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Leveraging *Gynura procumbens* (Lour.) Merr. response to drought and climate change in tropical country on plant productivity in backyard

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ABSTRACT

Food is a primary requirement and source of life, which is important as it nourishes the body and sustaining the very existences of humans. It is found to be increasing by number of calories from 2441 kcal in 1970 to 2,950 kcal in 2015, and projected to be 3,040 kcal per capita in 2030. The calories increment is determined from different types of food, including vegetables. This study aims to leverage Gynura procumbens response to drought and climate change in tropical country, on plant productivity in backyard. The cultivation of Gynura procumbens was carried out experimentally with 4 different treatments for 6 months. The plant showed preference for microclimate conditions, such as soil moisture that varies between 70-90%, light intensity ranging from 128, and a temperature range of 31-32 °C. However, it was found that Gynura procumbens still survive in microclimate conditions above or below its preference.

Keywords: Backyard, Food, *Gynura procumbens*, Micro-climate

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1. Introduction

Food is a primary requirement and source of life, which is important as it nourishes the body and sustaining the very existences of humans. The number of food calories consumption per capita is found to keep rising every year starting from 2441 kcal in 1970 to 2,950 kcal in 2015, and is projected to increase to 3,040 kcal per capita in 2030 [1]. As a basic requirement of life, the aspects of quantity and quality of food becomes important, and needed to be prioritized [2, 3]. Food adequacy is a necessity to every individual, unfortunately, there are still 925 million people living in conditions of famine as recorded in 2010 [4]. Therefore, an effective strategy is needed in order to curtail the global hunger, such as food distribution. Meanwhile, the state plays a role in ensuring that all citizen have easy access to food [5]. One of the alternative concepts which is also a solution is the role of food sovereignty against the unfair and unsustainable food system [6]. Through the concept of food sovereignty, it is expected that the basic issues of food as well as hunger, malnutrition, and food insecurity are solved. Indonesia is keen on addressing these issues by promoting the concept of food sovereignty through the Act No. 18 of 2012 on Food, which emphasizes on respecting, fulfilling and protecting the right to food of its citizens. The basic controversy of the law is that the state did not systematically acknowledge the right to food of its citizens [6]. The process of not fulfilling the right to food is observed from the inadequacy of the Indonesian population of 2,015 calories kcal per capita, than the ideal number of 2,200 kcal [7-9], therefore, the basic problem of food insecurity still occurs widely [10]. In essence, the concept of sovereignty contributes to complement and optimize the achievement of food security. While food sovereignty is fundamentally the mainstream production ability, distribution, and consumption in a community or a region. The basic concept of food sovereignty is to increase the welfare of small farmers that are marginalized, through the utilization and improvement of land as many as 26,126 farm families, or 42.7% of total households nationwide [11]. Farmers and those that engage in food production should be sovereign because basically, food sovereignty is the people's right to getting healthy and culturally appropriate food through environmentally friendly farming systems and sustainability [12]. When this is achieved, then Indonesia is set to rebuild the Global Hunger Index score (21.9), which ranked 73rd globally [13].Another important aspect is that, through food sovereignty, the local culture adequately appreciated and diversification easily manifest. Naturally, these conditions are obtained when the farmer plant varieties of crop by heeding to the wishes and needs of the consumers [14]. Food sovereignty encourages agro-ecological agricultural production and trade protectionists in order to grow the local market. Also, it rejects the notion of "food can come from anywhere", which indicates that the concept of food sovereignty does not recognize the existence of importation [15, 16]. This concept is interpreted as the right of every individual, community, and country to have the access and supervision of productive resources. And also, define and control the food system independently by following the conditions of ecological, economic, and social factors [17, 18]. Also, it fully supports family-based farming, in which they grow and consume their farm products themselves (land to mouth). Therefore, this concept is a crucial basis of food security of a country, and through the power of sovereignty, making countries, such as Indonesia, a region with justice in the context of food [19]. Indonesia has the ability to achieve food sovereignty in the aspect of ecological and geographical climate, with more of the advantages at the equator, making the land very productive [20]. This