration may collaborate with various extension linkages in promoting the Guso (*Eucheuma sp.)* Ice Cream Enhanced with Blueternate innovation to the community and the market as well.

6. Farmers may consider cultivating more Guso and Blueternate to support the raw material demand when the product is mass-produced for commercialization.

7. The researcher may secure the intellectual property protection of the product by patenting its process and composition.

8. Future researchers who wish to undertake a parallel study may try other flavors and ingredient

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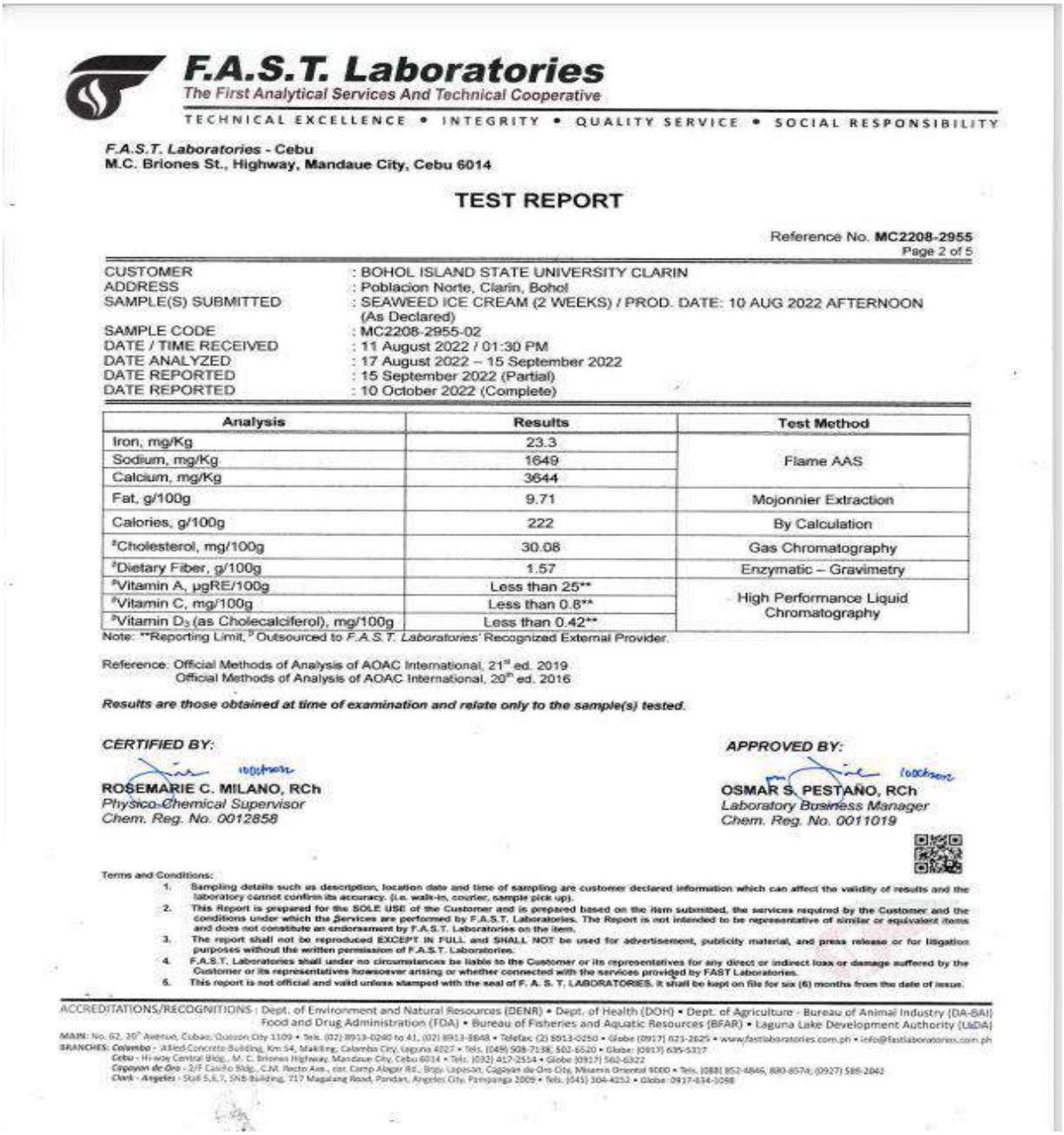
Areas of Concern	**Objectives**	**Strategy**	**Persons Involved**	**Time Frame**	**Budget Allocation**	**Outcomes**
1.Secure Permit to Conduct the Study.	To write a letter of permission to conduct the study	Send letter of permission to the administration and the honorable mayor of Municipality of Clarin	● Researcher ● Faculty ●Administrative staff	October 2021	P1,000.00	The researcher will be permitted to conduct the study with the support of the administration
2. Conduct the experiment per treatment, nutritional, and microbial analysis.	To be able to gather the data needed in the study	1.Conduct product testing 2. distribute fliers of the product 3. conduct product nutritional and microbial analysis 4. determine the marketability	● Researcher ● A resident of the Municipality of Clarin ● R.D.E. staff	December 2021	P 80,000.00	Product Tasting was done, data will be gathered, nutritional value, microbe and toxicology in the product was analyzed
3. Present the product to the market for marketability purposes	To determine the marketability of Guso Ice Cream	1. display the product at the municipality of Clarin Public Market	• Researcher • A resident of the Municipality of Clarin • R.D.E. Staff	January 2022	P 20,000.00	Introduced and developed the product through its product marketability
4. Extension Program	To transfer the Technology to the community (Technology Guide)	1.establish community linkage through the extension project of the university 2. conduct seminar- training on preparing for Guso Ice Cream	● School ● Community ● Researcher ● R.D.E. Staff	February 2023s	P20,000.00	Increase production of Guso Ice Cream from the extension.

5.Mass Production/ commercialization of the product	To generate income out from research output	1. protect intellectual property through patenting 2. conduct a market survey for a low-cost ingredient to produce affordable and quality product 3.produced capital for the people of the community	● Dean ● Faculty ● Researcher ● R.D.E. Staff ● Community	Year-round	P100,000.00	Mass-produced Guso Ice Cream and sell it.



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TEST REPORT

Reference No. **MC2208-2955**
Page 2 of 5

CUSTOMER : BOHOL ISLAND STATE UNIVERSITY CLARIN
ADDRESS : Poblacion Norte, Clarin, Bohol
SAMPLE(S) SUBMITTED : SEAWEED ICE CREAM (2 WEEKS) / PROD. DATE: 10 AUG 2022 AFTERNOON (As Declared)
SAMPLE CODE : MC2208-2955-02
DATE / TIME RECEIVED : 11 August 2022 / 01:30 PM
DATE ANALYZED : 17 August 2022 – 15 September 2022
DATE REPORTED : 15 September 2022 (Partial)
DATE REPORTED : 10 October 2022 (Complete)

Analysis	Results	Test Method
Iron, mg/Kg	23.3	Flame AAS
Sodium, mg/Kg	1649	
Calcium, mg/Kg	3644	
Fat, g/100g	9.71	Mojonnier Extraction
Calories, g/100g	222	By Calculation
[3]Cholesterol, mg/100g	30.08	Gas Chromatography
[3]Dietary Fiber, g/100g	1.57	Enzymatic – Gravimetry
[3]Vitamin A, µgRE/100g	Less than 25**	High Performance Liquid Chromatography
[3]Vitamin C, mg/100g	Less than 0.8**	
[3]Vitamin D_3 (as Cholecalciferol), mg/100g	Less than 0.42**	

Note: **Reporting Limit, [3] Outsourced to *F.A.S.T. Laboratories'* Recognized External Provider.

Reference: Official Methods of Analysis of AOAC International, 21st ed. 2019
Official Methods of Analysis of AOAC International, 20th ed. 2016

Results are those obtained at time of examination and relate only to the sample(s) tested.

CERTIFIED BY:
ROSEMARIE C. MILANO, RCh
Physico-Chemical Supervisor
Chem. Reg. No. 0012858

APPROVED BY:
OSMAR S. PESTAÑO, RCh
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Microbial Assessment of Solid Waste and Bioaerosol Associated with Open Dumping Sites of the Kathmandu City, Nepal

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Abstract *— The study aims to isolate and identify bacteria and fungi (mold) present in solid waste and its associated bioaerosol in the Kathmandu city. A total of 10 samples; 5 different solid waste samples and 5 different bioaerosol samples, collected from 5 open dumping sites in the Kathmandu city, were transported to the microbiology laboratory of St. Xavier's College for processing. Standard microbiological procedures were followed for the identification of isolates. The Kirby-Bauer disk diffusion method was used to determine the antibiotic susceptibility of bacterial isolates following CLSI 2020 standards. In the collected solid waste samples, the bacterial colony count ranged from 1.27 × 10^8 to 2.8 × 10^8 CFU/ml, whereas the fungi colony count ranged from 1 × 10^5 to 4 × 10^5 CFU/ml. Bacterial colony counts from bioaerosol samples ranged from 116 to >300 CFU/90mm/15 minutes, whereas fungi colony counts were between 2 and 6 CFU/90mm/15 minutes. Out of 48 bacteria and 34 molds identified, Bacillus spp. (27%) and Aspergillus niger (29%) were found to be predominant than other isolates. Citrobacter spp., Salmonella spp., and Escherichia coli isolated from solid waste samples of dump site S3 showed maximum resistance to the different antibiotics used. The common microbial isolates from solid waste samples and bioaerosol samples included 7 different bacteria and 4 different molds. The presence of antibiotic-resistant bacteria and pathogenic fungi in waste dump sites pose public health-related risks.*

Keywords *— **Open dumping, Solid waste, Bioaerosol, Bacteria, Fungi, Antibiotic susceptibility***

I. INTRODUCTION

Solid waste can be either solid or semi-solid materials varying in physical and chemical characteristics based on their origin, usually generated as a result of anthropogenic activities, and comprises yard waste, food waste, plastics, wood, metals, papers, rubber, leather, batteries, inert materials, textiles, paint cans, and other sources that are difficult to categorize [1].

In many developing countries, such as Nepal, there is a widespread practice of open and unscientific disposal of waste [2], [3]. The existing practice of illegal dumping at unallotted locations, usually in streets, vacant spaces, and water streams has several environmental and public health-related implications [4], [5]. The healthcare, pharmaceutical, food and cosmetic industries, academic and industrial research laboratories, veterinary facilities, and household and animal discards are the largest generators of infectious waste products [6], [7]. The whole collection, processing, and disposal of solid waste is a labor-intensive operation with several chances of human exposure to microorganisms taking place at nearly every step along the way from the generation to disposal [6].

Bacteria and fungi are the most commonly identified organisms in solid waste [8]. The bacteria commonly isolated from the dumpsites include *Salmonella* spp., *Klebsiella* spp., *Pseudomonas* spp., *Bacillus* spp., *Lactobacillus* spp., *Streptococcus* spp., *Staphylococcus* spp., and *Micrococcus* spp., while fungal species include

Penicillium spp., *Mucor* spp., *Aspergillus* spp., *Fusarium* spp., *Saccharomyces* spp., and *Candida* spp., [9]–[11]. *Escherichia coli*, *Proteus mirabilis*, *Staphylococcus sciurii*, *Staphylococcus xylosus*, *Aspergillus fumigatus*, and *Aspergillus flavus* are involved in the degradation of solid waste [12].

Solid waste can release bioaerosols which are airborne entities that either contain microorganisms or biological materials derived from living organisms, mixed with solids or fluids [13], [14] with particle size ranging from 0.001 nm to 100 µm [15]. Due to their controlling influence on the growth of microorganisms, environmental factors like temperature and moisture content can significantly affect the amount of bioaerosol formation and dispersion [16]. Albeit good management and maintenance, landfills can emit and disperse bacterial and fungal aerosols up to a distance of 1000–1200 m, which implies that the vicinity may pose risks to its neighboring residents [17]. Because of their minimal size, bioaerosols can easily deposit in different parts of the body via the lungs and circulatory system [15]. Bacteria and fungi are the major microbial constituents along with their endotoxins, mycotoxins, and allergens [18].

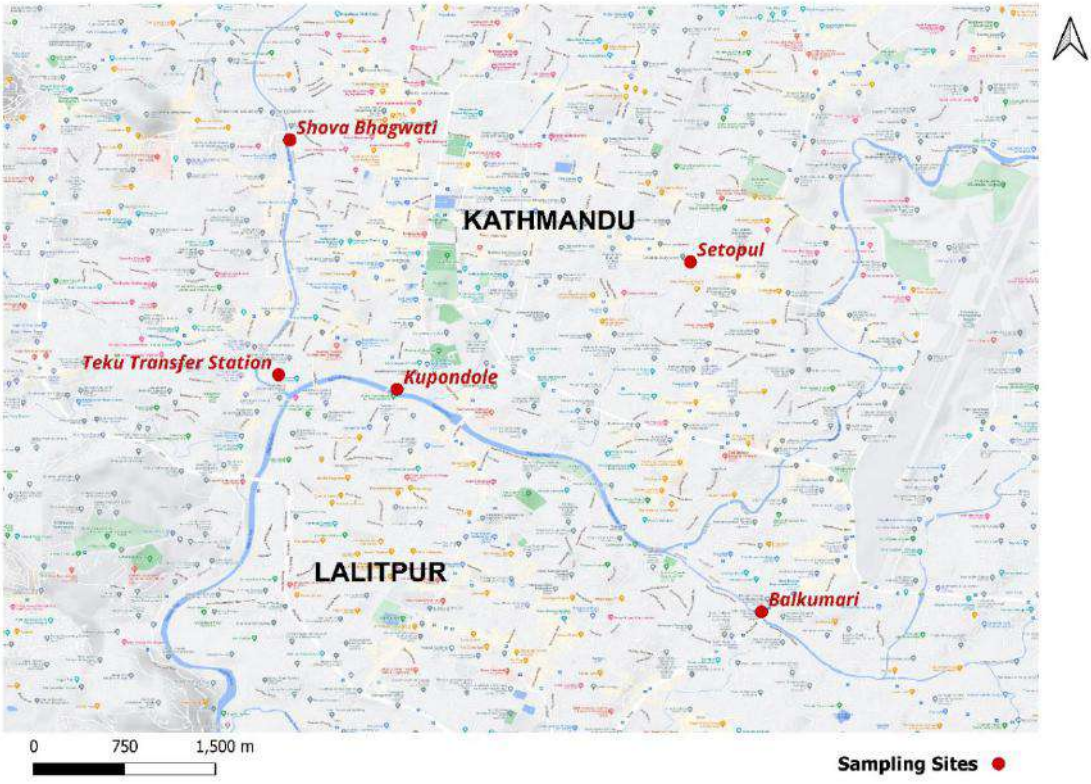
The commonly isolated bacteria during bioaerosol testing of samples collected from municipal solid waste were mostly from *Enterobacteriaceae* family which included *Escherichia coli*, *Salmonella*, *Enterobacter*, *Klebsiella*, *Serratia*, and *Proteus* species [17], [19]. Similarly, *Bacillus*, *Streptococcus*, *Staphylococcus aureus*, and *Clostridium perfringens* are also reported [20], [21]. *Aspergillus fumigatus* is the most identified fungus [22]–[24]. Other reported fungi include *Penicillium*, *Alternaria*, *Cladosporium*, *Mucor*, *Rhizopus*, and *Fusarium* [17], [19].

Solid wastes and their bioaerosols have a comparative relationship leading to various diseases in humans caused by various microorganisms, especially bacteria and fungi [21]. This study intends to account for different bacteria and fungi present in solid waste and bioaerosol samples isolated from open solid waste dumping sites in the Kathmandu city.

II. MATERIALS AND METHODS

Study design, study area, and sample size

A random sampling method was employed comprising field visit for sample collection followed by laboratory-based procedures for processing. Kathmandu city was selected the study area. Solid waste samples and bioaerosol samples were collected from various open solid waste dumping sites. Samples were collected from *Kupondole*, *Balkumari*, *Seto pul*, *Shova Bhagwati*, and *Teku* Transfer Station. A total of 10 samples; 5 different solid waste samples and 5 different bioaerosol samples, were collected from 5 different open waste dumping sites.



Sample collection and transportation

For solid waste samples, surface waste was carefully removed using sterile forceps. A sterile spatula was used to scoop the subsurface at the depth of 10 cm. About 10 grams of solid waste sample was transferred to a sterile plastic container [11].

Bioaerosol samples were collected by exposing culture media plates to the same open dumping site's air for 15 minutes, where solid waste samples were collected [25]. The plates were then sealed with parafilm tape.

The selectively used culture media plates included Plate Count Agar (PCA), Xylose Lysine Deoxycholate Agar (XLD), MacConkey Agar (MA), Cetrimide Agar (CA), Mannitol Salt Agar (MSA), and Sabouraud Dextrose Agar (SDA).

Samples were labeled properly, kept inside the ice box maintaining a temperature of 4ºC and then transported to the Microbiology Laboratory of St. Xavier's College, Kathmandu. The collected samples were processed within 2 hours of collection.

Sample processing

One gram of solid waste sample was weighed and transferred to 9 ml sterile saline. Serial dilution was performed up to 10^{-6} dilutions. Then, 0.1 ml sample, from 10^{-2}, 10^{-4}, and 10^{-6} dilutions, was inoculated into different respective culture media plates (PCA, XLD, MA, CA, MSA, and SDA) [11].

Bioaerosol samples collected in culture media plates were incubated directly.

Isolation of bacteria and fungi (mold)

For isolation of bacteria in solid waste samples, the respective culture media were incubated at 37°C for 24 hours. Bacterial counts were made from plates with 30-300 colonies. The calculation of the total number of bacteria was done by multiplying the number of colonies and dilution by the volume of sample used. Colony morphologies of similar-looking, selective bacterial colonies were recorded and subcultured on Nutrient Agar (NA) plates and incubated at 37°C for 24 hours [26].

For isolation of fungi (mold) from solid waste samples, SDA plate was incubated at 28°C for 120 hours. The total number of fungi (mold) was calculated by multiplying the number of colonies and dilution by the volume of sample used. Each distinct fungus (mold) was subcultured on SDA plates using the point-inoculation technique and incubated at 28°C for 72 hours [26].

