**Current Research in Agricultural Sciences**
*2023 Vol. 10, No. 2, pp. 62-69*
*ISSN(e): 2312-6418*
*ISSN(p): 2313-3716*
*DOI: 10.18488/cras.v10i2.3583*


# Cultivation practices of leafy vegetable production during the wet season in Ambon, Indonesia

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**Article History**
Received: 7 October 2023
Revised: 10 December 2023
Accepted: 20 December 2023
Published: 29 December 2023

**Keywords**
Climate
Disease incidence
Planting distances
Rain shelter
Rainfall
Yield.

## ABSTRACT

Green cabbage, water spinach, and spinach are important vegetables in the diet of the Ambonese communities, so the vegetables have economic value and contribute to the inflation of Ambon City. The main obstacle for optimizing leafy vegetables in urban farming of Ambon City in Ambon Bay neighborhood is excess water during the rainy season which possibly induces plant diseases and reduces the yield. The purpose of this study was to verify the 11-year weather of Ambon Bay; and the adaptation of vegetable farmers in Ambon City to the change of rainy season as well as precipitation in the study location The research was conducted using a qualitative descriptive method based on interviews with farmers supported by climate data for 11 years. This study explains that the rainfall was variable during 10 years; In 2010-2013 and 2017-2020, the annual rainfall was 3.950-5.264, while in 2014-2016 it ranged from 2.017-2.995 mm. Farmers adapt to high rainfall by installing plastic rain shelters, shortening the planting distance from 20 cm to 10 cm, and changing the planting calendar. However, in general growers install rain shelters during vegetable cultivation in the wet season resulting in high productivity of leafy vegetables.

**Contribution/Originality:** This is the first published-study related to the adaptation of vegetable grower in Ambon Bay to the change of rainfall. High rainfall in Ambon is suggested to change the leafy-vegetable cultivation practice but the rainfall data was not published; and the way of farmer change their cultivation in order to mitigate high precipitation has not been published. The results of study contribute to the improving method of growing vegetable in rainy season.

## 1. INTRODUCTION

The main livelihood of Maluku Province is agriculture, which is practiced in almost every district, even though the land area is limited compared to Java Island. The total area of Maluku Province is 712,480 km² but 2.4% is the ocean. In 2010, the population of Maluku was 1.533.506 and there was an increase of approximately 22.7% population resulting to 1.881.727 people in 2022. Currently, Maluku still imports raw food particularly vegetables and meats from outside the province including North Sulawesi, South Sulawesi, and East Java. However, Maluku

province is self-sufficiency in leafy vegetables; the consumptions of green cabbage (*Brassica juncea* L.), water spinach (*Ipomoea Aquatica* Forsk), and Indonesia's spinach (*Amaranthus* spp.) become a food habit.

Commonly, farmers grow leafy vegetables throughout the year with a monocropping system on small-scale vegetable farms. The vegetable production in Ambon Bay stretches from Paso, Nania, and Waiheru to Hative Besar village. Vegetable production throughout the Ambon Bay has a significant impact on communities' revenue and the local economy. The challenges for maintaining and increasing the vegetable yield in the study area are low soil properties, high rainfall in certain months, and changes in the rainy season that increase the soil and air-borne disease intensity. The high demand for leafy vegetables during the wet season caused inflation in two cities of Maluku, namely Ambon and Tual due to its limited production and supply.

The agricultural area at the low altitude of Ambon Island is adjacent to the coast; the soil is formed from Alluvial parent material [1] so the soil texture is loamy sand with good drainage. In general, the soil area in Waiheru is Entisols with low soil fertility; the soil contained low organic-C (1.6-1.76%), low total N (0.12-0.14%) with low $P_2O_5$ availability; The pH is slightly acidic 5.5-5.8 [1]. Farmers depend on inorganic fertilizers to increase soil N and P availability during vegetable cultivation. Nitrogen (N) and Phosphorus (P) are the major essential macronutrients that increase the above-ground biomass, growth and productivity of crops. It is well known that nitrogen and phosphorus fertilization correlate significantly with chlorophyll and the biochemical constituent of leaves [2-4].