country has a parent material, topographic and diverse climates, which are very suitable for agricultural floating [21, 22]. Approximately 191.09 million hectares of Indonesia's land area are available, and about 95.90 million has (50.19%) potential for agriculture, limited production forests (6.79 million hectare), production forest (20.35 million hectare), and other utilization (7,44 milion hectare). Indonesia has essentially a land that is biophysical, especially from the aspect of topography, climate, wet and dry. While the physical, chemical, and biological soil has the suitability to be developed into agricultural land [23]. In addition, topography has the technological and agronomical suitability, climate variability, a multifaceted type of soil, full contour area from an altitude of 0 to 5,400 meters above sea level, and common food crops. There is no extreme temperature changes which is 23-33 °C in the lowlands and 15-27 °C in the highlands, and the average rainfall is 2,400 mm wide, and ranges between 1000-4500 mm per year [24]. Indonesia is considered as an agricultural country where agriculture has existed as the major of the national economy and creates jobs for a large part of the society. Currently, about 50% of their population are directly or indirectly involved in the agricultural sector. The central characteristics of the agricultural system in Indonesia are based on the family, ownership of small farms, small capital, subsistence, and traditional management [25] . Historically, agricultural development in Indonesia has been in existence for more than four decades (since 1970), however, the total production has not been able to fulfill all regulations of national food, and most farmers still fall below the poverty line. Though Indonesia ranks fourth in the world as a country with the largest population after China, India, and the United States with the total of 250 million inhabitants [26, 27]. And the population is estimated to rise 1:45% per year, therefore, the issue of adherence to food law becomes noticeably significant. However, the unexpected increase in urbanization has given rise to new cities in Indonesia. The urban population in 1950 was only about 12%, then increased to 16% in 1960 and to 20% in the 1980s, and increased dramatically in 2010 to 49.8% [25]. With the rapid urbanization, the transformation of the agricultural policy of Indonesia has acknowledged the importance of environmental, social, and economic factors that apply green agricultural systems, through the reduction of farm emissions that contribute to global climatic change [28]. Therefore, the need for an alternative agricultural system that accommodates the urban community and agricultural activities while contributing to the alleviation of global climatic change. The appropriate solutions to deal with these challenges is adaptive climate smart-agriculture-based urban farming. It is a theory formulated by FAO in response to the increasing threat to food security and the high implications of climate change [29-32]. The concept consists of three components, namely (1) to increase agricultural production sustainably, (2) adaptive and build resilience to climate change, and (3) create opportunities to reduce emissions and able to absorb carbon [30]. Urban farming is able to support the carbon dioxide sequestration and water utilization program as part of an adaptive climate-smart agricultural system [33, 34]. When applied by many parties, it contributes and respond to the challenges of food sovereignty, while decreasing the emission rate [35, 36]. Plants that are tolerant to drought, carbon dioxide sequestration, and optimized productions are chosen and used to mitigate climate [37] Indonesia has a total of 10.3 million or 14% backyard of the total area of agricultural land [38, 39]. When the yard area is utilized for growing crops, it would be very beneficial for the execution of family farming and climate change mitigation [40-43]. Moreover, it is used to respond to the challenges in enhancing the resilience of staple foods as supplemental nutrition and healthy foods. The backyard in Indonesia has potential for many types of plant, as the sources of greening, carbohydrates, proteins, fats, vitamins, minerals, and drugs for health. Family farming serve to increase their income, improve food security, tackling malnutrition, and as a provider of family medicine. This study uses Gynura procumbens as the type of crop in the backyard. It was chosen because it delivered many benefits, such as health, economic value, and was able to absorb carbon dioxide in large quantities. Gynura procumbens has flavonoid containing compounds, unsaturated sterol, triperten, polyphenols, and essential oils. It contains, triterpenoids, chlorogenic acid, acid kafeat, acid vanilat, acid is kumarat acid, p-hydroxy, asparaginase and many other compounds [44]. Therefore, Gynura procumbens is a potential medicinal plants grown in backyard. This study was conducted to examine the rate at which Gynura procumbens were grown in backyard in response to stress microclimate. Its growth response should be optimized by variations in the microclimate stresses which serve as a role model of Gynura procumbens cultivation in backyard farming.