The exact protocol was followed for the isolation of bacteria and fungi (molds) from bioaerosol samples, while only the microbial enumeration was performed by calculating the total number of colonies as a colony forming unit (CFU)/90 mm plate/exposure time [25].

Identification of bacteria and fungi (mold)

The isolated bacterial colonies were identified using standard microbiological techniques which comprised colony morphology, Gram-staining reactions, and various biochemical properties while fungi (mold) were identified based on colony morphology and lactophenol cotton blue (LPCB) staining [26]–[28].

Antibiotic susceptibility test (AST)

The selection of culture media (Mueller Hinton Agar) and antibiotic discs were as per the Clinical and Laboratory Standard Institute (CLSI) guidelines 2020 [29]. AST was performed by the Kirby-Bauer disk diffusion method [30].

Isolated colonies from NA plates were taken and incubated in nutrient broth at 37º C for 6 hours and the turbidity of the broth was matched with 0.5 McFarland standard. A sterile cotton swab was used to evenly inoculate the Mueller Hinton Agar (MHA) surface three times while rotating the plate containing the culture. At room temperature, the plates were allowed to dry for 20 minutes. Upon incubation of the plates at 37ºC for 24 hours, the zone of inhibition around the antibiotic discs was observed. The diameter of the inhibition zone was measured and reported as susceptible, intermediate, and resistant according to the CLSI guidelines 2020.

The antibiotics used were Cefotaxime (30µg), Meropenem (10µg), Gentamycin (10µg), Ofloxacin (5µg), Imipenem (10µg) and Nalidixic Acid (30µg), Chloramphenicol (30µg), Ampicillin (10µg), Azithromycin (15µg), and Amoxicillin (10µg).

III. RESULTS

A total of 90 bacteria and 34 molds were isolated from 5 different solid waste samples and 5 different bioaerosol samples, where 54 bacteria and 15 molds were from solid waste samples, and 36 bacteria and 19 molds were from bioaerosol samples.

The results obtained are expressed as follows:

Microbial load of bacteria and fungi (mold)

The average bacterial load (CFU/ml) was enumerated from PCA plates and the average fungal load (CFU/ml) was enumerated from SDA plates collected from different dump sites (S1, S2, S3, S4, and S5).

In solid waste samples, the bacterial colony count ranged from 1.2×10^8 to 2.8×10^8 CFU/ml, whereas the fungi colony count ranged from 1×10^5 to 4×10^5 CFU/ml. In bioaerosol samples, the bacterial colony count ranged from 116 to >300 CFU/90mm/15 minutes, whereas fungi colony counts were between 2 and 6 CFU/90mm/15 minutes.

Table 1: Microbial load from solid waste samples

Dumpsite	Solid waste		Bioaerosol	
	Bacterial (CFU/ml)	Fungal (CFU/ml)	Bacterial (CFU/90mm/15 min)	Fungal (CFU/90mm/15 min)
S1	1.2×10^8	1×10^5	TMTC	2
S2	1.9×10^8	4×10^5	TMTC	2
S3	1.3×10^8	2×10^5	116	4
S4	2.4×10^8	4×10^5	217	5
S5	2.8×10^8	4×10^5	245	6

Distribution of identified bacteria

Out of 90 isolates, 48 isolates were identified; 29 isolates from solid waste samples and 19 isolates from bioaerosol samples, and included 9 different bacterial species.

Table 2: Distribution of identified bacteria

Organism	Solid waste					Bioaerosol				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Escherichia coli	1	1	1	1	1	-	-	-	1	-
Klebsiella spp.	1	-	-	1	1	-	-	-	-	1
Citrobacter spp.	1	-	1	-	-	-	-	1	-	-
Enterobacter spp.	-	1	-	-	-	1	1	-	1	-
Proteus spp.	-	-	-	1	1	-	-	-	-	-
Salmonella spp.	-	-	1	-	-	-	-	-	-	-
Staphylococcus aureus	-	1	-	1	1	1	-	1	-	-
Micrococcus spp.	1	1	1	1	1	1	1	1	1	1
Bacillus spp.	1	1	1	2	2	2	1	1	1	1
Total	**5**	**5**	**5**	**7**	**7**	**5**	**3**	**4**	**4**	**3**

Distribution of identified fungi (molds)

A total of 34 molds were isolated and identified, which included 9 different types of molds.

Table 3: Distribution of identified fungi (molds)

Organism	Solid waste					Bioaerosol				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Aspergillus niger	1	1	1	1	1	1	1	1	1	1
Aspergillus flavus	-	-	-	1	1	1	1	1	1	1
Aspergillus fumigatus	-	-	-	-	-	-	-	1	1	1
Aspergillus nidulans	-	-	-	-	-	-	-	-	-	1
Aspergillus tamarii	-	1	-	-	-	-	-	-	-	-
Trichoderma spp.	-	1	-	-	-	-	-	-	-	-
Neurospora spp.	-	1	-	-	-	-	-	-	-	-

Mucor spp.	-	-	1	1	1	-	-	1	1	1
Rhizopus spp.	-	-	-	1	1	-	-	-	1	1
Total	**1**	**4**	**2**	**4**	**4**	**2**	**2**	**4**	**5**	**6**

Antibiotic susceptibility test of identified bacteria from solid waste samples

A total of 10 different antibiotic discs of various concentrations were used against 7 different bacteria as per CLSI guidelines 2020. S represents Sensitive, I represents Intermediate, and R represents Resistant results.

Table 4: Antibiotic susceptibility test of identified bacteria from solid waste samples

Sample	Organisms	CTX	MRP	GEN	OF	NA	IPM	CPL	AMP	AZM	AMX
S1	*Escherichia coli*	S(31)	S(24)	S(25)	S(15)	S(31)	-	-	-	-	-
S1	*Citrobacter* spp.	I(24)	S(31)	S(18)	S(22)	S(22)	-	-	-	-	-
S1	*Klebsiella* spp.	S(27)	-	S(17)	S(26)	S(24)	S(27)	-	-	-	-
S2	*Escherichia coli*	S(29)	S(32)	S(22)	S(15)	S(30)	-	-	-	-	-
S2	*Enterobacter* spp.	S(28)	S(34)	S(28)	S(25)	-	S(29)	-	-	-	-
S2	*Staphylococcus aureus*	-	S(39)	S(25)	S(24)	-	-	S(30)	S(31)	-	-
S3	*Escherichia coli*	**R(9)**	**R(19)**	I(13)	S(19)	I(17)	-	-	-	-	-
S3	*Citrobacter* spp.	**R(11)**	**R(18)**	**R(12)**	**R(-)**	**R(-)**	-	-	-	-	-
S3	*Salmonella* spp.	S(27)	-	-	**R(15)**	**R(13)**	-	-	-	**R(9)**	**R(11)**
S4	*Escherichia coli*	S(28)	S(35)	S(16)	S(23)	S(29)	-	-	-	-	-
S4	*Klebsiella* spp.	S(30)	-	S(19)	S(30)	S(26)	S(32)	-	-	-	-
S4	*Proteus* spp.	S(31)	S(31)	S(15)	S(24)	**R(-)**	-	-	-	-	-
S4	*Staphylococcus aureus*	-	S(40)	S(27)	S(27)	-	-	S(29)	S(32)	-	-
S5	*Escherichia coli*	S(27)	S(30)	S(16)	S(26)	S(24)	-	-	-	-	-
S5	*Klebsiella* spp.	S(34)	-	S(18)	S(27)	S(24)	S(35)	-	-	-	-
S5	*Proteus* spp.	S(32)	S(30)	S(16)	S(22)	**R(-)**	-	-	-	-	-
S5	*Staphylococcus aureus*	-	S(39)	S(27)	S(24)	-	-	S(30)	S(32)	-	-

Antibiotic susceptibility test of identified bacteria from bioaerosol samples

A total of 10 different antibiotic discs of various concentrations were used against 5 different bacteria as per CLSI guidelines 2020. S represents Sensitive, I represents Intermediate, and R represents Resistant results.

Table 5: Antibiotic susceptibility test of identified bacteria from bioaerosol samples

Sample	Organisms	CTX	MRP	GEN	OF	NA	IPM	CPL	AMP	AZM	AMX
S1	*Enterobacter* spp.	S(29)	S(31)	S(28)	S(21)	-	S(42)	-	-	-	-
S1	*Staphylococcus aureus*	-	S(39)	S(25)	S(24)	-	-	S(30)	S(31)	-	-
S2	*Enterobacter* spp.	S(28)	S(34)	S(28)	S(25)	-	S(36)	-	-	-	-
S3	*Citrobacter* spp.	S(28)	S(34)	**R(12)**	S(26)	S(26)	-	-	-	-	-
S3	*Staphylococcus aureus*	-	S(30)	S(20)	S(21)	-	-	S(25)	S(25)	-	-

S4	*Escherichia coli*	S(35)	S(36)	S(17)	S(26)	S(27)	-	-	-	-	-
S4	*Enterobacter* spp.	S(32)	S(35)	S(17)	S(28)	-	S(25)	-	-	-	-
S5	*Klebsiella* spp.	S(31)	-	S(17)	S(24)	S(22)	S(32)	-	-	-	-

Common identified bacteria and molds between solid waste and bioaerosol

Out of 9 different bacteria identified and 9 different molds identified from solid waste samples and bioaerosol samples, 7 bacteria and 4 molds were common.

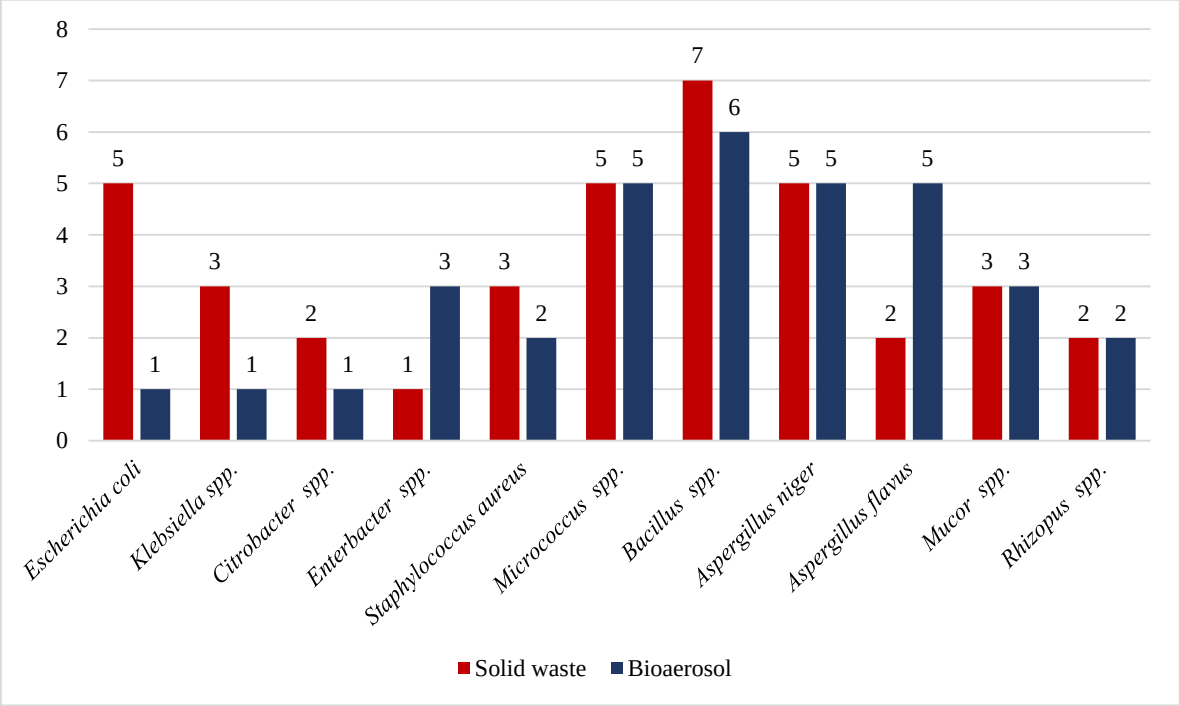
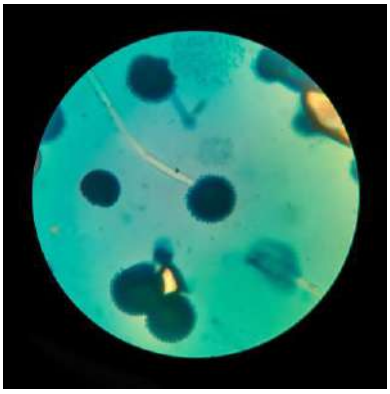


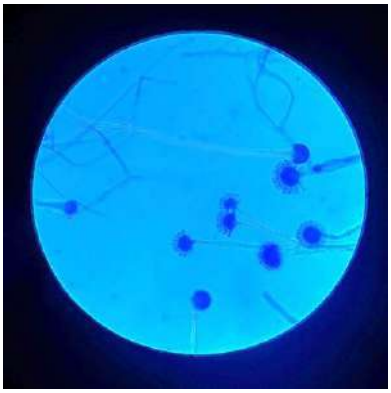
Fig.1: Common identified bacteria and molds between solid waste and bioaerosols

Photograph 1: Isolated colony of Aspergillus niger on SDA plate after incubation



Photograph 2: Aspergillus niger LPCB Staining (40X)

Photograph 3: Isolated colony of Aspergillus flavus on SDA plate after incubation



Photograph 4: Aspergillus flavus LPCB Staining (40X)

Photograph 5: Dumpsite 5 - Teku Transfer Station

IV. DISCUSSION

Isolation of microbes is an essential step in the microbiological studies performed to obtain pure cultures [31]. Depending on environmental conditions and stresses, microorganisms exist in different metabolic states and growth phases, whereas active replication of cells is not included in all the states [32].

In both the samples of solid waste and bioaerosol, the bacterial load is higher than the fungal load (Table 1). When compared to the other habitats, the soil environment is recognized to be heterogeneous, rich in substrates, and supports the highest bacterial species [33], while air harbors less diverse and more homogenized bacterial communities [34]. The growth rates of prokaryotes vary widely, with doubling times ranging from under 10 minutes to several days for laboratory-reared organisms. However, the majority of prokaryotic organisms' optimum or even adequate culture conditions are unknown, making it challenging to determine the true diversity of microbial maximal growth rates [35].

In solid waste samples (Table 2), *Bacillus* spp. constituted the higher percentage (27%) followed by *Micrococcus* spp. (17%), *Escherichia coli* (17%), *Klebsiella* spp. (10%), *Staphylococcus aureus* (10%), *Citrobacter* spp. (7%), *Proteus* spp., (7%) and, *Enterobacter* spp. and *Salmonella* spp. (4% each) which were similar to the finding of Sitotaw et al., (2021) [36]. A study by DM et al., (2017) and Emmanuel et al., (2017) isolated *Bacillus* spp., *Streptococcus* spp., *Staphylococcus* spp., and *Micrococcus* spp. from solid waste [8], [11].

Bioaerosol samples (Table 2) also resulted in the highest percentage of *Bacillus* spp. (32%) while *Escherichia coli*, *Klebsiella* spp., and *Citrobacter* spp. constituted the least; 5% which was similar to the findings of Kaźmierczuk and

Bojanowicz-Bablok (2014), Agarwal et al., (2016), and Frączek and Kozdrój (2016) who performed research on bioaerosol concentration in the air surrounding the municipal solid waste landfill [12], [17], [20].

The wide range of physiological abilities such as extracellular enzymes, formation of extremely resistant endospores to harsh physical and chemical conditions, and production of metabolites with antagonistic effects on other microorganisms are likely to be the causes of *Bacillus* spp. relatively higher percentage [37]. The presence of microorganisms in solid waste as well as in bioaerosol, particularly pathogenic organisms such as *Escherichia coli*, *Klebsiella* spp., *Citrobacter* spp., and *Aspergillus flavus* can trigger respiratory symptoms and gastrointestinal diseases which is discussed by Nair (2021) [21]. This can corroborate the fact that open dumping sites can be the source for the emission and dispersal of pathogenic bacteria as bioaerosols.

From solid waste samples (Table 3), the identified molds included *Aspergillus niger* (33%) which was predominant followed by *Mucor* spp. (20%), *Aspergillus flavus* (13%), *Rhizopus* spp. (13%), and *Aspergillus tamarii*, *Trichoderma* spp., and *Neurospora* spp. (7% each). A study by Ashraf et al., (2017) reported the presence of *Aspergillus niger*, *Aspergillus flavus*, *Penicillium expansum*, and *Trichoderma harzianum* in kitchen waste [38]. Similarly, *Aspergillus* spp. and *Mucor* spp. were reported by Janet and Kelechi (2016), and Emmanuel et al., (2017) from municipal solid waste [10], [11].

From bioaerosol samples (Table 3), *Aspergillus niger* and *Aspergillus flavus* constituted 26% of the total mold identified followed by *Aspergillus fumigatus* (16%), *Mucor* spp. (16%), *Rhizopus* spp. (11%), and *Aspergillus nidulans* constituted 5% which was similar to the findings of Breza-Boruta (2012), and Patil and Kakde (2017) [19], [40].

Most of the molds isolated from solid waste and bioaerosol samples were similar, whereas some were unique particular to the sample site and nature of the sample. Fungi's ability to grow and reproduce for prolonged periods of time, their capacity for branching and bifurcation, as in the case of *Aspergillus* species, and their ability to excrete goloco-protein, as in the case of *Mucor* species, may all contribute to their presence [39]. *Aspergillus* spp. is widespread and makes use of a variety of nutrients and can grow on the majority of organic and inorganic nutrients and does not require any particular nutrients [41] which may be the reason for the higher percentage of *Aspergillus* spp. found in both samples. *Aspergillus fumigatus* and *Aspergillus flavus* are the most potent fungi known for causing respiratory illness in humans, such as allergic bronchopulmonary aspergillosis, chronic pulmonary aspergillosis and invasive aspergillosis [42], especially in immunocompromised people. Prolonged exposure to the air around these dumping sites leading to the inhalation of sufficient spores of fungi can give rise to several fungal-related diseases.