High rainfall in Ambon Bay is strongly related to plant diseases; according to the local Meteorological Office, changes in the rainy season and dry season as well as higher rainfall have occurred. Southeast Asia as well as the Pacific Islands will be affected by climate change in the next decades due to the growing population, long coastlines, and low altitude area [5]. Farmer's reliance on the agricultural sector and high dependency on natural resources increase the impact of climate change in such areas. Climate change has a severe impact on the average temperature and precipitation; increases of floods and droughts, hence the economic growth [6].

A small discussion with vegetable farmers in Ambon Bay in 2018 and 2021 revealed lower yield and revenue during rainy-season vegetable cultivation. At that time small communities of farmers installed rain shelters to avoid high precipitation but the plastic price was not affordable so they depended on the Corporate Social Responsibility program of the Central Bank of Indonesia. The intensity of certain diseases in tropical agricultural areas in the rainy season is higher than in the dry season due to the high rainfall [7-9]. Despite the constraint of vegetable production in rainy seasons, the farmer's adaptability to high precipitation in maintaining vegetable productivity in Ambon Bay has not been studied. The objective of this descriptive research was to 1) confirm the climatic variation – mainly related to the rainfall – in the Ambon Bay area over 11 years, 2) get information from the farmers concerning the way to cope up with the change of wet season, and 3) inventory the plant diseases in the wet season.

## 2. MATERIALS AND METHODS

The study was conducted in the Waiheru village in Ambon City at an altitude of 4 m above sea level with the geographical coordinates of -3.628805, and 128.2214317 (Figure 1). To confirm the change in rainy season and rainfall, the Pattimura Meteorological Station at Laha of Ambon provided sets of daily weather data from 2010-2020. The station measures the daily weather of Ambon Bay and is located in the geographical position of -3.7110876 S, 128.0828262 E. The office provides temperature, humidity, rainfall, rainy days, and days of sunshine data. The annual weather elements and monthly rainfall are calculated based on daily data and depicted in the Tables.

Primary data related to the productivity of green cabbage, water spinach, and spinach was collected from 10 vegetable farmers of Waiheru Village. A Focus Group Discussion (FGD) was done involving farmers in Waiheru Villages in 2018 and 2023. The information obtained from FGD was the general method of vegetable cultivation, mainly the use of rain shelter and organic matter application, as ways to reduce the disease attack and crop growth

failure during the rainy season. The discussion also included the vegetable production and quality during higher precipitation; and their profit compared to the dry season. A field survey has been conducted to identify common diseases in the vegetable areas of Ambon during the rainy season.