2. Material and Method

2.1. Plant growth theory

The life of each type of organism depends on environmental conditions, which include biotic or physical and chemical, and abiotic components or living things (biological). All types of organisms need a favorable environment to grow and reproduce properly [45, 46]. This is as a result of the requirement of different types of environmental condition for each type of organisms [47, 48]. When a type of organism does not obtain the suitable environmental conditions, it experiences growth retardation or even death. Therefore, it identified the limiting factors in the environment that affect living organisms.The limiting factor is the presence of an element or compound in the environment in small quantities, affecting the life of the organism. However, it should be understood that excessive quantity of components also affects the life of the organism [49]. The limiting factor commonly originated from the physical and chemical components that were initially located or incorporated into a habitat, intentionally or unintentionally. This happened because of the process of interaction in the ecosystem between the abiotic and biotic components. Abiotic factors comprise of a climate, such as light, temperature, rainfall, humidity, and wind, edaphic components, and physiographic which includes land, geology, and topography. Then biotic factors consist of plants, animals, and people [47]. The various biotic and abiotic components in a region (habitat) is referred to as a micro-climate.

2.2. Microclimate

Microclimate is defined as the physical and chemical factors that serve as habitat for organisms in this plant. Microclimate as well as environmental factors grow plants that consist of light, water, temperature, humidity, and mineral soil [50]. Each of these physical and chemical components have an uneven effect on the growth and improvement of plants [23]. Furthermore, there are plants that have specific preferences of a particular micro-climate [51]. This happened because of the microclimate role and the physiological function of the plant.

Microclimate provides a very strong influence on the physiological techniques of organisms, especially plants. The entire physiological processes occurring in plants is influenced by light, water, humidity, temperature, and mineral soil [52, 53]. Besides the topography, altitude factors also affect the survival of plants and basically, the elevation effect on temperature and humidity. Therefore, altitude affects the distinctiveness of ecosystems and species in it [54]. Therefore, optimum condition is an outstanding microclimate that a type of plant grows optimally and give maximum yields.

2.3. Backyard

Backyard area is a land biophysical system which exist around the home environment and has two substantial point, which are the ecological and economic value. Ecological value refers to the roles and functions of the yard as water catchment areas and habitat for flora and fauna. Yard area has commodity suitability for the cultivation of vegetables, fruit trees, and plants kitchen spices, plants toga, which when managed appropriately, it empowers the family economically [55, 56]. Although the concept of the yard does not only give a physical role in the function of beauty and coolness alone. Moreover, it has a value of environmental services that is not evaluated by the material [55].

Utilization of the yard for the production of foodstuffs or other uses still on a small scale (for and by families) [57]. These conditions need to be optimized due to the large capacity of existing agricultural land. Improving the potential of yard area for agriculture generates high incomes. Also, it increased revenue opportunity to shorten the distance or economic inequality in the society. It is an opportunity that needs to be speculated for the optimization of yard area for the family agricultural cultivation to be comprehended appropriately. According to Goenadi, manure increases the activity of microorganisms in the soil and boost its structure by increasing the number, rises aggregate stability, and facilitate the development of roots. The existence of microbes contained in the organic fertilizer works to increase the solubility of nutrients that plants need, both those derived from mineral fertilizers or soil, and enriched the nutrient-absorbing roots with the formation of hair follicles. Giving easily decomposed organic material, for example, manure assist to improve soil structure [58]. Soepardi states that, an organic constituent of manure that is valuable is the living component, namely micro, which are generally found in animal bodies (cattle and sheep), the waste contains a lot of bacteria and other microbodies. Between a quarter and a half of dirt ruminants, is a network of microbodies, most of them continue weathering the manure. Components of a good medium for growing plants consist of soil, organic matter, water, and air. The main elements of the soil for excellent plant life by consist of 50% of the pore space, 45% mineral (inorganic) and 5% organic matter. However, the planting medium is relative on heavy soil when applied, resulting in a vertical garden that do not last long [59].

2.4. Method

The study used a quantitative approach with field observation methods and measurement of microclimate parameters as a factor in the influence of *Gynura procumbens*. This research was conducted for seven months in the dry and rainy seasons to get a complete of the effect of microclimate conditions in tropical area. *Gynura procumbens* were placed in four different treatments, namely full semi open, full open, full canopy, and full non canopy. All treatments were given the same as the control variable, which was watering once a week. Measurements of soil moisture, air temperature, and lighting were execute for seven months with consistent measurement times at 06.00 am GMT+7, 11.00 am GMT+7, and 04.00 pm GMT+7. Each treatment consisted of four polybags containing one stem of *Gynura procumbens* initially had the same height, which was 15 cm. Observation of growth rate was carried out by measuring the increase in stem length from the 15 cm limit to the highest shoot of the plant every day using a ruler, each shoot was marked used a permanent marker to be measured the next day. The measurement results were calculated on average every sixth days based on previous research at the age of sixth days the growth rate could be observed and the influence of microclimate could be identified. The average obtained every sixth days is shown in the graph to show the effect of microclimate on the growth rate. The data obtained were used exploratory descriptive analyzed.