Bacteria like *Pseudomonas*, *Streptococcus*, *Serratia*, *Acinetobacter*, and *Clostridium* species and fungi like *Penicillium*, *Fusarium*, *Alternaria*, and *Cladosporium* species were not detected [10], [17], [21]. Numerous factors, including variations in the complexity of the disposed waste and physicochemical characteristics of the dump site, may be responsible for the difference in microorganisms found in this study and earlier studies. A diverse community of microorganisms may exist at the dumpsite due to the environment's variability [36].

Bacterial pathogens, mainly Gram-negative than Gram-positive, are among the leading pathogenic microorganisms and have been posing serious public health problems globally by developing antibiotic resistance (ABR) [36], [43]. ABR was highly observed in bacteria *Citrobacter* spp., *Salmonella* spp., and *Escherichia coli* isolated from dump site S3 with the antibiotics used while *Klebsiella* spp., *Enterobacter* spp., and *Staphylococcus aureus* were found to be sensitive (Table 4). A study by Emmanuel-akerele and Peter (2020), and Bashir et al., (2021) reported similar findings [44], [45]. *Salmonella* spp. and *Escherichia coli* are listed in Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report [46] because of their extensive resistance to different classes of antibiotics. Increased antibiotic resistance of *Citrobacter* spp. has been reported worldwide, with some strains harboring extended-spectrum β-lactamase (ESBL) [47]–[49]. The antibiotic resistance observed in *Proteus* spp. to Nalidixic Acid has also been reported in studies conducted by Pathirana et al., (2018) and Bashir et al., (2021) [44], [50]. Ventola (2015) describes excessive use, inappropriate prescribing, extensive agricultural use, lack of new antibiotics, and regulatory barriers are the major reasons for ABR [51]. The occurrence of a high level of antibiotic resistance to commonly used antibiotics could pose a risk of spreading the ABR to opportunistic pathogens, ultimately giving rise to different public health-related hazards. This demands a proper waste management system, as well as research programs to monitor for antimicrobial resistance determinants in municipal solid wastes [36].

Bacillus spp. and *Micrococcus* spp. were the most common among the identified bacteria in both solid waste and bioaerosol samples while *Aspergillus niger* and *Mucor* spp. were the most common among identified molds (Figure 1). Occurrence of the same organism in two different samples can imply that bacteria and molds present in solid waste of open dumping sites can be aerosolized.

V. CONCLUSION

Open dumping of solid waste is a common practice in Kathmandu city where dumping sites are mostly located in close proximity to the human settlement areas. This solid waste harbors different bacteria and molds and can be aerosolized. Due to the presence and distribution of antibiotic-resistant bacteria in waste dump sites there is a risk of spreading antibiotic resistance to opportunistic pathogens. *Aspergillus fumigatus* and *Aspergillus flavus* observed in bioaerosol samples are known for their pathogenic effects. The occurrence of these pathogenic organisms present the possibility of public health hazards. Development of proper waste disposal sites far away from residential areas of Kathmandu city and periodic monitoring of antibiotic resistance is imperative.

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Relationship between traffic density, metal accumulation, pollution status, and human health problems in adjoining soils and vegetables within the South-South Region of Nigeria

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Abstract**—** *Road transport is associated with the elevation of trace metals in the adjoining soils and vegetables and rate of metal accumulation on these media is directly related to the traffic density. This research investigated the association between traffic density, metal accumulation, pollution status, and human health problems in adjoining soils and vegetables within the southern Region of Nigeria. Top soils and vegetables (Vernonia amygdalina and Jatropha tanjorensis) were obtained from roadsides along roads with high traffic density namely: Abak, Aka, Ikot Ekpene, Nwanaiba, and Oron. Top soils and vegetables were also obtained from roadside along a road with low traffic density (Ekpri Nsukara) and used as the Controls. These samples and their Controls obtained within Uyo Metropolis using standard procedures were subjected to acceptable analytical treatments and determined the levels of Cd, Cu, Fe, Ni, Pb, and Zn using Spectroscopic methods. Results obtained revealed that, the mean concentrations of these metals in studied soils and vegetables were within their acceptable limits by FAO/WHO. However, higher mean concentrations of these metals were obtained in soils and vegetables from roads with high traffic density than in the Control. Higher mean levels of all the metals were recorded in J. tanjorensis than in V. amygdalina. The contamination factor of the metals in soil varied between moderate and very high contamination classes. The ecological risk factor of the metals ranged from low to the very high risk classes for the respective metals. Potential ecological risk factor revealed very high risks for the metals determined. Higher transfer factors were obtained for J. tanjorensis than V. amygdalina, though below one. Principal component analysis identified one key factor for the accumulation of these metals in the studied soils and vegetables. The metals were within their oral reference doses but, Cd and Pb were above their recommended daily intake limit. The consumption of V. amygdalina and J. tanjorensis exposed the consumers to risks associated with high Cd and Pb, respectively though; the consumers of J. tanjorensis were generally more susceptible to more non-cancer risks. The potential cancer risks associated with the trace metals via the consumption of the studied vegetables varied between the low and moderate cancer risk classes. However, the target cancer risk values obtained for the metals were higher than the threshold risk limit for ILCR < 1 × 10^{-4} by USEPA. The total cancer risk revealed that, Cd and Cu were the major carcinogens in the studied vegetables while, the consumers of V. amygdalina have a higher risk of developing cancer than J. Tanjorensis. The study has shown the relationship between road transport and traffic density on the*

accumulation of metals in soil and vegetables. Health risks associated with the exposure to metals via the consumption of the studied vegetables has also been exposed.

***Keywords*— Road transport, Traffic density, Roadside soil, Roadside vegetable, Pollution risk, Human health risks, Southern Nigeria.**

I. INTRODUCTION

The aspirations of human beings on earth have modified the natural settings of the environment thereby resulting the serious degradation and devastations (Ebong *et al*., 2014). Road transport as one of the human aspirations is major routes for metals accumulation in soil and plants. Globally, the negative impact of road transport is becoming a serious problem to human health. Vehicular emission is one of the main causes of the contamination of roadside soil and vegetation by toxic metals (Nabulo and Oryem-Origa, 2006; Chen *et al*., 2010; Ekundayo and Fatoba, 2020). These metals through biogeochemical cycling are transferred to the roadside vegetables and eventually impact negatively on the health of the consumers. However; the impact related to road transport in an area is directly proportional to the traffic density (Chen *et al*., 2010). Worldwide, human beings depend on vegetable as a good source of vitamins, essential metals, nutrients and antioxidants (Ali *et al*., 2020; Dada *et al*., 2021). As at 2005, literature has shown that there were almost 8.0 billion of cars on the roads globally and the number is expected to be higher now (Mavrin *et al*., 2020). Currently, within the European Union Nations road transport is the source of almost 73% of the carbon (IV) oxide emissions and the major route of environmental contamination/pollution (Mavrin *et al*., 2020). Considering the negative impact associated with exposure to roadside soils and vegetables, these media should be closely monitored to avert serious health hazards on the consumers (Jankowski *et al*., 2015).

Studies have shown that roadside dust and soils contain high level of trace metals (Adamiec *et al*., 2016; Ebong and Moses, 2016; Krailertrattanachai *et al*., 2019). Road transportation affects the metal loads of adjoining soils and vegetables through diverse ways such as combustion of fuel and lubricants, asphalt, tyres, abrasion of brake linings and pads (Radziemska and Fronczyk, 2015; Penkała *et al*., 2018; Fussell *et al*., 2022). Cd in roadside soils and plants originates mainly from the combustion of fuel and lubricants, asphalt, brake lining abrasion and tyres (Lindgren, 1996; Akbar *et al*., 2006; Pulles *et al*., 2012). The utilization of Zn for tyre and engine oil production as additive has resulted in the accumulation of the metal in roadside soil and plants caused by tyre attrition and oil leakage (Councell *et al*., 2004; Adamiec *et al*., 2016). Brake abrasion, combustion of fuel and lubricants, and corrosion of tyre are the major sources of Cu and Ni in relation to road traffic (Hjortenkrans *et al*., 2007; Lu *et al*., 2009). Fuel and lubricant oil combustion, tyre corrosion and brake lining are the sources of Pb to roadside soils and plants (De Miguel *et al*., 1997; Ikenaka *et al*., 2010; Apeagyei *et al*., 2011). The accumulation of Fe in the studied roadside soils and vegetables is closely related to abrasion of brake (Apeagyei *et al*., 2011; Adamiec *et al*., 2016; Skorbiłowicz *et al*., 2020; Skorbiłowicz *et al*., 2021).

Reports have revealed that, apart from the greenhouse gases emanated from road transport, other harmful substances have also been released into the human environment (Condurat *et al*., 2017; Nwagbara and Iyama, 2019; Gnap *et al*., 2020; Mavrin *et al*., 2020). The negative impact of these toxic substances released will eventually manifest in human health (Briffa *et al*., 2020). Consequently, the inhabitants of an area with high traffic density should be aware of the harmful effects associated with the cultivation and subsequent consumption of edible plants by the roadside and possibly proffer some management measures.

Studies on the impact of road transport on metal loads in roadside soils and plants abound both within and outside Nigeria (Aslam *et al*., 2013; Tanee and Albert, 2013; Mohammed *et al*., 2019; Olajumoke and Ojo, 2020; Kuklová *et al*., 2022). Nevertheless, most studies conducted in the Study area concentrated specifically on the impact of road transport on the contaminants loads on air environment without assessing the metal loads on the adjoining soils and vegetables. Previous researches never assessed the health risks related to the consumption of vegetables from roadsides with high traffic density (Akpan *et al*., 2014; Mmom and Essiet, 2014; Ebong and Moses, 2016; Daniel *et al*., 2017).

One of the major problems of accurate management of traffic congestion is inadequate data collected. Hence, the installation and utilization of efficient technology including traffic lights that can provide accurate data on the traffic density and improve the traffic flow at all the necessary points in an area should be encouraged (Shepelev *et al*., 2020; Villagra *et al*., 2020).

This study has evaluated the impact of road transport on the metal loads in soil and vegetables from roadsides with high and low traffic density. It has also assessed the human health risks (non-carcinogenic and cancer related) associated with the utilization of vegetables

from roadsides with high traffic density. The pollution status of trace metals associated with road transport in roads with high and low traffic density has also been appraised. Hence, the gap that existed in the area of road transport and the associated negative impact on adjoining soil, plants and the consumers in Uyo has been closed by this research. It is the belief of the authors that, the findings of this study will benefit the road users, Town Planners, consumers, road transport workers, civil Engineers, and environmental workers.

II. MATERIALS AND METHODS

Study Area

Uyo is the capital of Akwa Ibom State and is lying between latitudes 4°52′N and 5°07′N) and longitudes (7°47′E and 8°03′E). Uyo has a land mass of approximately 28.48km^2 and is located about 55km from the Atlantic Coast (Akpan *et al*., 2014). The State capital is bounded by many other local government areas namely: Ikono, Ibiono Ibom, Ibesikpo Asutan, Nsit Ibom, Etinan, Itu and Abak. The population of Uyo as at 2006 was 847,500 and the figure is expected to double this year 2023 (NPC, 2006). As a capital of a major oil producing State, the population and traffic density is expected to be high. Consequently, the volume of wastes generated and level of environmental contamination are also expected to be alarming. Uyo has dominant seasons, namely: dry (March to December) and wet (April to November). Based on the climatic conditions of the area, farming activities at both commercial and subsistent levels is highly favoured and various vegetables are cultivated and widely utilized in Uyo.

Sample Collection and Preservation

Top soil samples were collected at roadsides along roads with high traffic density according to Akpan *et al*. (2014) and Guaman *et al*. (2022) namely: Ikot Ekpene, Aka, Oron, Abak, and Nwanaiba using Soil Augar. Soil samples were also obtained from a road with low traffic density (Ekpri Nsukara) and used as the Control (Akpan *et al*., 2014; Guaman *et al*., 2022). The high and low traffic density classifications are Soil samples were collected at four different points at each location designated for this study and put together to form a composite sample for the location. Soil samples collected were dried under the sun for 3 days, homogenized and sieved. The sieved soil samples were preserved in dry polyethene containers for digestion and analysis.

At each of the locations where studied samples and Control were obtained, leaves of *Vernonia amygdalina* (Biter leaf) and *Jatropha tanjorensis* (Hospital too far) were also collected using stainless steel knife. The fresh leaves collected were washed first with tap water to remove dirt, then with distilled water and at last with deionized water. These leaves were later air dried, chopped into pieces and dried again in an oven at 60 ºC for 24 hours. Thereafter, the leaves were homogenized into powdered form with a porcelain mortar and pestle. The resulting material was preserved in polyethene containers for digestion and analysis.

Sample digestion and Analysis

One gram each of the samples was weighed into a 100ml beaker, and then 10ml of $HNO_3/HClO_4$ in the ratio of 2:1 was added on a hot plate with continuous stirring for complete digestion. The digested samples were later filtered into a 25ml volumetric flask and made to mark with deionised water. The total concentrations of metals in the soil and vegetables were analysed for in the filtrates obtained using UNICAM 969 atomic absorption spectrophotometer.

Pollution Indices Assessment

The pollution status of trace metals in the studied soils at the different locations investigated was established by the assessment of contamination factor, degree of contamination, ecological risk factor and potential ecological risk factor.

Contamination Factor (CF)

The contamination factor of trace metals in the studied roadside soils was assessed using Equation (1) below.

$$CF = \frac{Cm}{Bm} \text{ ---------- (1)}$$

Where Cm and Bm signify metal concentration in the studied soils and Control, respectively. According to Pekey *et al*. (2004) contamination factor is classified as low contamination (CF < 1), moderate contamination (1 ≤ CF ≤ 3), considerable contamination (3 ≤ CF ≤ 6), and very high contamination (CF > 6).

Degree of Contamination (C_{deg})

The degree of contamination of the different locations investigated was evaluated by the use of Equation (2).

$$C_{deg} = \Sigma CF \text{ ---------- (2)}$$

Where ΣCF represents the sum of contamination factor of the trace metals for a particular location. Contamination factor is classified as low degree of contamination when Cdeg < 8, moderate degree of contamination if 8 < Cdeg < 16, considerable degree of contamination when 16 < Cdeg < 32), and very high degree of contamination when Cdeg > 32 (Hakanson, 1980).

Ecological Risk Factor (ERF)

The ecological risk factor of trace metals in the studied soils was determined by the means of Equation (3).

$$ERF = TR\ x\ CF \text{----------} (3)$$

In Equation (3) above, Tr is the toxic-response factor of trace metals and CF stands for the contamination factor of metals. The response factor for each of the metals based on the report by Hakanson (1980) for Cd, Cu, Fe, Ni, Pb, and Zn are 30.0, 5.0, 1.0, 5.0, 5.0, and 1.0, respectively (Gbadamosi *et al*., 2018; Huang *et al*., 2020). According to Ren *et al*. (2007) ERF are classified as follows: ERF < 40 = Low ecological risk, 40 < ERF≤ 80 is Moderate ecological risk, 80 < ERF ≤ 160 = Appreciable ecological risk, 160 < ERF ≤ 320 = High ecological risk, ERF > 320 = Severe ecological risk.

Potential Ecological Risk Index (RI)

In this study, potential ecological risk index of the trace metals determined in the studied roadside soils was evaluated using Equation (4).

$$\text{RI} = \Sigma(ERF) - - - - - - - - - - - - - - - - - (4)$$

Where Σ(ERF) represents the summation of all the metals determined at each of the roads investigated. According to Ren *et al*. (2007) RI is divided into various classes namely: RI < 150 is low ecological risk, 150 < RI < 300 indicates moderate ecological risk, 300 < RI < 600 signifies high ecological risk, and RI > 600 shows significantly high ecological risk.

Transfer Factor (TF)

The transfer factor of trace metals from soil to vegetable was computed using Equation (5).

$$TF = \frac{Mp}{Ms} \text{----------} (5)$$

Where Mp indicates the mean metal concentration in the vegetables, while Ms Stands for the metal concentration in the studied soils.

Assessment of Health Risk

The probable human health risk associated with trace metals due to the consumption of the studied vegetables was appraised by assessing the daily intake rate (DIM), non-carcinogenic risk index (THQ), hazard index (HI), and target cancer risk (TCR) of the trace metals determined (Chary *et al*., 2008; Adedokun *et al*., 2016; Ogu and Akinnibosun, 2020; Asrade and Ketema, 2023).

Daily Intake Rate (DIM)

The daily Intake of trace metals via the consumption of the studied vegetables was calculated using Equation (6).

$$\text{DIM} = \frac{Cm\ x\ Cf\ x\ Dv}{Bwt} - - - - - - - - - - - - - - - - - (6)$$

Where Cm signifies the concentration ($mgkg^{-1}$) of trace metal in the studied vegetables, Cf is the Conversion factor from fresh to dry weight which is 0.085, Dv indicates the daily intake of vegetable (65 g/kg) while, Bwt shows the average body weight in kg per individual (65 kg) (Ojiego *et al*., 2022).

Total Hazard Quotient (THQ)

The non-carcinogenic risk index otherwise known as hazard quotient of the metals was evaluated using Equation (7).

$$THQ = \frac{DIM}{RfDo} \text{----------} (7)$$

In Equation (7) above, DIM is the daily intake rates of the trace metals through the consumption of studied vegetables and RfD indicates for the oral reference dose of the metals determined. The RfDo values of 0.001, 0.04, 0.700, 0.002, 0.0035, and 0.300 mg/kg/day were used for Cd, Cu, Fe, Ni, Pb, and Zn, respectively (USEPA, 2010).

Hazard index (HI)

Hazard index (HI) denotes the sum of all the hazard quotients (HQs) for all the metals determined was calculated with Equation (8).

$$HI = \Sigma HQ = HQCd + HQCu + HQFe + HQNi + HQPb + HQZn - - - - - - - - - - (8)$$

Where HI stands for hazard index and HQ is the hazard quotient of the metals determined in the vegetables. When the value of HI is less than one, the consumers of these vegetables are secured but if the HI value is equal to or higher than one, then the consumers are at risk of metal toxicity and related health problems (Cao *et al*., 2015)

Cancer risk assessment

Cancer risk shows the likelihood of the consumers of the studied vegetables developing cancer over a lifetime as a result of exposure to metals.