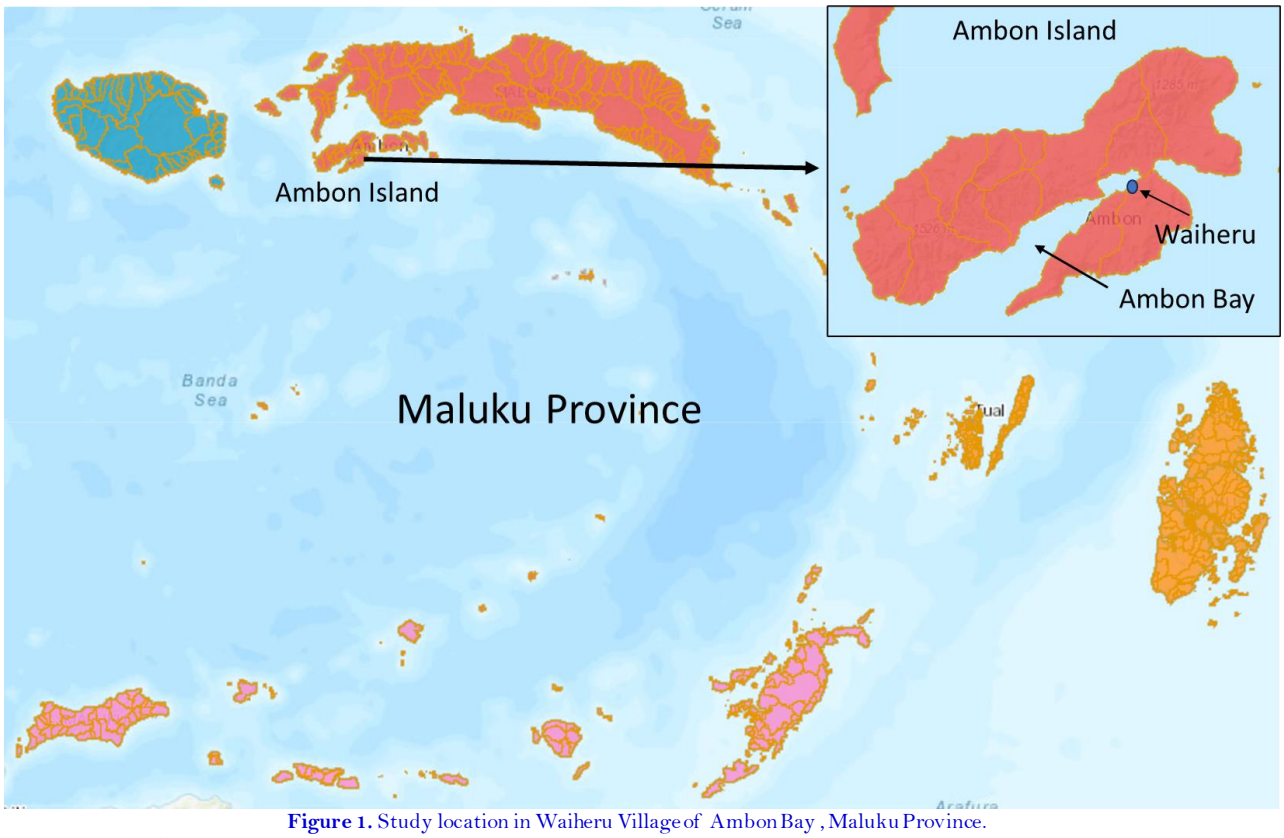


**Figure 1.** Study location in Waiheru Village of Ambon Bay , Maluku Province.

**Source:** ArcGis online.

## 3. RESULTS AND DISCUSSIONS

### *3.1. Annual Weather in Ambon Bay*

Weather in Ambon Island for 10 years has been quite consistent with minor changes in temperature and humidity throughout the year, however there is a major change in the rainfall variation (Table 1). The average temperature is constant 26-27$^0$C but the maximum temperature was likely decreased in 2019 and 2020. The annual rainfall in Ambon was huge; during ten years, the annual rainfall was approximately 3.617 mm. The rainy day lasted approximately 250 days, which is almost two-thirds of the year.

**Table 1.** The annual weather in Ambon Bay from 2010-2020 calculated from daily data.

| Weather elements | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Av. temperature ($^0$C) | 26.7 | 26.2 | 26.4 | 26.5 | 26.6 | 26.5 | 27.3 | 26.5 | 26.9 | 26.7 | 27.05 |
| Max. temperature ($^0$C) | 30.7 | 29.7 | 29.9 | 29.8 | 30.2 | 30.8 | 31.9 | 30.8 | 30.9 | 28.3 | 28.7 |
| Humidity (%) | 86 | 86 | 86 | 86 | 84 | 83 | 84 | 86 | 83 | 83.25 | 84 |
| Days of sunshine (%) | 56 | 50 | 55 | 56 | 59 | 66 | 63 | 48 | 57 | 55 | 52 |
| Rainfall (mm) | 3,932 | 4,610 | 5,042 | 5,147 | 2,592 | 2,017 | 2,995 | 5,435 | 3,948 | 2,303 | 4,518 |
| Rainy day | 257 | 257 | 232 | 235 | 229 | 210 | 215 | 280 | 252 | 261 | 265 |

**Source:** Pattimura meteorological office of Laha, Ambon.

According to Oldeman Climate Classification, the wet month is a month with rainfall over 200 mm, the dry month is a month with rainfall less than 100 mm, and the humid month has rainfall in between [10]. The average of the wet and dry months in a row is 7.5 and 1.6 respectively; the Climate type of Ambon Bay according to Oldeman climate type is B1.

Indonesia's Meteorological Office classified the monthly rainfall into three categories: low (0 – 100 mm), medium (100 – 300 mm), high (300 – 500 mm), and very high (>500 mm). Table 2 shows that precipitation in Ambon Island is dominated by medium to high rainfall. In the wet season, the rainfall was mostly very high. The pattern of rainfall during 10 years was changed (Table 2).