3. Result and Discussion

Gynura procumbens growth is determined by physiological processes in its biological structure. The downfall of a physiological process is observed visually, and also based on the appearance of plant morphology. As the study of Hidayati et al. [60] which stated that the malfunctioning indicators of plants physiology, include the pale brownish colour of the leaves, withering, drying up, and lack of buds. This is strengthened by the results of [61] Buntoro et al. that climate fluctuations directly influence plant respiration, photosynthesis rate, and other biogeochemical processes. Therefore, regular observations within a specified period have important role in ascertaining the conditions that occur in plants.

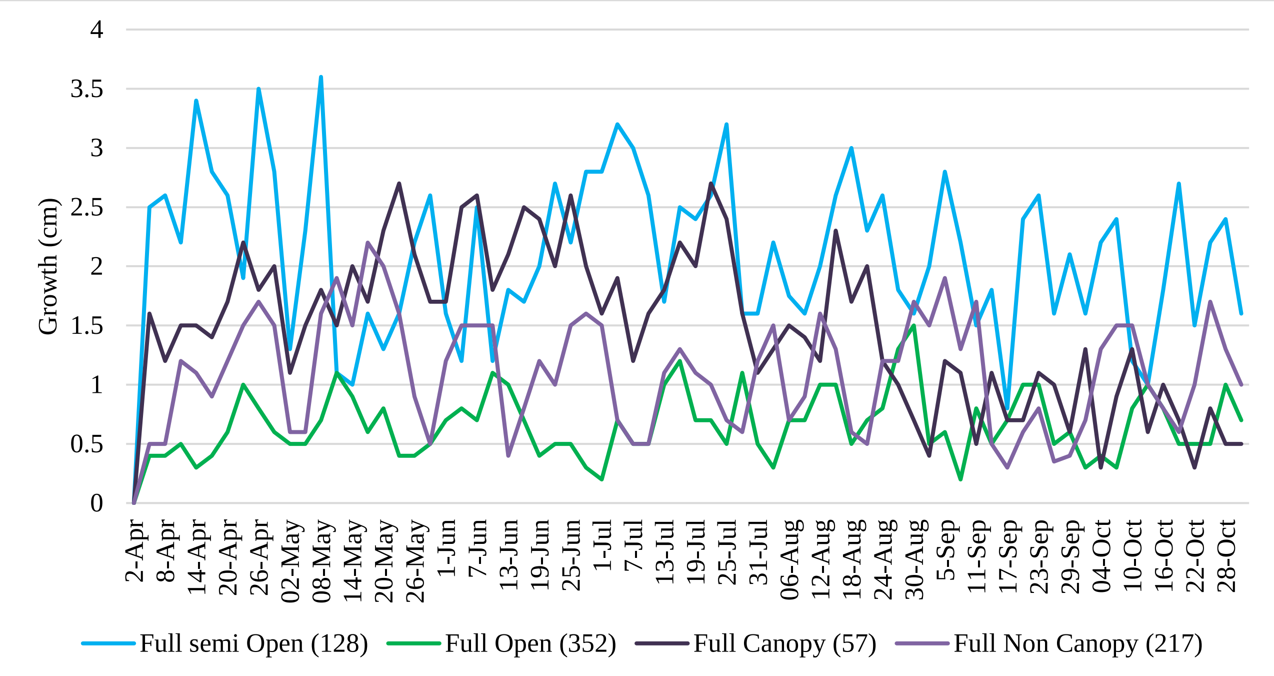

Figure 1. Effect of sunlight on the growth response to *Gynura procumbens*

Fig. 1 shows that the difference in light intensity that illuminates the habitat Gynura procumbens response varied on growth. Light is one factor for the macro-climate and micro-habitat biosphere Gynura procumbens of great influence for growth and survival. Also, it is the core energy for Gynura procumbens required for the photosynthesis process, and contributes to starch and oxygen. This process becomes an instant determinant of the growth process, because the whole activity of plant physiology needs a product of the process of photosynthesis. This is supported by the study of [66] Ferreira (2004) which stated that the ability of plants to perform photosynthesis is crucial to continuity of its life. The results of photosynthesis are used as input physiological processes in all parts of the plant. Therefore, the presence of sunlight is a vital element for the survival of an organism autotroph.