Incremental lifetime cancer risk (ILCR)

Incremental lifetime cancer risk (ILCR) by exposure to Cd, Cu, Ni, and Pb via the consumption of studied vegetables was estimated with Equation (9).

$$ILCR = CSF(oral)x\ DIM - - - - - - - - - - - - - (9)$$

Where CSF(oral) signifies the oral cancer slope factor for the metals and DIM is the daily intake rates of the trace metals. In accordance with USEPA (2020) the values of CSF are 0.38, 1.5, 1.7, and 0.0085 mg/kg/day for Cd, Cu, Ni, and Pb, respectively. There were no CSF values for the calculation of CR for Fe, and Zn. The tolerable range of predicted lifetime risk for carcinogens is 10^{-4} to 10^{-6} (USEPA, 2011).

Target Cancer Risk (TCR)

The TCR of Cd, Cu, Ni, and Pb through the consumption of the studied vegetables was evaluated using Equation (10).

$$TCR = \Sigma ILCR = ILCRCd + ILCRCu + ILCRNi + ILCRPb - - - - - - - - - - (10)$$

Where $\Sigma ILCR$ indicates the summation of incremental lifetime cancer risk of all the trace metals determined in the studied vegetables.

Data Analysis

Results of this research were subjected to statistical analysis with IBM SPSS Statistics 20 (IBM USA). Multivariate analysis was done on six (6) trace metals by means of Varimax rotation method, and values from 0.707 and higher were regarded as being significant.

III. RESULTS AND DISCUSSION

Table 1: Concentrations ($mgkg^{-1}$) of trace metals in the studied roadside soils and Control

	Cd	Cu	Fe	Ni	Pb	Zn
Ikot Ekpene Road	1.03	8.35	512.69	2.21	8.64	12.20
Aka Road	1.12	8.21	488.16	1.95	8.27	11.64
Oron Road	1.18	8.09	541.47	3.61	9.10	13.31
Abak Road	1.14	9.17	493.35	3.42	8.32	12.46
Nwanaiba Road	0.78	5.42	465.68	1.84	6.72	10.60
Minimum	0.78	5.42	465.68	1.84	6.72	10.60
Maximum	1.18	9.17	541.47	3.61	9.10	13.31
Mean	1.05	7.85	500.27	2.61	8.21	12.04
SD	0.16	1.42	28.47	0.84	0.90	1.01
Control	0.24	3.17	261.32	0.40	1.68	4.25
Recommended Limit	3.00[a]	100.00[b]	5000.00[b]	50.00[a]	50.00[a]	300.00[b]

a = FAO/WHO (1999); b = (FAO/WHO (2001)

Trace metal levels in roadside soils from roads with high and low traffic density

The concentration of trace metals in surface soils from roadsides with high traffic density and Control (road with low traffic density) are shown in Table 1. The concentrations of cadmium (Cd) varied from 0.78 $mgkg^{-1}$at Nwanaiba Road to 1.18 $mgkg^{-1}$ at Oron Road. This range is lower than 5.15 - 5.79 μgg^{-1} obtained in roadside soils in Jos by Abechi *et al*. (2010). Levels of lead (Pb) varied from 6.71$mgkg^{-1}$ in Nwanaiba Road to 9.10 $mgkg^{-1}$ at Oron Road. This range is lower than 3.02 - 30.08 $mgkg^{-1}$ reported in Ogun State by Adedeji *et al*. (2013). Zinc (Zn) ranged between 10.60 and 13.31 $mgkg^{-1}$ for Nwanaiba Road and Oron Road, respectively. The obtained range is below 26.46 - 215.02 $mgkg^{-1}$ reported in roadside soils at Białystok-Budzisko Route, North-eastern Poland by Skorbiłowicz *et al*. (2021). Iron (Fe) that indicated the highest concentration amongst the metals determined varied between 465.68 $mgkg^{-1}$ in Nwanaiba Road and 541.47 $mgkg^{-1}$ at Oron Road. These values are much lower than 67,100.00 – 187,800.00 ppm obtained in roadside soils at Dhaka Aricha highway, Bangladesh by Ahmed *et al*. (2016). Concentrations of nickel (Ni) ranged from 1.84 $mgkg^{-1}$in Nwanaiba Road to 3.61 $mgkg^{-1}$ at Oron Road. The obtained range is lower than 16.16-24.60 μgg^{-1} reported in roadside soils in Garki Area Council of Abuja, Nigeria by Kabiru *et al*. (2018). Concentrations of copper (Cu) ranged from 5.42 mgkg-1 in Nwanaiba Road to 9.17 mgkg-1 at Abak Road. This range is below 7.39 – 23.24 mgkg-1 obtained in roadside soils along Zaria-Giwa Road, Kaduna State, Nigeria by Upahi *et al*. (2021). Generally, the mean concentrations of all the metals in soil from roads with high traffic density were higher than the levels reported in soil from the road with low traffic density (Table 1). This is an indication of artificial inputs of these metals from road transportation into the studied roadside soils. Nonetheless, the mean concentrations of all the metals are within their recommended limits by FAO/WHO (1999) and (2001) (Table 1). However, since metals have the potential to bio accumulate and exhibit negative tendencies along the food chain, a regular assessment of their accumulation rates should be encouraged (Emurotu and Onianwa, 2017).

Table 2: Concentrations (mgkg^{-1}) of trace metals in the studied vegetables and Control

	Vernonia amygdalina						***Jatropha tanjorensis***					
	Cd	Cu	Fe	Ni	Pb	Zn	Cd	Cu	Fe	Ni	Pb	Zn
Ikot Ekpene Road	0.07	2.14	2.75	0.04	0.11	1.24	0.18	2.42	3.45	0.08	0.21	2.80
Aka Road	0.05	2.21	2.59	0.05	0.08	1.22	0.16	2.40	3.28	0.11	0.25	3.06
Oron Road	0.09	2.46	4.32	0.07	0.12	1.41	0.20	2.58	3.63	0.16	0.29	3.14
Abak Road	0.06	2.17	3.44	0.06	0.10	1.30	0.15	2.24	3.31	0.14	0.22	2.96
Nwanaiba Road	0.04	1.03	2.37	0.02	0.07	1.07	0.11	2.16	3.07	0.08	0.16	2.53
Minimum	0.04	1.03	2.37	0.02	0.07	1.07	0.11	2.16	3.07	0.08	0.16	2.53
Maximum	0.09	2.46	4.32	0.07	0.12	1.41	0.20	2.58	3.63	0.16	0.29	3.14
Mean	0.06	2.00	3.09	0.05	0.10	1.25	0.16	2.36	3.35	0.11	0.23	2.90
SD	0.02	0.56	0.79	0.02	0.02	0.12	0.03	0.16	0.21	0.04	0.05	0.24
Control	0.01	0.68	1.34	BDL	0.01	0.71	0.02	0.83	1.82	0.01	0.03	1.04
*Recommended Limit	0.2	73.3	425.5	67.9	0.3	99.4	0.2	73.3	425.5	67.9	0.3	99.4

*** FAO/WHO (2011).**

Trace metal levels in roadside vegetables from roads with high and low traffic density

Concentrations of trace metals in the vegetables (*Vernonia amygdalina* and *Jatropha tanjorensis)* from roadsides with high and traffic density are shown in Table 2. Generally, concentrations (mgkg^{-1}) of the trace metals determined varied as follows: 0.04 – 0.20, 1.03 – 2.58, 2.37 – 4.32 and 0.02 – 0.16 for Cd, Cu, Fe, and Ni, respectively. While the concentrations of Pb and Zn in both vegetables ranged from 0.07 to 0.29 and 1.07 to 3.14, respectively. Results in Table 2 indicate higher mean concentrations for the metals in vegetables from roads with high traffic density than the control site (Road with low traffic density). This shows anthropogenic addition of these metals to the soil from road transportation as previously opined by Naser *et al*. (2012). The study also revealed relative higher concentrations of the metals in *J. tanjorensis* than in *V. amygdalina.* The observed variations could be attributed to the difference in plant species, tolerance levels, growth rate etc as reported by Duman *et al*. (2009). Consequently, *J. tanjorensis* has higher potentials to accumulate these metals from a contaminated soil than *V. amygdalina.* It can also be deduced that, the cultivation of vegetables by the roadside should be discouraged to avoid bioaccumulation of toxic metals and associated health problems on the consumers. The utilization of *J. tanjorensis* from roadside as a medicine should also be discouraged since it is consumed raw without exposure to high temperature that may have reduced the metals load and their toxicities (Inobeme *et al*., 2020; Adjei-Mensah *et al*., 2021; Phrukphicharn *et al*., 2021). The level of Cd reported in this study is higher than that reported by Sulaiman and Hamzah (2018) whereas; concentrations of Cu are lower than that reported by Ogundele *et al*. (2015). Concentrations of Fe and Ni obtained in the studied vegetables are lower than values reported by Inoti *et al.* (2012) and Naser *et al*. (2012), respectively. Nevertheless, the concentrations of Fe reported for both vegetables were relatively higher than the concentrations of other metals. This is similar to the results obtained by Skorbiłowicz *et al*. (2021) in vegetables from roadsides with high traffic density. The mean values of Pb and Zn obtained in the studied vegetables are also higher than those reported by Olasupo *et al*. (2020) and Kuklová *et al*. (2022), correspondingly. However, the concentrations of all the metals determined in both vegetables are within the permissible limits for leafy vegetables by FAO/WHO (2011) (Table 2). Hence, these vegetables may be suitable for human consumption.

Pollution Indices of Trace metals in Roadside Soils

Contamination Factor

Table 3: Contamination factor and Ecological risk factor of trace metals in the studied roadside soils

	Cd	Cu	Fe	Ni	Pb	Zn	Cd	Cu	Fe	Ni	Pb	Zn
	Contamination Factor (CF)						Ecological Risk Factor (ERF)					
Ikot Ekpene Road	4.29	2.63	1.96	5.52	5.14	2.87	128.70	13.15	0.00	27.60	25.7	2.87
Aka Road	4.67	2.59	1.87	4.88	4.92	2.74	140.10	12.95	0.00	24.4	24.6	2.74
Oron Road	4.92	2.55	2.07	9.03	5.42	3.13	147.60	12.75	0.00	45.15	27.1	3.13
Abak Road	4.75	2.89	1.89	8.55	4.95	2.93	142.50	14.45	0.00	42.75	24.75	2.93
Nwanaiba Road	3.25	1.71	1.78	4.60	4.00	2.49	97.50	8.55	0.00	23.00	20.00	2.49

Results for the contamination factors (CF) of trace metals determined in roadside soils are shown in Table 3. CF values of the trace metals varied as follows: 3.25 – 4.92, 1.71 – 2.89, 1.78 – 2.07, and 4.60 – 9.03 for Cd, Cu, Fe, and Ni, respectively. The CF values for Pb and Zn ranged from 4.00 to 5.42 and 2.49 to 3.13, respectively. Based on the classifications by Pekey *et al.* (2004), Cd and Pb belong to the considerable contamination class. Cu and Fe are in the moderate contamination class while, the CF of Ni vary between considerable and very high contamination classes. Zn varies between moderate and considerable contamination class. The highest CF value was recorded for Ni at Oron Road. This can be attributed to the high traffic density in the area as reported by Zhang *et al.* (2012) and Kuklová *et al*. (2022). The sequence for CFs of trace metals determined in roadside soils follows the order: Ni>Pb>Cd>Zn>Cu>Fe. This reveals the high relative availability of toxic metals in the roadside soils than the essential ones. The results also indicate the various degree of trace metals enrichment in roadside soils by road transportation.

Ecological Risk Factor

The ecological risk factors (ERF) of trace metals determined in roadside soils are shown in Table 3. The ERF values for the metals varied as follows: 97.50 – 147.60, 8.55 – 14.45, 23.00 – 45.15, and 20.00 – 27.10 for Cd, Cu, Ni, and Pb respectively. The ERF for Zn ranged from 2.49 to 3.13 whereas; Fe has no ERF value because it is not considered as a toxic metal hence without a toxic response factor. Based on the classifications of Ren *et al.* (2007), Zn belongs to the low risk class while Cu varied between moderate and considerable risk classes. Ni and Pb belong to the high risk class while Cd is in the very high risk class. Consequently, living cells including humans exposed soils from these roads directly or indirectly are susceptible to high concentrations of Cd, Ni, and Pb alongside their attendants' health problems. This also indicates that, road transportation has the potential of elevating metal loads in adjoining soil environment (Wang and Zhang, 2018; Skorbiłowicz *et al*., 2021).

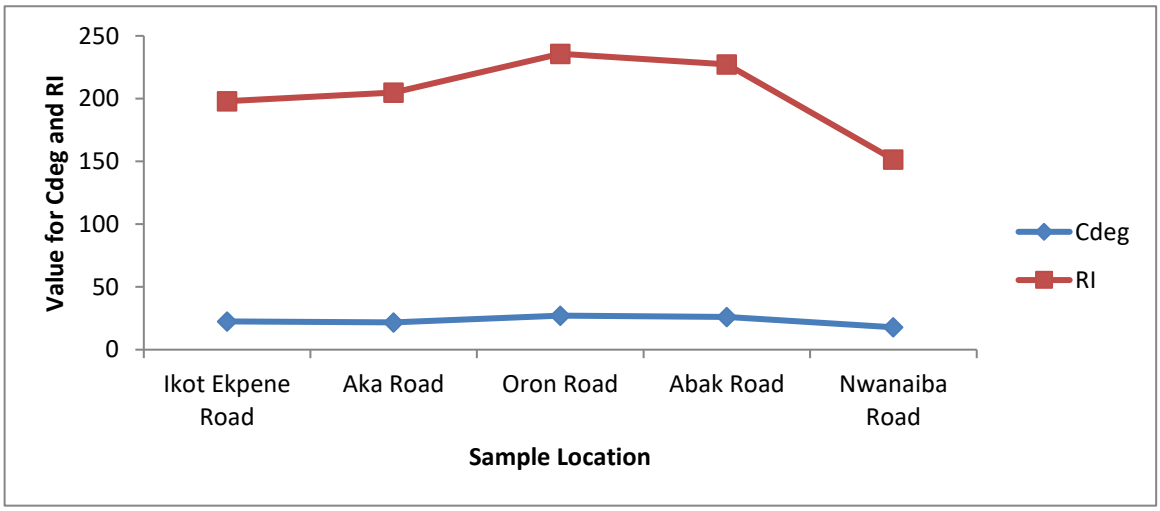

Fig.1: Degree of contamination (Cdeg) and Potential ecological risk index (RI) in the studied soils.

Degree of Contamination

Results for the degree of contamination (Cdeg) of the different roadside soils are illustrated in Figure 1. The results revealed that, Cdeg ranged for 17.83 at Nwanaiba Road to 27.12 at Oron Road. This reveals that the degree of contamination of the various roadside soils is exclusively in the considerable degree of contamination (Hakanson, 1980). The observed variations of Cdeg value from one road to the other may be due to the disparity in traffic density along each road. The Cdeg for the different roads investigated followed the trend Oron > Abak >Ikot Ekpene>Aka > Nwanaiba. This corroborates the findings by contamination factor in Table 3 concerning the high traffic density of Oron Road. The key contributors to the reported Cdeg for the studied roads are Cd, Ni, and Pb.

Potential Ecological Risk

Results for the potential ecological risk index (RI) for the studied roadside soils varied between 151.54 at Nwanaiba to 235.73 at Oron Road (Figure 1). This indicates that the potential effects of trace metals determined in the roadside soils are solely in the very high risk class (Ren *et al*., 2007). This is dangerous to those exposed to soils along these roads either directly or indirectly since high RI values is directly related to human health according to Mugosa *et al*. (2016). The RI values of trace metals in the different roads following the sequence: Oron>Abak>Aka>Ikot Ekpene> Nwanaiba. The high traffic density and the associated health problems along the food chain along Oron Road are also confirmed.

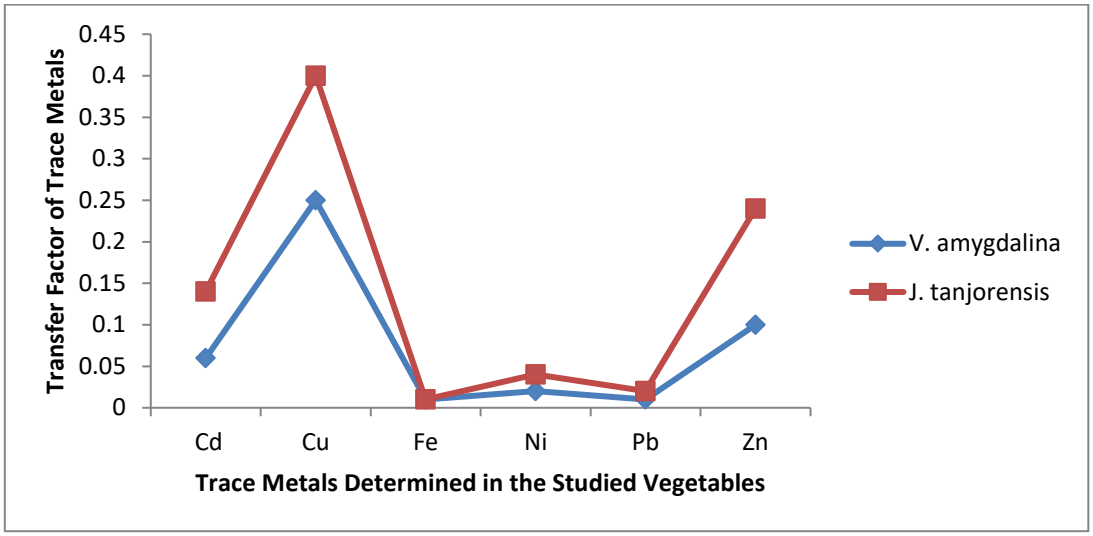

Fig.2: Transfer factor of trace metals from soil to vegetables

Transfer factor of Trace Metals from the Studied Soils to Vegetables

The transfer factor (TF) of a metal in vegetable indicates the level of such metal that is readily available along the food chain. Consequently, it is this level of the metal that can impact on the consumers of these vegetables (Chojnacka *et al*., 2005; Etuk *et al*., 2022). The mean transfer factors of the metals obtained in *V. amygdalina* are as follows: 0.06, 0.25, 0.01, 0.02, 0.01, and 0.10 for Cd, Cu, Fe, Ni, Pb, and Zn, respectively. However, relatively higher mean TF values were reported in *J. tanjorensis* for all the metals except Fe (Figure 2). The mean TF values of the metals in *J. tanjorensis* are 0.14, 0.40, 0.01, 0.04, 0.02, and 0.24 for Cd, Cu, Fe, Ni, Pb, and Zn, respectively. Accordingly, the consumers of these vegetables are more exposed to the trace metals determined via *J. Tanjorensis* than *V. amygdalina.* However, the transfer factors of all the metals were below one (1) which is consistent with the reports by Ebong (2015) and Baburo *et al*. (2022). Consequently, these vegetables could be applied as excluders and for phytostabilization but may not function effectively for phytoremediation (Suman *et al*., 2018; Nedjimi, 2021). The low TF values reported also signifies the low human exposure to these metals via the consumption of these metals (Jolly *et al*., 2013; Kulkarni *et al*., 2014).