**Table 2.** Annual rainfall in Ambon Bay from 2010-2020 calculated from daily data.

| Month | Rainfall (mm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| January | 166 | 228 | 100 | 252.1 | 307 | 160 | 71 | 284 | 236 | 234.8 | 98.6 |
| February | 32 | 202 | 119 | 194.8 | 177 | 196 | 34 | 152 | 120 | 47.1 | 81.8 |
| March | 109 | 127 | 298 | 77.6 | 62 | 120 | 153 | 143 | 203 | 221.4 | 176.8 |
| April | 113 | 240 | 80 | 166.9 | 155 | 298 | 355 | 129 | 292 | 315.5 | 87.3 |
| May | 353 | 1468 | 908 | 295.1 | 418 | 180 | 239 | 753 | 797 | 267.7 | 679.5 |
| June | 833 | 691 | 1252 | 359.6 | 386 | 718 | 199 | 1430 | 847 | 534.4 | 960.2 |
| July | 763 | 694 | 1157 | 1923.1 | 225 | 164 | 914 | 1046 | 542 | 272 | 842.1 |
| August | 849 | 323 | 639 | 629.3 | 448 | 70 | 347 | 452 | 299 | 95.9 | 302.2 |
| September | 213 | 304 | 254 | 360 | 117 | 3 | 342 | 501 | 411 | 101.6 | 573.6 |
| October | 106 | 143 | 136 | 128.5 | 128 | 67 | 185 | 180 | 29 | 171.8 | 440.6 |
| November | 146 | 44 | 25 | 91 | 32 | 14 | 37 | 18 | 27 | 27.4 | 137.1 |
| December | 276 | 147 | 75 | 220.2 | 137 | 118 | 119 | 176 | 146 | 14.2 | 138.3 |
| Total | 3,959 | 4,611 | 5,043 | 4,698.2 | 2,592 | 2,108 | 2,995 | 5,264 | 3,949 | 2,303.8 | 4,518.1 |

**Note:** *According to Oldeman classification.
**Source:** Pattimura meteorological office of Laha, Ambon.

The monthly rainfall in 2014-2016 was lower than other years of 2010-2020. The wet season lasted for 8 consecutive months with 3 months in a row of very high rainfall in 2020. However, heavy rainfall in 2010 lasted for 4 months between May to August. There are only two seasons in Ambon: wet (rainy) season (West Season) and dry season (East Season) with two transition periods. During 10 years, the transition period from the wet to dry season was November-December; and from the dry to wet season was March to April.

### *3.2. Cultivation Methods*

#### *3.2.1. Planting Distance*

The farmers in Ambon transplanted the green cabbage seedlings with a shorter planting distance (Figure 2) compared to the recommended distance given by the Research and Development Institute of the Indonesia, Ministry of Agriculture. They preferred shorter distances (20 cm x 20 cm) since the green cabbages were harvested on 19-21 days instead of 30 days. This is related to the preference of consumers who like low-content fiber vegetables in their daily diet. In the rainy season, the planting distance of green cabbage becomes shorter (10 cm x 10 cm) to avoid the water splashing from the soil surface to the leaves. Some growers planted water spinach in rows of 10-15 cm but usually water spinach and spinach were grown by broadcasting method with various planting distances ranging from 1-2 cm resulting in dense population (Figure 2).

#### *3.2.2. Rain Shelter*

The productivity of leafy vegetables grown without rain shelter were lower compared to that grown under a plastic rain shelter; the green cabbage yield reduced up to 77%, water spinach by 51%, and spinach by 43%. However, the productivity of leafy vegetable under a plastic rain shelter (Figure 2) was still lower compared to that in the dry season since the light intensity is lower and reduces photosynthesis. If the green cabbage is grown in the wet season and without any rain-shelter, its yield is observed to be reduced by 50% compared to the wet season crop grown under rain shelter.

**Figure 2.** Dense population of green cabbage (b) under the rain shelter.

### *3.3. Plant Diseases*

The pathogens as shown in Table 3, are most common pathogens attacking leafy vegetables throughout the year in Ambon. Disease intensity during wet-season vegetable cultivation was high mainly in the field without rain shelter.