Gynura procumbens as one type of autotrophs organisms need light in the optimum proportion to grow properly. The optimal light needed for each plant species differs, depending on the type of photosynthesis, such as C3, C4, or CAM. Category C3 plants require light intensity and low-frequency radiation for photosynthesis. While the category C4 plants need light intensity and high-frequency radiation, because the rate of photosynthesis takes place quickly. However, for the category of CAM, more adaptive plants grow and develop optimally in both conditions, either shaded or in the open with high-intensity of light and radiation. When the light intensity and frequency of the radiation do not correspond with the photosynthesis categories of plant species, a disruption of physiological functions occurs. When the condition lasts longer, it impacts on the failure of physiological function to deter the growth, or even lead to death. It occurs simultaneously as reported by [62] Ashcroft et al. which stated that abiotic components either light or temperature and humidity act as an inhibiting factor for an organism, when the amount is above or below the tolerance limit of an organism. It coincides with findings from [62] Ashcroft et al. which stated that abiotic components either light or temperature and humidity, act as an inhibiting factor for an organism when the amount is above or below the tolerance limit. Based on Fig. 1, it was observed that Gynura procumbens survives in an adaptive micro-climatic condition, especially light, as it grew on a light intensity range of 57-352. This means that Gynura procumbens carries out their physiological functions to grow and develop in the lighting variations. However, it should be understood that from the fourth difference lighting conditions, are treatments that provide the best growth response. The semi-shaded treatment has a mean high light intensity of 128, while those added with Gynura procumbens has semi-shaded treatment of 0.7 cm/day. This means that to complete the harvest with a height of 30 cm, it takes the first plant for 43 days. Then the next leaf harvest is performed daily or weekly. The mean height increases for the third Gynura procumbens and other treatments include: open to the light intensity of 352 is 0.22 cm/day, in a place shaded by the light intensity of 57 is 0.54 cm/day, and unshaded by 217 is 0.36 cm/day. Based on the comparison of the four treatments, a more suitable Gynura procumbens were found planted in the semi-shaded spot range of light intensity of 128. Therefore, the yards are generally planted with trees or ornamental plants that are ideal when combined with a Gynura procumbens (planting the land surface), and in a place not shaded with a light intensity of 217 is 0.36 cm/day.