Multivariate Analysis of Trace Metals in the Studied Soils

Table 4: Result of principal component analysis indicating relative loading for trace metals of the studied roadside soils and vegetables

	Soil	***V. amygdalina***	***J. tanjorensis***
Variable	Factor	Factor	Factor
Cd	0.936	0.938	0.940
Cu	0.845	0.890	0.924
Fe	0.880	0.917	0.932
Ni	0.812	0.933	0.764
Pb	0.963	0.920	0.974
Zn	0.984	0.996	0.920
% Total Variance	82.0	87.0	83.1
Eigen value	4.9	5.2	5.0

Results for the Principal component analysis of trace metals in the studied soils are shown in Table 4.The principal component analysis revealed one major factor responsible for the metal loads in the studied roadside soil, *V. amygdalina and J. Tanjorensis*. In soil, the factor has Eigen value of 4.9 and a total variance of 82.0% with significant positive loadings on all the metals determined in the soil. *V. amygdalina* has Eigen value of 5.2 and 87.0% total variance with strong positive loadings on all the metals. Eigen value and total variance of 5.0 and 83.1%, respectively were recorded for *J. Tanjorensis* with strong positive loadings on all the parameters (Table 4). This indicates exclusively the negative effects of road transportation on the accumulation of metals on roadside soil and plants as reported by Altaf *et al*. (2021) and Skorbiłowicz *et al*. (2021).

Health Risks Indices

Table 5: Results of non-carcinogenic hazard of trace metals determined in V. amygdalina and J. Tanjorensis from roadsides with high traffic density in Uyo metropolis

	Vernonia amygdalina						***Jatropha tanjorensis***					
	Cd	Cu	Fe	Ni	Pb	Zn	Cd	Cu	Fe	Ni	Pb	Zn
DIM	8.5E-4	1.70E-4	2.63E-4	4.24E-6	8.50E-6	1.06E-4	1.36E-5	2.01E-4	2.85E-4	9.35E-6	1.96E-5	2.47E-4
HQ	8.5E-3	4.25E-3	3.76E-4	2.12E-4	2.43E-3	3.53E-4	1.36E-2	5.03E-3	4.07E-4	4.68E-4	2.67E-2	8.23E-4
HI	1.61E-2						4.70E-2					

Daily intake rate (DIM) of trace metals through the consumption of V. amygdalina and J. Tanjorensis

The health implications of trace metals on human through the consumption of the studied vegetables could be established by the assessment of DIM (Etuk *et al*., 2022). Results for the daily intake rate of trace metals through the consumption of the studied vegetables are shown in Table (5). Results obtained revealed that, the mean DIM values for all the metals were lower than their recommended oral reference doses (RfDs) by USEPA (2010). The mean values for Cd and Pb were higher than their recommended daily intake (DI) limit of trace metals for the consumers studied vegetables between the ages of 19 and 70 years by (FDA 2001) and Garcia-Rico (2007). However, the mean DIM values of Cd and Pb were within their upper tolerable daily intake level (UL) by (FDA 2001) and Garcia-Rico (2007). This is consistent with the report by Adedokun *et al.* (2016) who obtained higher DI values for Cd and Pb. The low mean DI values for other trace metals reported is similar to the report by Ara *et al*. (2021). The mean DIM values for the trace metals followed the sequence Cd > Fe > Cu > Zn > Pb > Ni for *V. amygdalina* and Fe > Zn > Cu > Pb > Cd > Ni for *J. tanjorensis.*

Non-carcinogenic risks

Results for the non-cancer health risks THQ and HI of trace metals via the consumption of studied vegetables are shown Table 5. The mean THQ values of the metals through the consumption of both *V. amygdalina* and *J. Tanjorensis* was less than one. Hence, the consumption of the studied

vegetables may not pose serious health problems to the consumers (Kigigha *et al*., 2018). The low mean THQ values reported for the metals in this study is consistent with the findings by Adedokun (2016). The THQ of the exposure to metals via the consumption of *V. amygdalina* and *J. Tanjorensis* varied as follows: Cd>Cu>Pb>Fe>Zn>Ni and Pb>Cd>Cu>Zn>Ni>Fe, respectively. This reveals that, the consumers were more exposed to health risks associated with Cd toxicity and its attendants' health implications as reported by Jaishankar *et al*. (2014) via *V. amygdalina.* Whereas, the consumption of *J. Tanjorensis* may expose the consumers to Pb toxicity and the related health problems as reported by Kumar *et al*. (2020). Generally, relatively higher mean THQ values were reported for the trace metals via the utilization of *J. Tanjorensis* than *V. amygdalina.* Consequently, the consumption of *J. Tanjorensis* from roadsides with high traffic density may expose the consumers to high non-cancer health risks.

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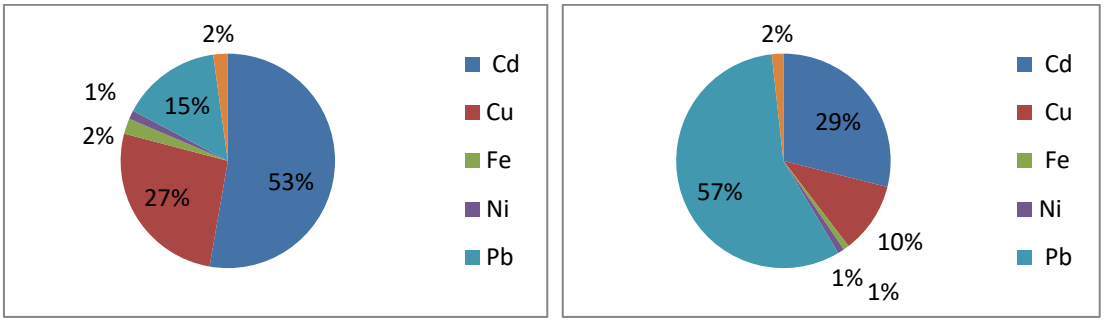

Fig. 3: Mean hazard quotient for trace metals via the consumption of V. amygdalina (A) and J. Tanjorensis (B)

Results for the mean hazard index (HI) of the metals via the utilization of the studied vegetables are indicated Table 5. Mean HI values of 1.61E-2 and 4.70E-2 were reported for the metals via the utilization of *V. amygdalina* and *J. Tanjorensis*, respectively. This confirms the high exposure of the consumers to the non-carcinogenic health risks via the consumption of *J. Tanjorensis.* Although, the mean HI values of the metals via both vegetables were less than one, the level of exposure should be minimized as metals have the tendency to bio-accumulate over time (Ojiego *et al*., 2022). In *V. amygdalina*, Cd, Cu and Pb contributed 53, 27, and 15%, respectively to the HI (Figure 3A). Figure 3B also illustrates that in *J. Tanjorensis*, Pb, Cd, and Cu contributed 57, 29, and 10 %, respectively to the HI. Consequently, Cd, Cu and Pb in *V. amygdalina* contributed a total of 95% of the HI while Fe, Ni and Zn contributed only 5%. However, in J. *Tanjorensis* Pb, Cd, and Cu contributed a total of 96% of the HI while Fe, Ni and Zn contributed 4% only. Thus, for both vegetables, Cd, Cu and Pb were the major contributors to the HI and this is very risky for the consumers as Cd and Pb are highly toxic even at very low concentrations (Haider *et al*., 2021; Collin *et al*., 2022).

Carcinogenic Risks Indices

Table 6: ILCR and the cumulative cancer risk value (ΣILCR) of trace metals via the consumption of studied vegetables

	Vernonia amygdalina						***Jatropha tanjorensis***					
	Cd	Cu	Fe	Ni	Pb	Zn	Cd	Cu	Fe	Ni	Pb	Zn
ILCR	3.23E-4	2.25E-4	-	7.21E-6	7.23E-8	-	5.17E-6	3.02E-4	-	1.59E-5	1.67E-7	-
TCR	5.55E-4						3.23E-4					

USEPA recommended safe limit (ILCR < 1 × 10^{-6}); threshold risk limit (ILCR < 1 × 10^{-4}). Source: USEPA (2015).

Incremental Lifetime Cancer Risks (ILCR)

Results for the carcinogenic risks associated with the consumption of studied vegetables are shown in Table 6. According to USEPA (2018) cancer risk values of ≤ 10^{-6} belong to the low cancer risk class, values ranging between 10^{-5} and 10^{-3} are in the moderate cancer risk, while values varying from 10^{-3} to 10^{-1} are in the high cancer risk. Consequently, the potential cancer risks related to Cd and Cu via the consumption of *V. amygdalina* are moderate, whereas Ni and Pb are low over a life time duration of exposure. The cancer risk associated with Cd and Pb through the consumption of *J. Tanjorensis* is in the low category whereas; risks related with the exposure to Cu and Ni via *J. Tanjorensis* are moderate (USEPA, 2018). According to USEPA (2015) Cd, Cu, Ni, and Pb are categorized as cancer causing agents. Hence, exposure to these metals through the consumption of the studied vegetables even at low concentrations may cause cancer and

cancer-related ailments (WHO, 2010). Results for the target cancer risk in Table 6 indicate mean values of 5.55E-4 and 3.23E-4 for the consumers of *J. Tanjorensis* and *V. amygdalina*, respectively. These values are within the USEPA recommended safe limit of ILCR $< 1 \times 10^{-6}$ but higher than the threshold risk limit of ILCR $< 1 \times 10^{-4}$ (USEPA, 2015).

Target Cancer Risk (TCR)

Results of the target cancer risk in Table 6 indicates a mean values of 5.55 E-4 and 3.23E-4 for those exposed to the metals via the consumption of *V. amygdalina and J. Tanjorensis*, respectively. It was also observed that, Cd, Cu, and Ni contributed 58, 41, and 1%, respectively to the total TCR value via the consumption of *V. amygdalina* but, 2, 93, and 5% via the consumption of *J. Tanjorensis.* However, Fe, Pb and Zn did not contribute substantial value to the total TCR value via the consumption of both vegetables. Consequently, the consumers of the studied vegetables are susceptible to cancer due to high Cd and Cu. Thus, Cd and Cu are the main carcinogens in the locations investigated and this should be properly managed to forestall exposure of the population to cancer risks. The study revealed that, the consumers of *V. amygdalina* have a higher risk of developing cancer than *J. Tanjorensis.* It was also observed that, Cd, Cu, and Ni contributed 58, 41, and 1%, respectively to the total TCR value while Fe, Pb and Zn did not contribute any value via the consumption of *V. amygdalina.* In *J. Tanjorensis*, Cd, Cu, and Ni contributed 2, 93, and 5% to the total TCR while Fe, Pb and Zn did not have substantial impact on the total TCR reported.

IV. CONCLUSIONS

The study has shown that, road transport has the potential of contaminating and subsequently polluting the environment especially the adjoining soils and plants. The mean concentrations of all the trace metals in the studied soils and vegetables were within their acceptable limits. However, higher concentrations of the metals were obtained in soils and vegetables from roads with high traffic density than in the control site. The highest mean concentrations of the metals were recorded in samples from Oron Road while the lowest was at Ekpri Nsukara Road. Consequently, the mean concentrations of metals were closely related to the traffic density on each of the roads investigated. The study also identified road transport as the major factor responsible for the accumulation of trace metals in the adjoining soils and vegetables. *Jatropha tanjorensis* exhibited higher potentials for the accumulation of metals than *Vernonia amygdalina.* Nevertheless, the potential was not high enough for its utilization for phytoremediation. The roads with high traffic density were highly contaminated with the trace metals. The consumption of these vegetables exposed the consumers to health risks associated with Cd and Pb. This research discovered Cd and Cu as the major cancer-causing agents associated with the consumption of these vegetables and the consumers of *Vernonia amygdalina* being more vulnerable to cancer risks. This work has established that road transport has the ability to elevate metal loads in adjoining soils and plants. It has shown that, metal accumulation in the adjoining soils and plants has a close relationship with traffic density along the road. Hence, the cultivation crop plants and their consumption should be discouraged to avoid the accumulation and associated health problems on the consumers.

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Agronomic Characteristics of Upland Red Rice Lines Resulted from Crossing IPB3S and Promising Line of Red Rice in Medium Elevation Areas

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Abstract— *Red rice is one of the important functional food sources because its anthocyanin content is very beneficial for human health. One of the processes to produce new superior varieties of rice is by cross-breeding. The aim of this study was to determine the agronomic performance of the promising lines of red rice resulted from crossing of IPB3S variety with the promising line of red rice compared with the parents and comparison genotypes in the medium elevation lands. The experiment was carried out in June - September 2022 in medium lowland rice fields (375 m asl) in Central Lombok district, NTB, Indonesia, which was designed using a Randomized Block Design (RCBD) consisting of 14 treatments, namely 9 ideal type red rice lines resulted from Pedigree F5 selection, 1 promising line of red rice from crosses between Kenya and Angka, two parents (the promising line of paddy red rice "GH F2BC4P19-36", and IPB3S variety), and two control varieties (Situ Patenggang and Inpago Unram 1), repeated 3 times. Observation variables included plant height, days to harvest, number of productive and non-productive tillers, length of panicles, number of filled and unfilled grains per panicle, weight of 100 grains, grain weight per clump and yield potential (tons/ha). The results showed that the red rice line G6 (F5 IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/17) showed higher grain yield potential (4.79 t/ha) compared to the two parents, namely IPB3S (3.34 t /ha), GH parent (3.27 t/ha), Situ Patenggang (3.92 t/ha) and Inpago Unram 1 (3.35 t/ha). Plant height, number of productive and non-productive tillers per clump, panicle length, numbers of filled and unfilled grains per panicle, grain weight per clump and potential grain yield per hectare were significantly different between genotypes while days to harvest and 100-grain weight were not significantly different.*

Keywords— ***Red rice lines, upland rice, medium plains, cross-breeding, yield potential***

I. INTRODUCTION

The development of upland rice cultivars is an alternative to increasing national rice production, because the expansion of lowland rice is increasingly difficult to implement. One of the strategies that can be implemented is to utilize unused land and to use varieties that are adaptive to the upland environment. In Indonesia, there are around 2 million ha of dry or rainfed land suitable for upland rice. However, the average national productivity of upland rice in Indonesia is still around 2.36 tons/ha, far below the average productivity of paddy rice, which is on average 4.98 tons/ha (BPS, 2021) [1]. Therefore it is necessary to carry out research activities to develop genotypes that are tolerant to drought stress to increase the productivity of upland rice [2]. Improving the agronomic characteristics of upland rice can be carried out using various plant breeding methods, one of which is by carrying out crosses between germplasms that have the opportunity to produce new superior upland rice varieties.

Red rice is one of the local germplasm whose grains contain anthocyanins, which are very beneficial for human health. Red rice is efficacious for increasing the body's resistance to disease, repairing damage to liver cells (hepatitis and cirrhosis), preventing impaired kidney function, preventing cancer/tumors, slowing aging, functioning as an antioxidant, cleaning cholesterol in the

blood, and preventing anemia. The existence of red rice in Indonesia is increasingly scarce due to the planting of new superior rice varieties which are dominated by white rice [3-6].

The superior varieties released by the Ministry of Agriculture to date amount to more than 233 varieties consisting of 144 superior varieties of inbred lowland rice (INPARI), 35 hybrid rice varieties (HIPA), 30 superior varieties of upland rice (INPAGO) and 24 swamp rice varieties (INPARA), and most of these varieties were produced by the Agency for Agricultural Research and Development [7]. Several varieties have been released by several universities such as IPB with its varieties IPB 3S and IPB 4S (2012) in the form of lowland rice varieties, UNSOED with INPAGO Unsoed 1 (2011) and UNRAM with INPAGO UNRAM 1 (2011) through the activities of the National Rice Consortium, which was initiated by the Sukamandi Rice Research Center. Almost all of the high yielding rice varieties released were white rice, except for INPAGO Unram I, which is a superior variety of upland red rice. Meanwhile, the ideal type of superior varieties of upland red rice has not yet been released.

Sources of new genes that have the potential to lead to the formation of superior varieties of upland rice of the ideal type which have the potential for high yields and early maturaty are urgently needed considering that there is still a lot of germplasms for these traits that have not been identified. From the results of research conducted by Aryana et al. [8] through back crosses of four times between the promising line of drought tolerant red rice and the local cultivar of red rice "Kala Isi Tolo" (which has high anthocyanin content and early maturity) has produced the promising line of upland red rice "GH F2BC4P19-36" (which has high anthocyanin content, large number of tillers, and early maturity (107 days), but still has a relatively low yield of 5.8 tons/ha). This promising line was then crossed with IPB 3S (which has a yield potential of 11.2 tons/ha, 112 days maturity, the texture of rice is fluffier with white rice color, the number of tillers is low) through single crosses and repeated cross selection, which was then followed by Pedigree selection until F5, resulting in new superior red rice lines of ideal types [9]. These lines have not been tested for their agronomic properties in medium upland plains. Therefore, the purpose of this study was to determine the agronomic performance of the red rice lines on medium elevation dry land.