**Table 3.** Common diseases during vegetable cultivation in the wet season.

| Diseases | Target organs | Pathogens |
|---|---|---|
| Damping off | Stem base | *Rhizoctonia solani* (Fungi) |
| Leaf blight | Leaves | *Rhizoctonia solani* (Fungi) |
| Wilt disease | Stem base | *Sclerotium rolfsi* and *fusarium oxysporum* (Fungi), Pseudomonas solanacearum and Erwinia caratofora (Bacteria) |
| White rust | Leaves | *Albugo* sp. (Not true fungi; eumycota) |

Damping off and leaf blight are soil-borne diseases commonly found in leafy vegetables; both of them were caused by *Rhizoctonia solani* fungi. Vascular wilt disease is caused by soil potential pathogens that results in plant wilting and loss of vigor. White rust is mainly found in water spinach leaves grown in Ambon; this is an important disease of Cruciferous vegetables (Family Brassicaceae) caused by *Albugo candida*; the oomycetes.

## 4. DISCUSSION

A dense plant population reduces the risk of splashing soil droplets to the leaves that might contain pathogenic microbes. Even though most of the bacteria were removed by runoff water, soil-borne microbes might cause plant pathogens [11]. Moreover, warmer temperatures in the tropics increase the proliferation of soil and air-borne potential plant pathogens [12]. The yield of leafy vegetables largely depends on the light intensity and day of sunshine; the benefits of using rain shelter for growing vegetable is reported to improve crop performance compared to the outdoor environment [13-15]. However, in Ambon the high rainfall results in cloudy days that reduce the light intensity. For vegetable cultivation, the light intensity is prominent to increase plant height, leaf numbers, leaf area, net assimilation rate, and relative growth rate of spinach, *Spinacia oleraceae* L [14].

The weight of a 50 cm bunch of green cabbage under a rain shelter was 100-150 g, but in the dry season about 300 g. Based on the FGD with farmers in Waiheru, the vegetable price in the rainy season was lower compared to 6-7 years ago since most farmers in Ambon now use rain shelters in the high-precipitation season. The Chinese cabbage growers in Mississippi operate small- to medium-sized farms by using polyethylene (plastic) tunnels in winter producing the highest marketable yield than those without tunnels [16]. In Indonesia, rain shelter in the wet season causes higher shoots and more branches of chili [17]. However, the production of leafy vegetable in Ambon during the rainy season under rain shelter was reduced.

Plant pathogen virulence, survival, and reproduction are influenced by temperature and humidity; the concept in plant pathology is the result of interaction between pathogens, host plants, and the environment [18]. The severity of damping-off in Ambon increased in the rainy season; the higher virulence and reproduction of *R. solani* is likely caused by the alternate low-high temperature combined with soil water availability. The temperature range for *R. solani* growth is 20 to 30°C with optimal temperature at 25°C [19] which is actually observed prevailing temperature of Ambon. In the wet season soil water is ample; even though the virulence of *R. solani* was not determined by soil moisture; the pathogen could not survive even in the extremely dry soils [20]. The soil in the study area is loamy sand with good drainage. Puddled situation is not common in the study area, even during high rainfall events.

In general, plant disease intensity is increased by high air humidity, and high soil moisture which occurs in the rainy season [18]. The virulence of the fungus Sclerotiorum has a positive correlation with the air humidity increases [21]. In the rainy season, the duration of the water presence in the leaves is longer; resulting in disease development on the leaf's surface [22]. In general, sunny weather is observed after the rainy days in Ambon, this increase the disease development in leaves. Rain shelters significantly reduce the soil and air humidity and the pathogen proliferation in soil and hence reduce the disease intensity.

## 5. CONCLUSION

According to the monthly climate data, high climatic variability has occurred in Ambon; there was a fluctuation of rainfall during 11 years (2010-2020). The rainfall ranged from 2,108 in 2015 to 5,264 in 2017, and the average rainfall was 3.617 mm. The low productivity in the rainy season in Ambon is likely not only caused by high rainfall but also by cloudy days that induce low light intensity. Rain shelter installation and shorter planting distances are local cultivation practices to avoid high disease intensity, but it doesn't increase the yield during the wet season. Nonetheless, by using both cultivation practices, vegetable cultivation can be conducted all year round, either in the dry season or wet season.

**Funding:** This research is supported by Universitas Padjadjaran (Grant number: 542/UN6/WR3/2018).
**Institutional Review Board Statement:** Not applicable.
**Transparency:** The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
**Competing Interests:** The authors declare that they have no competing interests.
**Authors' Contributions:** The concept and design of the study, R.H., M.K. and S.B.; provide and analyzed the weather data, R.S.S. and W.P.; wrote the manuscript, R.H. and S.B. All authors have read and agreed to the published version of the manuscript.

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