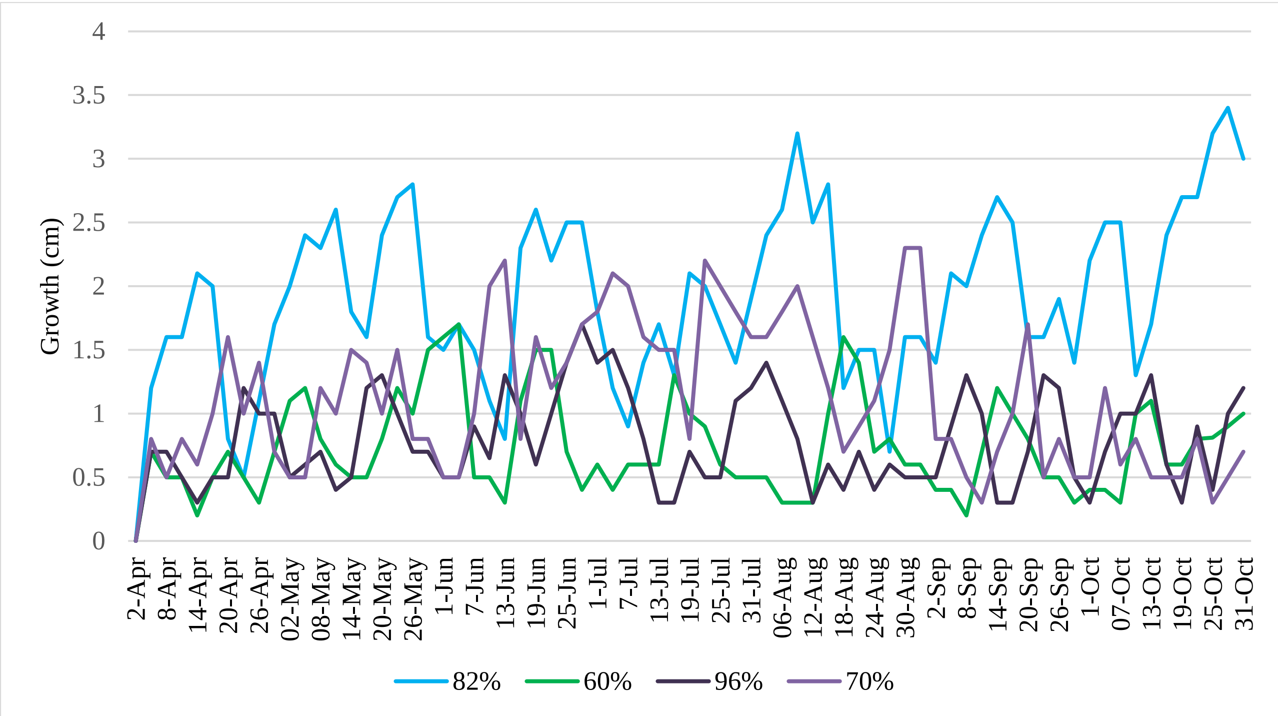

Figure 2. Effect of moisture on the growth response to Gynura procumbens

Fig. 2 shows that soil moisture provides a potential position for the growth of Connect Lives, therefore, the humidity difference is a crucial growth rate. Every plant has a preference for a certain humidity, part of tolerant to drought and other partially tolerance of water abundance. This is supported by the study of [23] which stated that each plant species has tolerance limits, which varies on the availability of micro-climates including soil humidity. However, it should be comprehended that every plant requires water in the ecosystem, which correlated with soil moisture. Humidity formed due to the concentration of water vapor in the soil increases, and the water concentration is lessened due to the moisture absorption by plant roots as well as the evaporation. Therefore, soil moisture needs to be handled as an important part of the process of growth and development of an individual plant.

The water content in the soil correlated with its moisture (high humidity and water content) required by plants including Gynura procumbens as raw material for the process of photosynthesis. Molecules of water into the basic components required for the photosynthesis process in addition to chlorophyll. Water from the soil to be absorbed by the roots and then flowed to all parts of the plant via the xylem vessels. Furthermore, water molecules are stored at the root of the plant, and have chlorophyll in that section, therefore, when exposed to light, photosynthesis process takes place. The molecules of water and chlorophyll are broken down by the light through the light-reaction, generating Adenosine Triphosphate (ATP). While the H + and OH- ions occurs in dark reaction processes that producing O2, compound Nicotinamide adenine dinucleotide phosphate (NADPH), and C6H12O6. Therefore, the water content in the soil defines the rate of the photosynthesis process that has implications on the growth and development of plants. This is the conclusion of the research which declared that, there is a link between the pace of photosynthesis process to speed plant growth. In addition, humidity becomes a major factor that indirectly affects plant growth and productivity rate. Based on preliminary research, the water content in plants Gynura procumbens reached about 90%, i.e., it requires a lot of water for physiological processes. However, based on Fig. 2, the most optimal growth was found among Gynura procumbens planted on soil moisture treatment 82% (0.64 cm/day). Basically, the minimum legal suit Leibig and the entire organism has a limit of tolerance to chemical factors and the physical environment. The observation from Fig. 2, showed that 70% soil moisture (0.4 cm/day) was a second sequence for optimal growth, the third place was 96% (0.26 cm/day), and the final 60% (0.24 cm/day). Therefore, it is found that Gynura procumbens basically have a good tolerance of water saturation, however, it is less in responding to stress/lack of water. This means that, in the cultivation of Gynura procumbens, those ideally planted in humidity ranging from 70-90% yielded the highest productivity.