II. MATERIALS AND METHODS

The experiment was carried out in medium plain rice fields in the village of Tampak Siring Mujur, North Batukliang sub-district, Central Lombok, West Nusa Tenggara, with an elevation of 375 m above sea level, from June to September 2022. The experiment was arranged using a Randomized Block Design consisting of 14 treatments (Table 1), namely 9 upland red rice lines of ideal types resulted from F5 Pedigree selection (G1 to G9), 1 promising line of red rice from crosses of "Kenya" with "Angka" variety (G10), 2 parents (the promising line of red rice "GH F2BC4P19-36" (G11) and IPB3S (G12)), and comparison upland varieties (Situ Patenggang and Inpago Unram 1), which were repeated 3 times.

Table 1. Rice genotypes tested in this experiment

Treat-ments	Genotypes
G1	F5 IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/7
G2	F5IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/15
G3	F5 IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/20
G4	F5 IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/13
G5	F5 IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/71
G6	F5 IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/17
G7	F5IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/25
G8	F5 IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/30
G9	F5 IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/23
G10	The promising line "GH-SBCSKA"
G11	"IPB 3S" parent variety
G12	GH parent line of red rice (GH TM)
G13	"Situ Patenggang" upland white rice variety (SP)
G14	"Inpago Unram 1" upland red rice variety (IU-1)

The observed variables included plant height, days to harvest, number of productive and non-productive tillers, panicle length, number of filled and unfilled grains per panicle, weight of 100 filled grains, grain yield per clump and potential yield of tons/ha with a moisture content of 14% (which was converted from the grain yield of 1 m^2 to tons/ha). Each treatment genotype was planted in as upland rice in 2 x 4 m plots, plant spacing of 25 x 25 cm, with 1 plant per hill, fertilized with Phonska 15-15-15 fertilizer as basal fertilization (300 kg/ha), and Urea (45% N) dibbled at 50 days after seeding (200 kg/ha). The data were analyzed with analysis of variance (ANOVA) and DMRT (Duncan Multiple Range Test) at 5% significance level, which was carried out using the SAS program.

III. RESULTS AND DISCUSSION

Based on the results of the analysis of variance (ANOVA), all variables showed significant differences between the

genotypes tested, except for the days to harvest and the weight of 100 filled grains (Table 2).

Table 2. Summary of the ANOVA results `

Variables	p-value	Sig
Days to harvest (DTH)	0.2363	ns
Plant height (PH)	0.0001	s
Number of productive tillers (NPT)	0.0362	s
Number of non-productive tillers (NNPT)	0.0028	s
Panicle length (PL)	0.0001	s
Number of filled grains per panicle (NFGP)	0.0001	s
Number of unfilled grains per panicle (NUGP)	0.0001	s
Weight of 100 filled grains (W100)	0.2312	ns
Grain yield per clump (GYC)	0.0005	s
Potential yield per ha (PYH)	0.0001	s

When the rice plants have reached optimum maturity, they are ready to be harvested. Harvesting can usually be done 30 days after flowering [10]. The Rice Research Center classifies the maturity of rice plants as ultra early maturity <90 days, very early maturity 90-104 days, early maturity 105-124 h; moderate maturity 124-150 days; and late maturity >150 days. Based on this classification, all the genotypes tested were categorized as early maturity, which ranged from 110 days to 112 days to harvest (Table 3). However, the days to harvest for all the genotypes tested was not significantly different between genotypes (Table 2).

Plant height is a measure that is often observed as an indicator of growth as well as a variable used to determine crop production [11]. IRRI [12] classifies plant height into short (<110 cm), medium (110-130 cm) and tall (>130 cm) categories. Based on these categories, all the rice lines tested were classified as having medium plant height, except for G2 (133.64) and G8 (130.67 cm), which were classified as tall genotype. Rice plants that are classified as tall tend to fall down easily as a result of environmental factors such as strong winds, which usually decrease grain yields. Zen [13] added that dwarf plants will avoid being collapse due to the wind, so these plants are easy to care for.

The number of productive tillers per clump ranged from 8.30 to 13.54 (Table 3). The lowest number of productive tillers was found in the variety “Situ Patenggang” (8.30), and the highest number was in the G4 line (13.54). There was no difference in the number of productive tillers between lines and with the two parents (Table 2). According to Endrizal et al. [14], productive tillers per clump is the number of panicles, thus these tillers have a direct effect on the high and low grain yields. Hatta [15] added that the number of productive tillers is related to yield, and a small number of productive tillers can reduce yields. Aryana et al. [8] also added that the tillers formed in the final stages of the vegetative phase tended to be unable to produce panicles, while the number of non-productive tillers between lines resulting from crosses of IPB3S vs. GH TM as well as vs both parents and the comparison varieties were not significantly different (Tabel 3). Thamrin et al. [16] stated that non-productive tillers are competitors to productive tillers in utilizing solar energy and nutrients. In addition, the more non-productive tillers, the more humid the micro-environment will be, thus providing opportunities for the development of pests and diseases.

Panicle length is a selection criterion for rice plants because it affects yield. Of all the genotypes tested, the panicle length ranged from 19.74 – 25.57 cm (Table 3). The panicle length is classified into 3 (three) categories, namely short panicles (<20 cm), medium panicles (20-30 cm) and long panicles (> 30 cm) [17]. Based on this classification, all genotypes showed medium panicle length (20-30 cm). Plants that have long panicles will produce more grains so that the yields are higher [18]. The highest panicle length was seen in the lines G2 (25.53 cm) and G6 (25.57 cm) and was different from the two parents.

The number of filled grain per panicle ranged from 86.20 (in IPB3S variety) – 163.43 (in the Situ Patenggang variety). All the lines showed higher filled grain number than the IPB3S parents except for the G5 (98.68 grains) and G9 (103.42 grains) (Table 4). Bobihoe and Nafisah [19] stated that the number of filled grains per panicle correlated with rice yields but was also influenced by the number of unfilled grains. Rice yield is determined by several yield components such as the number of filled grains per panicle, the number of panicles per clump and the weight of 100 grains. Wibowo [20] added that each genotype has a different ability to produce filled grains depending on its genetic characteristics.

Table 3. Average days to maturity, plant height, panicle length, productive and non-productive tiller number per clump for each genotype tested

Treatment	Days to harvest	Plant height (cm)	Panicle length (cm)	Productive tillers per clump	Non-productive tillers per clump
G1	110.34 a	114.60 c	24.28 ab	11.04 ab	2.74 bc
G2	111.67 a	133.64 a	25.53 a	10.54 bc	1.87 c
G3	112.34 a	126.20 b	24.35 ab	12.20 ab	1.97 c
G4	110.67 a	129.27 ab	23.02 bc	13.54 a	2.40 c
G5	111.67 a	110.47 cd	20.55 ef	11.67 ab	3.47 bc
G6	110.67 a	125.20 b	25.57 a	11.40 ab	2.70 bc
G7	111.34 a	115.05 c	21.52 cdef	9.64 bc	3.30 bc
G8	111.34 a	130.67 ab	22.14 cde	12.30 ab	1.80 c
G9	112.00 a	111.17 cd	21.01 def	7.83 bc	4.40 ab
G10/GH-AK	111.00 a	109.94 cd	19.74 f	11.34 ab	5.27 a
G11/IPB3S	111.34 a	111.44 cd	20.71 def	11.00 ab	3.04 bc
G12/GH-TM	112.00 a	116.50 c	22.28 cde	11.34 ab	2.20 c
G13/SP	111.00 a	107.00 d	22.60 bcd	8.30 c	1.80 c
G14/IU-1	110.34 a	125.70 b	21.20 cdef	11.44 ab	3.17 bc

Table 4. Average filled and unfilled grain number per clump, weight of 100 grains, grain yield per clump, and potential yield per ha for each genotype tested

Treatment	Filled grain number per panicle	Unfilled grain number per panicle	Weight of 100 grains	Grain yield (g/clump)	Potential yield (ton/ha)
G1	115.17 cd	40.60 ab	3.06	28.11 bcd	3.52 de
G2	143.21 ab	48.73 a	3.02	35.86 ab	3.50 de
G3	113.93 cd	36.47 abc	3.17	38.16 a	3.57 e
G4	128.92 bc	23.84 cd	2.99	33.93 abc	3.26 cde
G5	98.69 de	25.49 cd	3.13	22.47 d	3.34 abc
G6	151.46 ab	48.69 a	3.22	38.82 a	4.79 a
G7	122.52 bcd	31.36 bcd	3.24	33.24 abc	4.57 ab
G8	132.02 bc	24.17 cd	2.96	38.05 a	4.15 abcd
G9	103.42 de	25.05 cd	3.09	22.73 d	4.24 abc
G10/GH-AK	89.63 e	22.44 cd	3.16	25.13 cd	3.54 de
G11/IPB3S	86.20 e	24.12 cd	3.21	22.10 d	3.34 e
G12/GH-TM	139.82 ab	44.85 a	3.11	32.98 abc	3.27 e
G13/SP	163.43 a	31.08 bcd	2.93	36.71 ab	3.92 bcde
G14/IU-1	102.81 de	21.04 d	3.15	30.36 abcd	3.35 e

The high number of unfilled grains was found in the lines G2, G6 and the parent G12/GH-TM, namely 48.73; 48.69 and 44.85 grains per panicle and the lowest was in the comparison variety Inpago Unram 1 (21.04 grains per panicle). The level of unfilled grain number, apart from being a genetic influence, can also be influenced by

environmental factors [10]. Peng et al. [21] stated that the low seed filling rate was the result of a small apical dominance in the panicle, grain arrangement in the panicle, and limited vascular sheaths for assimilate transport to the panicles.

The weight of 100 filled grains was not significantly different between treatments (Table 4). However, the highest weight was seen in the line G7 (3.24 g) and the lowest in the "Situ Patenggang" upland rice variety (2.93 g). According to Ma et al. [22], for ideal type of rice, the weight of 1000 grains is between 28-30 g. The weight of 1000 grains is a component that affects the grain yield. The heavier the 1000 grains, the higher the grain yield will be [23].

Grain yield per clump of rice plants is generally strongly influenced by the number of filled grains, panicle length, number of panicles per clump, and 1000 grain weight [24]. Aryana et al. [10] also indicated that the amount of filled grains determines the weight of grain per clump. This can be seen in the G6 genotype which has long panicles, a relatively large number of filled grains per panicle and a high weight of 100 grains, resulted in a higher grain yield per clump in the G6 genotype, when compared with the two parents IPB3S (G11) and GH-TM (G12), which have shorter panicle lengths, small amount of filled grains per panicle and the lower 100 grain weight (Table 4).

The potential grain yield per hectare is a quantity that describes the amount of yield obtained in one ha of land in one planting cycle. According to Aryana et al. [10], high yields in rice plants can be caused by high yield components, such as panicle length, number of filled grains per panicle, and grain weight per clump. The G6 genotype, which is a red rice line resulted from a cross between the parents IPB3S and the promising line of red rice (GH-TM), had higher yield potential compared to both parents and the comparison varieties (Situ Patenggang and Inpago Unram 1) under upland growing conditions in medium elevation areas.

IV. CONCLUSION

From the results, it can be concluded that the G6 rice line (F5 IPB3S/F2BC4P19-63// Fat/F2BC4P19-63-PD3/17) showed higher yield potential (4.79 t/ha) compared with its two parents, namely IPB3S (3.34 t/ha), GH red parent (3.27 t/ha), and the comparison varieties "Situ Patenggang" (3.92 t/ha), and "Inpago Unram 1" (3.35 t/ha). Plant height, number of productive and non-productive tillers per clump, panicle length, number of filled and unfilled grains per panicle, grain yield per clump and potential grain yield per hectare showed significant differences between genotypes while days to harvest and weight of 100 grains were not significantly different between genotypes.

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Growth and Yield Responses of Chili (*Capsicum frutescens* L.) to Paclobutrazol Concentrations and P-Fertilizer Doses during the Rainy Season

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Abstract— *Field experiment conducted from November 2021 to April 2022 on farmers' fields in Sukamulia, East Lombok, Indonesia, aimed to determine the growth and yield response of chili (Capsicum frutescens L.) to treatment with Paclobutrazol concentrations and phosphorus fertilizer doses during the rainy season. The factorial experiment was arranged in a randomized block design with three blocks and two treatment factors, namely Paclobutrazol concentrations (0, 50, 100 and 150 ppm) and phosphorus fertilizer doses (0, 30, 60 and 90 kg/ha P_2O_5). Data were analyzed using ANOVA and Tukey's HSD at 5% significance level. The results showed that Paclobutrazol concentration significantly decreased growth rates of plant height and the doses of P fertilizer increased the number of productive branches per plant. However, the interaction between the treatment factors had a significant effect on flower initiation and fruit weight per plant, with the highest chili fruit yield, i.e. 549.5 g/plant, was obtained on chili plants receiving treatment combination of 150 ppm Paclobutrazol concentration and P-fertilizer dose of 90 kg/ha P_2O_5. This treatment combination also resulted in the earliest flower initiation (at 42.2 days after planting).*

Keywords—***Chili, Paclobutrazol, P-fertilizer, flower initiation, rainy season***

I. INTRODUCTION

Small chili (*Capsicum frutescens* L.) can be cultivated from the lowlands to the highlands (1000 m asl) and is the most important horticultural commodity in Indonesia. Chilies have quite high economic value, and high prices can be obtained when chilies are planted in the rainy season. However, the physiological obstacle in increasing chili production in the rainy season is the low percentage of fruit formation, which is mainly due to the fall of flowers, so some efforts must be made to increase chili production [1]. Increasing chili yields can be done by increasing the formation of flowers and fruits, so that the percentage of flower and fruit fall does not affect the yield per unit area. This can be done by using Paclobutrazol (Pbz) as a retardant or with phosphorus fertilizer [2].

Paclobutrazol (Pbz) is a growth regulator that inhibits vegetative growth without changing the pattern of plant development [3], by diverting the results of photosynthesis from vegetative growth to fruit formation [4]. Pbz application can be done by spraying through the leaves and sprinkling it on the ground [5-7]. The function of Pbz is to suppress plant growth resulting in shorter shoots of tomato plants, but better root growth, resulting in plants being more resistant to drought stress or waterlogging [8]. Pbz applied to *Syzygium campanulatum* resulted in shorter plants and decreased leaf area index [9]. The growth of the "Pitanga" ornamental chili can be controlled by treating it with Pbz of 150 ppm, besides being able to induce improvement in fruit characteristics [5, 10]. Pbz concentrations of 10 - 150 ppm significantly reduced the size of Sanseviera plants (Sanseviera trifasciata L.) [6].

Apart from its effect on plant growth, the application of Pbz of 100 -500 ppm can increase flowering, such as in chili plants [7]. An increase in the number of flowers and fruits is associated with a greater amount of chlorophyll even though the leaf area index is reduced [11-12]. In addition to the concentration of Pbz, the timing of its application is also important, because its effects depend on the type of plant, the size of the plant as well as the local climatic conditions. From the results reported by Baloch et al. [13], Pbz applied three times before the formation of flowers on ornamental chilies increased fruit yields and suppressed growth of plant height. In tomato plants, the application of Pbz twice before flowering can reduce plant height and increase fruit yield [14].

In addition to the application of Pbz, flower and fertilization induction can also be carried out by using Phosphorus fertilizer. The application of phosphorus fertilizers to chilies can increase the yield of chilies, which is caused by an increase in the number and length of the fruits [15]. The yield response of chili plants to doses of phosphorus from doses of 0 to 150 kg/ha P occurred in a quadratic manner with the highest yields occurring at a dose of 90 kg/ha [16]. In combination with Nitrogen fertilizers, increased doses of phosphorus fertilizers from 46, 92 and 138 kg/ha, were reported to significantly increase chili fruit yield and number of fruits per plant [17]. Based on those reports, a study has been carried out with the main objective to determine the growth and yield responses of chili (*Capsicum frutescens* L.) to Paclobutrazol concentrations and doses of Phosphorus fertilizer applied during the rainy season.

II. MATERIALS AND METHODS

The method used in this study was an experimental method by conducting a field experiment from November 2021 to March 2022, in Padamara Village, Sukamulia District, East Lombok Regency, Indonesia. The materials used in the experiment were chili seeds of the Ori 212 variety, Mutiara NPK fertilizer, Paclobutrazol (Cultar 250 SC) and SP36 fertilizer. The experiment was arranged in a randomized block design with three replications and two factorial treatment factors, namely Paclobutrazol (Pbz) concentrations (0, 50, 100 and 150 ppm) and P-fertilizer doses (0, 30, 60 and 90 kg/ha P_2O_5).

Observation variables included average growth rate (AGR) of plant height, number of productive branches, flower initiation age, number of flowers and fruit weight per plant. Data were analyzed using the Analysis of Variance (Anova) and the Honest Significant Difference Test (Tukey's HSD) at the 5% level of significance.

III. RESULTS AND DISCUSSION

Rainfall data during implementation of the experiment from November 2021 to March 2022, obtained from the Power Data Access Viewer, were 331.61; 277.78; 342.32; 207.67; and 191.42 mm/month, respectively, so that during the experiment, the climatic conditions of the location were in the wet months. High rainfall can affect the initiation of flowers and the number of fruits formed. The results of the analysis of variance (ANOVA) for the observation data are presented in Table 1.

Table 1. Summary of ANOVA results for all observation variables

Variables	Pbz conc.	P doses	Pbz*P
AGR of plant height	s	ns	ns
Productive branches	ns	s	ns
Flower Initiation age	s	s	s
Fruit yield per plant	s	ns	s

Remaks: s= significant; ns= non-significant

The interaction between Pbz concentration and Phosphorus fertilizer dosage had a significant effect on the age of flower initiation and fruit weight per plant, but had no significant effect on plant height and number of productive branches (Table 1). The application of Pbz can inhibit the formation of GA, resulting in stunted shoot growth, so that photosynthate is diverted to flower initiation, coupled with the function of P which can induce fertilization. Inhibiting plant vegetative growth as well as inducing flowering, by suppressing the formation of Gibberellins, photosynthate is more directed to fertilization than vegetative growth. Application of P fertilizer can also induce better flowering. This is in accordance with the statements of Desta & Amare [4] and Jayanti et al. [18] that the application of Paclobutrazol and Phosphorus increased the percentage of the number of flowers and fruits of chilies.