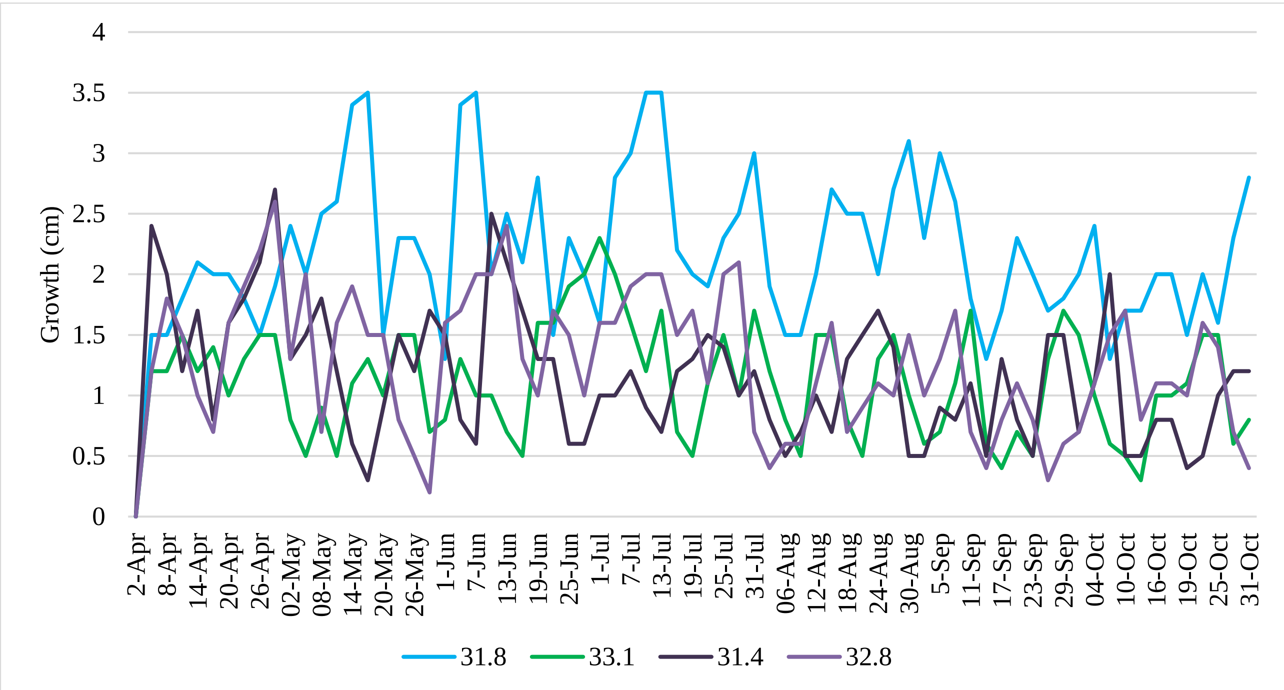

Figure 3. Effect of temperature (Celcius) on the growth response to Gynura procumbens

Fig. 3 shows that there are variations in the growth response to Gynura procumbens by the influence of temperature. However, air temperature affects the rate of evapotranspiration (evaporation and transpiration). This resulted in the loss of water from the soil surface and vegetation through a process of evaporation either evaporation on soil and transpiration from plants. The responses of plants to air temperature are affected by the type and age of the plant. Some plants have a good tolerance to high temperatures and vice versa. Gynura procumbens as tropical plants are different from other plants that have a savanna habitat. By the absence of a clear dry season, the plant is found to have a good tolerance to temperature. Based on Fig. 3, it was observed that in the temperature range from 31.4 to 32.8 °C, Gynura procumbens grew effectively (mean 0.47 cm/day). However, when categorized by rank, those planted in locations with 31.8 °C have the most optimal growth (0.72 cm/day), then 32.8 ° C (0.42 cm/day), followed by 31.4 ° C (0.38 cm/day), and 33.1 ° C (0.37 cm/day). Differences in Gynura procumbens growth rate in each temperature condition were influenced by the rate of photosynthesis. Basically, the higher the temperature of a location, the increase in transpiration or evaporation of water from plant. Therefore, the provision of water to the plant should also be balanced. The plants become withered when the water is too little because the transpiration rate is faster than the absorption of water from the soil, therefore, the plants lack water. This is according to Pramudianto et al. research [50] which stated that temperatures correlated with the intensity of lighting and has a significant influence on the growth of plants, which is related to its role in the process of photosynthesis, opening and closing of stomata, and the synthesis of chlorophyll.

4. Conclusion

Gynura procumbens tolerate air temperature, soil moisture, and light intensity. However, to obtain the highest production, there is a need to be treated in order to maintain soil moisture that ranges between 70-90%, light intensity ranging from 128, and a temperature range of 31-32 °C. When all these three factors are achieved on a range of these figures, the growth rate of Gynura procumbens reaches 0.7 cm/day. This means that during the first planting season, Gynura procumbens is harvested on day 43 and then every day. Taketogo salad consists 10 grams per pacs and Gynura procumbens as a leverage component. It is consumed by one million people; however, the government reduces the rice stock up to 47,300 tons/year. This is potentially carried out to increase the country's foreign exchange reserves.

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