As a single factor, the application of Pbz significantly affected the growth rate of plant height (Table 1), which suppressed the growth rate of plant height (Table 4), while the dose of Phosphorus only had an effect on the number of productive branches, namely increasing the number of productive branches (Table 4). Pbz increases the chlorophyll content of leaves so that photosynthetic activity can run better, but photosynthate is used more for fruit formation. These are in accordance with the statement of Harpitaningrum et al. [19] that the yield of cucumber plants increased in line with increasing concentrations of Pbz. Emongor and Mabe [15] also reported that phosphorus affects fruit yield in ornamental chilies.

3.1. Interaction effects on flower initiation and fruit yield

The earliest flowering date was found in the Pbz3P3 treatment combination, namely 42.2 days after transplanting (Table 2). This is presumably because Pbz suppresses vegetative growth of plants, resulting in faster flowering accompanied by the effect of P which accelerates flowering due to a larger dose of Phosphorus fertilizer. Adilah et al. [20] and Syahputra et al. [21] stated that application of 250 ppm Paclobutrazol could inhibit vegetative growth and increase fruit yields. This is because the applied Paclobutrazol is able to stimulate the formation of flowers in tomato plants [13, 22]. Phosphate has several functions including accelerating the process of flowering and fertilization, strengthening plant organs (leaves, flowers and fruit) so they don't fall off easily, producing enzymes that play a role in photosynthesis and translocation of photosynthesis results in the form of assimilates to the reproductive organs of plants [23], so that flowering dates become earlier.

Table 2. The interaction effect of the treatment factors on flower initiation age (days after transplanting)

Treatments	P0	P1	P2	P3
Pbz0	45.5 a	43.3 ab	44.8 a	45.0 a
Pbz1	42.6 b	43.0 ab	45.2 a	44.4 a
Pbz2	42.5 b	43.4 b	44.8 a	44.3 a
Pbz3	42.7 b	42.5 a	42.3 b	42.2 b
HSD	0.83			

Remarks: The mean values followed by the same letters indicate non-significantly different both vertically and horizontally

The interaction between Paclobutrazol concentration and Phosphorus dosage increased the percentage of flowering shoots. The results of previous studies showed that the Phosphorus and Paclobutrazol treatments increased the C/N ratio in the leaves during the flower bud differentiation period which in turn helped increase the initiation of flowering [10]. From Table 3, it can be seen that there was a significant interaction effect between Paclobutrazol concentrations and P fertilizer doses, where at each level of P fertilizer dose, an increase in Paclobutrazol concentration significantly increased fruit weight per plant. Pulungan et al. [24] also stated that the proper use of Paclobutrazol will have a significant effect on flower initiation and fruit formation. The inhibition of flowering time can be caused by the inappropriate concentration of Paclobutrazol applied because each plant has a different sensitivity to growth inhibitory substances [16, 20].

Table 3. The interaction effect of the treatment factors on the chili fruit yield (gram/plant)

Treatments	P0	P1	P2	P3
Pbz0	201.4 c	201.9 b	478.6 a	464.5 a
Pbz1	208.6 bc	215.7 ab	508.6 b	516.4 b
Pbz2	224.7 ab	224.5 ab	513.0 b	540.4 c
Pbz3	242.7 a	235.5 a	524.6 b	549.5 c
HSD	23.2			

Remarks: The mean values followed by the same letters indicate non-significantly different both vertically and horizontally

3.2. AGR of plant height and productive branch number

The application of Paclobutrazol at various concentrations had a significant effect on the growth rate of plant height, while the P doses only had a significant effect on the number of productive branches per chili plant (Table 1). This is because the effect of Paclobutrazol applied to plants functions as an inhibitor of plant height growth, so that an increase in Pbz concentration can inhibit the growth rate of plant height, as shown in Table 4.

Table 4. The main effect of the treatment factors on AGR of plant height (cm per 2 weeks) and number of productive branches per chili plant

Treatments	AGR of plant height (cm per 2 weeks)	Productive branch number per plant
Pbz0	10.88 a	17.79
Pbz1	10.06 b	18.12
Pbz2	9.87 b	19.77
Pbz3	9.17 b	20.24
HSD 5%	1.23	ns
P0	10.05	20.42 a
P1	9.8	23.65 b
P2	9.57	23.08 b
P3	9.58	23.92 b
HSD 5%	ns	1.90

Remarks: Mean values followed by the same letters are not significantly different between levels of a treatment factor

Based on Table 4, the results of Paclobutrazol application at various concentrations on plant height showed that the Paclobutrazol concentrations had a significant effect on the growth rates of chili plant height. The highest growth rate was in the Pbz0 treatment (Control) with an average

growth rate of 10.88 cm per 2 weeks, followed by the Pbz1 treatment (50 ppm) and the Pbz2 treatment (100 ppm), while under the Pbz3 treatment (150 ppm), the AGR of plant height was the lowest with an average of 9.17 cm per 2 weeks. The results of this study indicate that the application of Paclobutrazol at the concentrations ranged from 0 to 150 ppm can suppress the growth rate of plant height.

The growth rate (AGR) of plant height in the Paclobutrazol Pbz0 (Control) treatment was significantly different from that in Pbz1 (50 ppm), Pbz2 (100 ppm), and Pbz3 (150 ppm) treatments. This is in line with the statement of Moko et al. [25] as well as Guniarti & Suhardjono [26] that the absence of Paclobutrazol allows plant growth to proceed normally or without suppression of plant height and the treatment with 0 ppm produced the highest plant height. Based on the results of research by Syaputra et al. [21] and Dwi & Koesriharti [27], application of high concentrations of Paclobutrazol greatly reduced tomato plant height compared to low concentrations.

In contrast, the doses of P fertilizer had no effect on the growth rate of plant height (Table 4). This is because at the beginning of plant growth, P fertilizer plays a very important role in the tissues which actively divides parts of the plant tissue, because the more the plant height is suppressed, the more branching will be produced, which has the potential to produce a large number of branches [15, 28], as shown in Table 4, that P doses have more effect on the number of branches compared to the growth rates of plant height.

IV. CONCLUSION

Based on the research results, it can be concluded that the treatment combination of 150 ppm Paclobutrazol and P fertilizer dose of 90 kg/ha P_2O_5 accelerated flower initiation which resulted in the earliest flower initiation, i.e. at 42.2 days after planting, and produced the highest average of chili fruit yield of 549.5 g/plant.

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Characterisation of several isolates of *Fusarium oxysporum* f. sp. elaeidis for the selection of fusarium-resistant oil palm varieties

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Abstract— *This work was aim to evaluate the pathogenicity and the level of aggressiveness of ten strains of Fusarium oxysporum f. sp. elaeidis (Foe) on palm oil seedlings susceptible to vascular wilt. For this purpose, the radial growth, sporulation and the morphological characteristics of ten strains of Foe from the farm palm of the Cameroon Development Corporation (South-west) were studied in vitro. In addition, 500 oil palm seedlings susceptible to vascular wilt and aged 5 months were distributed in a randomized complete block device, and inoculated with said strains. External symptoms of Fusarium wilt were observed on those seedlings and the correlation between these parameters was also investigated. The data collected in prenursery did not establish a significant difference in the aggressiveness of the isolates. However, regarding the pathogenicity, 7 strains have shown a high pathogenicity. As for the radial growth, strain F presented fastest growth was 8.12 cm in diameter, unlike the strain **I** whose growth was the lowest is 3.98 cm in diameter. The **C** strain is one that is abundantly sporulated126,5x10^{5}spores/ml; however, isolates **B** and **J** do not sporulate. No correlation was detected between the different parameters. But, considering the results obtained, the **F** and **I** strains could be the most aggressive and can potentially be used to test the timber yard of the specialized Centre for oil palm research of La DIBAMBA to select the most resistant to vascular wilt.*

Keywords— ***Oil Palm, Fusarium oxysporum, Pathogenicity, aggressiveness, strains.***

I. INTRODUCTION

In Cameroon, the exploitation of oil palm by local communities is a social and cultural heritage. Before the colonial period, the plant was the main source of vegetable fats and a major source of income for local people. Drinks, medicines, household and building materials, art objects, fuel, livestock and agricultural products and cosmetics can all be obtained from this crop (Temgoua and Bakoume, 2008).

Unfortunately, Cameroon's palm oil production is not keeping pace with population growth in order to satisfy the ever-increasing demand for this product. Similarly, on the international stage, Cameroon's position in the world palm oil supply is steadily declining. Ranked 11th in 2008, with 160,000 t of palm oil produced (Ntsomboh-Ntsefong, 2015), the country came 13th in 2012, with production estimated at almost 230.000 t (Diabate et 2010 ; Renard et Franqueville, 1989). This situation stems primarily from the many problems facing the country's olive oil sector, namely the low rate of oil extraction from artisanal units, the low

use of fertilisers due to their very high prices, the ageing of plantations, the economic crisis that has led to the government's withdrawal from the sector, the use of inadequate selected planting material and the resurgence of diseases and pests (Henni et al., 1994).

Fusarium is the most devastating of the oil palm diseases (Flood, 2006 ; Chehri et al. 2011). This disease is caused by a fungus of telluric origin, *Fusarium oxysporum*. f. sp. Elaeidis (Foe). It slows plant growth, reduces organ size and in severe cases leads to plant death, causing partial or total loss of production. Losses can be as high as 100 % (Diabate, et al., 2010 ; Assohoun et al. 2016). It is present in all CDC and SOCAPALM palm groves in the Littoral, South-West and Centre regions (Tengoua, 1994; Tengoua, 2003).

Given the telluric and vascular nature of this pathogen, no chemical control method is economically feasible (Renard et Franqueville., 1989 ; Gbongue et al., 2012). However, it very quickly became apparent that, as with other fusarioses, the selection of plant material tolerant to the disease could limit its development (Bachy and Fehling, 1957; Diabate et al. 2010 ; Gogbe-Dibi et al. 2022).

The method used, and indeed the most effective, is the preventive method involving the use of tolerant plant material (Lepoivre, 2003. However, as the durability of varietal resistance is a major issue for the use of palm varieties, we need to update our knowledge of the capacity of pathogen populations to adapt to partial or total resistance (Andanson, 2010).

Research is therefore constantly being carried out to improve the tolerance level of oil palms. The most recent study is the confrontation of pathogenic and non-pathogenic strains of *Fusarium oxysporum* f.sp. elaeidis in the acquisition of resistance against fusariosis of oil palm (Assohoum et al., 2016 ; Kablan et al. 2016) carried out in Côte d'Ivoire, it stated that susceptible oil palm plants can be protected against Fusarium head blight by antagonism between saprophytic F. oxysporum strains and the pathogen *F. oxysporum* f.sp.elaeidis (Foe). Other studies are also being undertaken to assess the reaction to Fusarium head blight of seedlings from a Fusarium tolerant cross and a Fusarium non-tolerant cross of oil palm previously protected from a non-pathogenic strain of *Fusarium oxysporum* (Armstrong and Armstrong, 1981).

Furthermore, in order to produce tolerant oil palm seed in Cameroon, fusariosis-tolerant pollen grains have to be purchased from foreign partners at excessively high cost, notwithstanding the large number of genitors (4,000) available in Cameroon. Most of these genitors cannot be used because they have not been tested for Fusarium head blight (Tengoua, 2003). Indeed, to this day, the production of fusarium-tolerant seedlings for oil palm in Cameroon depends on tolerant pollen bought abroad at exorbitant prices (around 50,000 CFA francs for a unit of 0.0625g of fusarium-tolerant pollen grains).

This work consisted of testing several strains of F. oxysporum f.sp.elaeidis Foe on a few palm trees in order to identify the most aggressive strains to be used for tolerance testing of the broodstock used at CEREPAH (Dibamba Oil Palm Research Centre) for seed production or to better guide the oil palm variety improvement and selection programmes.

II. METHOD

Plant material

Five-month-old fusarium-susceptible oil palm seedlings were used in this trial. They were supplied by IRAD's Centre Spécialisez on oil palm reserch (CEREPAH) in Dibamba.

Fungi material

The fungal material used consisted of ten strains of F. oxysporum isolated from palms affected by chronic fusariosis in the palm groves of the CDC located in the South-West region, Department of Fako, more specifically in the localities of Matango, Ekona and Powo. The ten strains tested were labelled with the following designators: A; B; C; D; E; F; G; H; I; J. (Table 1).

Table 1 : Informations on isolates used (Temgoua and Bakoume, 2008).

Isolate	Sampling area on the trunk	Locality
A	Approximately 1 m from the ground	IRAD Ekona
B	Approximately 1 m from the ground	IRAD Ekona
C	Middle of the trunk	CDC Matango
D	Middle of the trunk	CDC Powo
E	Middle of the trunk	CDC Matango
F	Middle of the trunk	CDC Matango
G	Approximately 1 m from the ground	CDC Matango

H	Approximately 1 m from the ground	CDC Matango
I	Middle of the trunk	CDC Matango
J	Approximately 1 m from the ground	CDC Matango

Preparation of mycelium medium (MM) and strain maintenance

This is the most appropriate medium for the growth of Fusarium strains isolated from oil palm (Ntsomboh-Ntsefong, 2015). The various components [dipotassium phosphate (1 g), magnesium sulphate (0.5 g), iron sulphate (0.100 g), asparagine (1.5 g), agar agar (25 g), glucose (20 g), yeast extract (1 g)] were dissolved in 1 litre of distilled water. After homogenisation and autoclaving, the medium was poured into Petri dishes in a laminar flow hood at a temperature of 50-55ºC. After the medium had cooled and solidified in the dishes, the isolates were subcultured.

Isolate maintenance consisted essentially of renewing the isolates in the new media after one month..

Preparation of inocula

The inoculum for each strain was prepared on liquid medium (Armstrong medium) following the methodology described by Tengoua and Bakoume (2008), which consisted of taking a fragment of a five-day culture on solid medium and introducing it into a 100 ml flask containing 75 ml of Armstrong medium (Table 2). After shaking every ten minutes for four days, 2 ml were taken and placed in one-litre Roux dishes containing 100 ml of liquid medium. After shaking at the same rate for 10 days, the inoculum from each Roux dish was mixed with its counterpart from the flask, ground in a blender for 30 seconds and diluted in 4 litres of tap water for seedling inoculation.

Table 2 : composition of Armstrong culture medium

Compounds	Quantity (g)
Glucose ou sucrose	20,000
Magnesium sulphate	0,400
Chloride of potash	1,600
Potassium dihydrogen phosphate	1,100
Calcium nitrate	5,900
Iron chloride	Take 1ml of a stock solution 0,2g/L 1 cristal
Manganese sulphate	
Zinc sulphate	
Distilled water	1,000 (l)

Morphological characterisation of the various isolates

The different isolates were compared on the basis of colour, mycelial appearance, colony margin and colony surface.

a) Evaluation of radial growth of strains in Petri dishes

Each strain was transplanted into Petri dishes containing MM culture medium and repeated 3 times. The daily radial growth of the mycelium was recorded for each strain using a graduated ruler on 2 perpendicular axes joining at the centre of the Petri dish. Daily radial growth (V) was calculated using the following formula:

$V= (d_1+d_2)- d_0/2$ **(**Ntsomboh-Ntsefong, 2015).

d_1= diamèter 1 ; d_2= diamèter 2; d_0= 5 mm (diameter of mycelial disc).

b) Assessment of sporulation of the various isolates

It was carried out using a Malassez cell (Hematimeter), by microscopic observations of the isolate preparations. The aim was to count the asexual reproductive organs (microconidia and macroconidia) produced by each isolate. The chlamydospores were simply observed. For this quantification, each isolate was grown for four days in 100ml of liquid medium (Armstrong medium) from a four-day-old culture on solid medium. At the end of the 6 days, the cultures were filtered and appropriate dilutions were made to facilitate counting. For each strain, counting was repeated 2 times (Tengoua and Bakoume, 2008).

Pathogenicity test

a) Construction of the shade house

The shed was covered with oil palm leaves to limit sunlight penetration to 50% and reduce the kinetic energy of raindrops. In addition, a one-metre-high wire mesh fence surrounds the prenursery and prevents rodents from entering.

b) Experimental plan design

A randomised complete block design with five replicates (blocks) was used, with the ten strains as treatments (Fig. 1 a).

Each elementary plot contained 10 seedlings arranged in two rows of five (Fig. 1 b), and the distance between two elementary plots in the same block was 50 cm as long as two neighbouring blocks were 75 cm apart**.**

Block 1	Block 2	Block 3	Block 4	Block 5
P_1F	P_2E	P_3G	P_4J	P_5C
P_1H	P_2A	P_3B	P_4F	P_5B
P_1C	P_2B	P_3J	P_4D	P_5F
P_1A	P_2G	P_3E	P_4H	P_5D
P_1I	P_2D	P_3C	P_4G	P_5J
P_1G	P_2H	P_3A	P_4I	P_5E
P_1B	P_2I	P_3H	P_4C	P_5A
P_1D	P_2F	P_3I	P_4E	P_5G
P_1E	P_2J	P_3F	P_4A	P_5I
P_1J	P_2C	P_3D	P_4B	P_5H

Fig. 1 : a) plants in nursery ; b) differents plots

a) Plants maintenance

In order to prevent any interference from one or more undesirable factors, watering, fertilisation, phytosanitary treatments and weeding were carried out throughout the experiment.

The seedlings were watered every two days if it was not raining, at a rate of 10 litres of tap water per 500 seedlings, i.e. around 20 ml per seedling.

Fertilisers were applied at a rate of 10 g of Urea, 05 g of potassium chloride and 05 g of kieserite dissolved in 05 litres of water per 500 seedlings, starting one month after inoculation, i.e. as soon as the first symptoms of mineral deficiency were observed. It continued on a monthly basis. Immediately after spraying, the seedlings were watered abundantly to prevent leaf burn.

Insecticide treatments were applied to prevent insect attacks. Parastar 40 EC, a systemic and contact insecticide (20g/l imidachloprid + 20g/l lambdacyhalothrin) was used against Temnoschoita quadripustulata. Anti-slug (metaldehyde) was used against slugs and snails. Weeding was carried out by hand.

Inoculatioon

This operation involved removing the soil from the neck of each seedling to free the roots and wounding them with a pointed stick. The scarified roots were then rinsed with tap water before receiving 20 ml of diluted inoculum from each strain. After inoculation, the roots were covered with soil (Fig. 2).

Fig. 2 **:** inoculation of plants A= Root injury; B= Root washing; C= Administration of the inoculum.

Assessment of external and internal symptoms of fusariosis

Observation of symptoms in the prenursery began two months after inoculation of the seedlings and continued every fortnight until the symptoms stabilised. External symptoms characterised by yellowing and/or stunting of the leaves were noted, and the number of leaves of each type (green, yellow, stunted and dry) was counted.

At the end of the experiment, the seedlings were dissected in order to observe the internal symptoms of fusariosis (browning of the vessels).

Seedlings showing external symptoms were compared with those showing external symptoms in order to confirm or refute the origin of the external symptoms. Vessel atrophy is often considered to be a primary symptom that can cause secondary damage to the aerial part of the plant.

III. DATA ANALYSIS

The data obtained were analysed using SAS software to determine the effect of the treatments. Correlations between growth rate, spore count and external symptoms of Fusarium head blight were studied using SPSS 20.0 software.

IV. RESULTS

Morphological characteristics of strains

The development of isolates on MM medium varies from one isolate to another in terms of the appearance of the mycelium, its pigmentation and that of the culture medium (Fig. 3 a). However, these isolates can be grouped together in clusters with more or less similar cultural characteristics.

With the exception of isolate C, all the other isolates have cottony white aerial mycelium

Isolates A, B, D, E, F and I have abundant, well-developed aerial mycelium, which is whitish in colour at the start of growth. This pigmentation slowly turns yellow in isolates B and F, while D takes on a pink colouration. Strains G, H and J show a thin, short, pale white mycelium.

The view from below shows a purplish coloration evolving from the centre to the periphery of the dish as the cultures age (Fig. 3b). For strains A, E, F, I and J, this pigmentation conferred on the medium by the strain is more pronounced. Strain J in particular shows progressive darkening, but rapidly blackens the entire bottom of the dish when it is full. Strain C stands out the most for its strong brown pigmentation seen from both the front and the bottom.

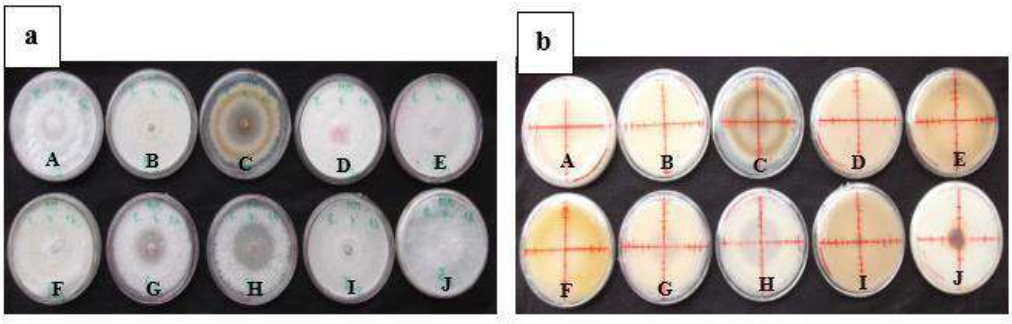

Fig. 3 : Morphological appearance of 10 Foe isolates grown on MM (a)= top view; (b) = bottom view.

Radial growth of isolates

Analysis of the results shows that there are highly significant differences in the radial growth of the isolates studied (p = 0.0001). The fastest-growing strain filled the Petri dish after 4 days, i.e. 8.12 cm, whereas the slowest-growing strain filled the dish on day 10. This means that the best time to compare the diameters of the isolates is day 4.

Statistical analysis of the mean diameters observed on day 4 reveals 5 statistically homogeneous groups (Table 2). The behaviour of the isolates varied from low growth (group e) to high growth (group a). Isolate F showed rapid and significantly different growth (8.12 cm) compared with the other isolates. It was followed by isolates B (6.56 cm), A (5.94 cm) and J (5.35 cm). In contrast, isolate I had the lowest growth rate (3.98 cm) and was also significantly different from the other isolates (H, E, G and D), which had intermediate values. Isolate C was statistically significantly different from isolates J, A and B. Isolates H, E, G and D were also statistically different from isolates A and B (Table 3).

Table 3 : Mean diameter of Foe isolates, 4 days after plating on MM medium

Isolates	mean diameter (cm)
F	8,12 a
B	6,56 b
A	5,94 bc
J	5,35 dc
D	4,77 de
G	4,58 de
E	4,50 de
H	4,26 de
C	4,02 e
I	3,98 e

Means followed by the same letter are not significantly different according to the Duncan test at the 5% threshold.

Sporulation of different isolates

Spores counted from four-day-old isolates on liquid medium showed that, with the exception of strains B and J,

all other strains sporulated. Furthermore, the concentration of spores varied significantly from one strain to another. Strains C and H were the most abundant sporulators, with average sporulation of $126.5x10^5$ spores/ml and $112.25x10^5$ spores/ml respectively. They were followed by strains G, I and F, which respectively had $45.1x10^5$, $39.75x10^5$ and $31.75x10^5$ spores/ml, while strains A, D and E sporulated weakly, with an average sporulation of less than $22x10^5$ spores/ml (Fig. 4).

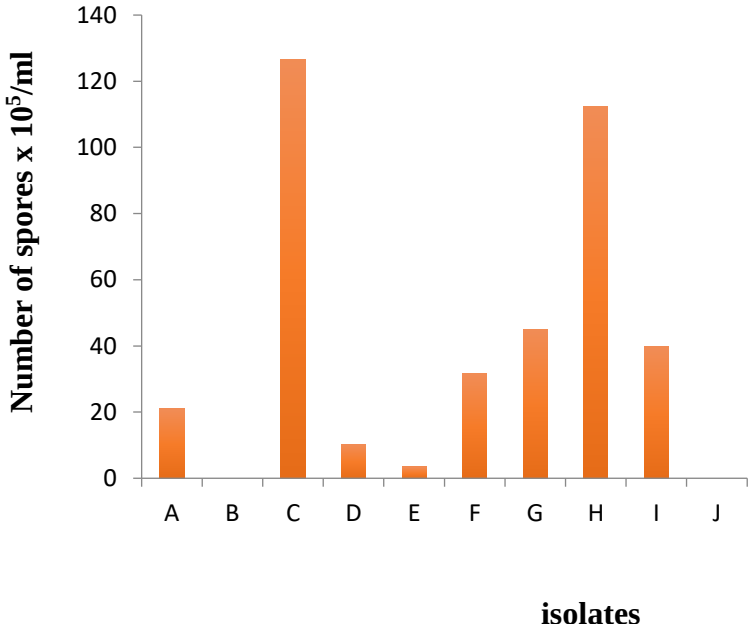

Fig. 4 : Rate of sporulation of differents strains

Types of spores observed

The main organs observed are microconidia, macroconidia and also chlamydospores, which are abundant in highly sporulating isolates (Fig. 5). Microconidia are unicellular, ovoid in shape and smaller than the other organs. Macroconidia are multicellular, septate, sickle-shaped and larger than microconidia. Chlamydospores have the same characteristics as macroconidia, the only difference being that they are larger and thicker..

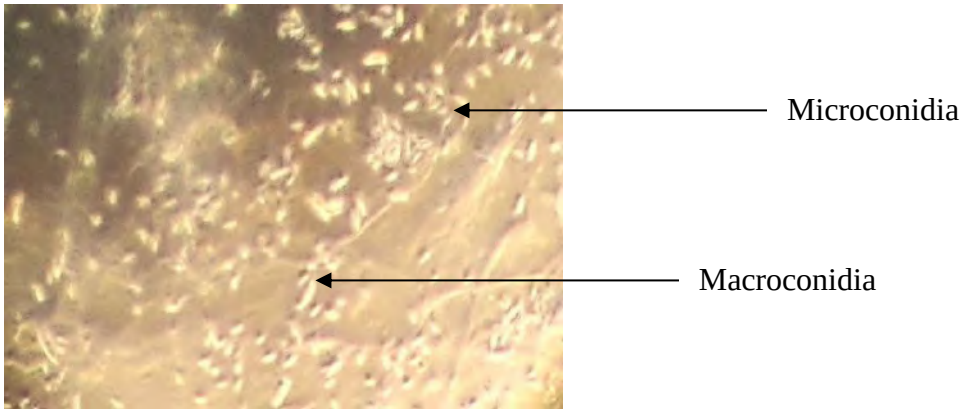

Fig. 5 **:** *Conidia of strain C under the light microscope (400X)*

External symptoms and pathogenicity of isolates

Seedlings inoculated with the strains tested showed secondary symptoms characterised by yellowing (Fig. 6 C), drying and stunting (Fig. 6 B) of the leaves (Fig. 6 A). After 12 weeks of incubation, the data collected showed expression by isolates I, F, E, C, H and G. The other isolates showed no perceptible external manifestations in the plautules in which they were inoculated. Yellowing

appeared to be the earliest symptom to appear. Strains D and G had a cumulative average of 0.32 chlorotic leaves for all the replicates, i.e. around 15 leaves per treatment and per block.

Fig. 6 : seedlings inoculated with isolates

A= without symptoms; **B**= stunted leaf; **C**= yellowed leaves.

After observation of the external symptoms, the data collected showed that there was no significant difference between treatments for the factors number of dry leaves and number of stunted leaves. However, for the number of yellow leaves factor, there was a significant difference (P>0.05) between treatments E and I compared with J (table 4).

Table 4 **:** external symptoms of plants (number of yellow leaves)

Isolates	Mean
J	1.660 b
H	1.380 ab
G	1.360 ab
C	1.300 ab
D	1.180 ab
B	1.160 ab
A	1.120 ab
F	1.080 ab
E	1.020 a
I	0.940 a

V. DISCUSSION

The pathogenicity of ten isolates was assessed in order to develop tolerance tests for Fusarium wilt for seed production. The morphological characteristics (colony appearance, radial growth, sporulation) and aggressiveness of the isolates on susceptible oil palm seedlings were observed..

The morphological parameters showed a variation in the pigmentation of the isolates, which increased with ageing. The colours observed were white, yellow, brown and pink respectively. Similarly, the appearance of the mycelium varied from thick to thin or short. This behaviour is consistent with that obtained by Tengoua (2003) and Dossa,

Correlations between sporulation, radial growth and external symptoms

The negative correlation coefficient (-0.002) shows a weak negative and significant correlation (p = 0.996) between the number of spores and the number of stunted leaves. The same result applies to the number of dry and yellow leaves. Similarly, there was a weak negative and significant correlation between the radial growth of isolates and the number of yellow and dry leaves. On the other hand, there was a weak positive correlation between the number of stunted leaves and the radial growth of the strains (Table 5). The only external parameter that showed a positive correlation, albeit a very weak one, was leaf stunting, which was correlated with the radial growth of the isolates..

Table 5 : Pearson correlation between spore number, radial growth of isolates and external symptoms of seedlings

		NS	D	YL	SL	SL
NS	r	1	-0.445	-0.249	-0.285	-0.002
	P		0.198	0.487	0.424	0.996
D	r	-0.445	1	-0.133	-0.189	0.109
	P	0.198		0.713	0.601	0.764

NS= Number of Spores; **D**= Diameter; **YL**= Yellow Leaves ;**FR**= Stunted leaves; **r**= coefficient of corrélation ; **P**= Probability.

(1993) who states that in *Fusarium oxysporum*, the morphology of the thallus is subject to strong variations under the influence of environmental factors (temperature, light). As a result, the morphological appearance of the mycelia is not an important criterion for identifying them. In fact, with the exception of isolate C, all the other isolates have a cottony white aerial mycelium (Tengoua and Bakoume, 2008).

The radial growth rate on day 4 after culturing enabled the different isolates to be classified into 5 statistically homogeneous groups. Isolate F has showed the highest radial growth (8.12cm) while isolate I showed the lowest (3.98cm). This variability in the behaviour of the isolates

can be explained both by the influence of genotypic and environmental factors such as light, temperature and humidity (Ntsomboh-Ntsefong et al 2015). The great variability observed in the radial growth rate of the different isolates shows that this parameter would be of interest for characterising these isolates. Radial growth can therefore be used for primary classification of the different isolates. (Renard and Revise, 1986)

Sporulation of isolates showed a significant difference between some treatments. However, all isolates sporulated with the exception of isolates B and J. This may be explained by the early spore count carried out on isolates that were only 4 days old. In fact, Kablan et al 2016 have shown that, the start of sporulation of the strains may not be at the same age for all strains. Furthermore, this absence may mean that the strains in question have lost their sporulation vigour as a result of permanent replanting during storage (Lepoivre, 2003). Isolates A, D and E showed a low sporulation rate, unlike isolates C and H, which showed abundant sporulation. This low sporulation rate is a limitation for the study of the pathogenicity of these isolates, as the spores are used as the infectious organ in the evaluation of pathogenicity.

Isolate J was the most aggressive, causing yellowing in a large number of seedlings. In contrast, isolates E and I were the least aggressive. It thus appears that all the strains tested are pathogenic to oil palm, but to varying degrees. The low pathogenicity may be due to successive subculturing of isolates in culture media. (Gbongue et al., 2012). Similarly, the use of 5-month-old seedlings may be sufficient to explain the delay in the edifying pronunciation of external symptoms, and hence the absence of any significant difference between treatments (Asssohoun et al., 2016).

The isolates with the greatest pathogenicity are not necessarily those that grow fastest in vitro, nor those that produce the most spores. This may explain the weak correlations obtained between the level of aggressiveness and morphological parameters (Flood, 2006). Nevertheless, a positive correlation was found between the number of stunted leaves and the radial growth of isolates. This means that strains with good radial growth can induce leaf stunting at an early stage.

At this stage of the trial, it is therefore difficult, if not impossible, to give an opinion on the aggressiveness of the strains. Notwithstanding this setback, an overview was given of the pathogenicity of the strains based on the isolates that showed external symptoms in advance. These are strains C, E, F, G, H, I and J, which, according to the observations made, are highly pathogenic. Once the external symptoms have stabilised, the strains can be classified according to their aggressiveness.

VI. CONCLUSION

The aim of this study was to classify ten isolates of *Fusarium oxysporum* f. sp. Elaeidis from the palm groves of the Cameroon Development Corporation (South-West Cameroon) according to their pathogenicity.

Isolate J was the most aggressive. In contrast, isolates E and I were the least aggressive.

The pathogenicity test can therefore be used to determine which varieties are resistant to fusarium wilt of oil palm.

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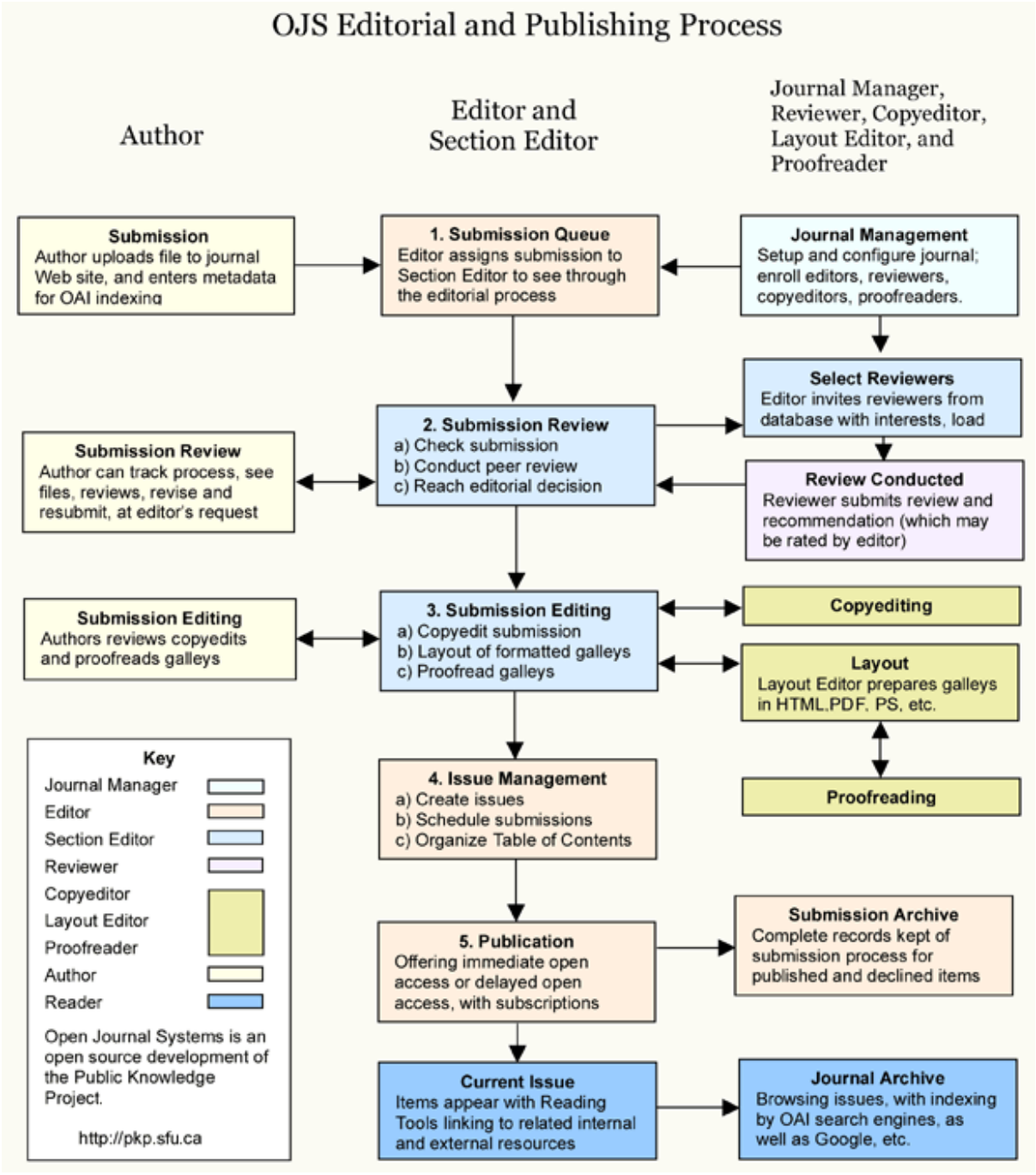

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