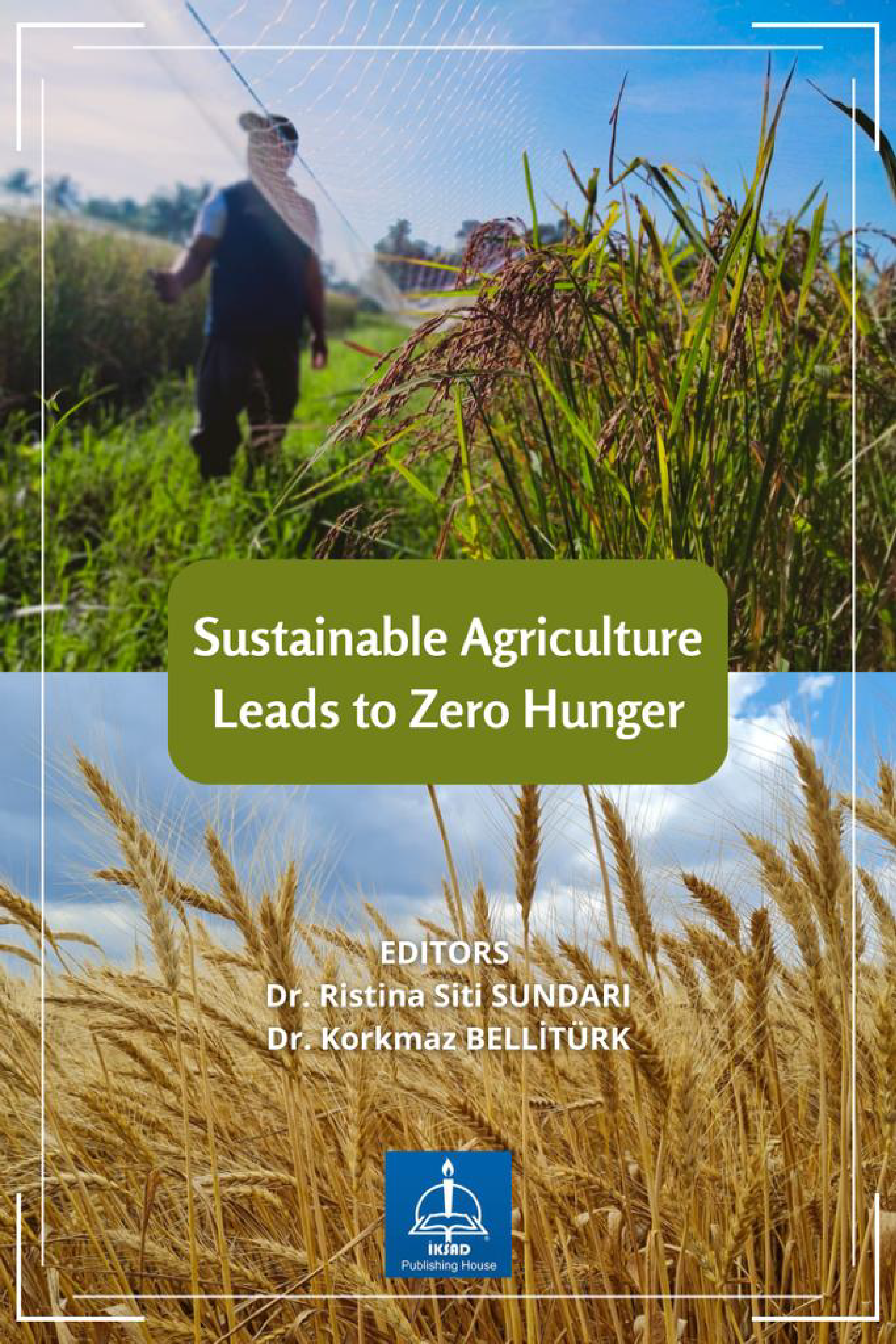

Sustainable Agriculture Leads to Zero Hunger

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SUSTAINABLE AGRICULTURE LEADS TO ZERO HUNGER

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PREFACE

We are grateful for the sake of Allah for blessing and helping us to complete this book chapter entitled Sustainable Agriculture Leads to Zero Hunger.

Achieving zero hunger needs agriculture from upstreams to downstream agribusiness to be sustainable. Achieving zero hunger requires agriculture and food systems to become more efficient, sustainable, climate-smart, nutrition-sensitive, and affordable economically regarding stunting and food insecurity in some regions. In addition, there is a crucial need for synchronization between malnutrition, dietary diversity, and production diversity. The world needs to produce an estimated 60percent more food by 2050 to ensure global food security, and it has to do to conserve and enhance natural resources. The increasing world population inflates the importance placed upon producing more food.

However, it must be realized that increased food production does not necessarily translate into improved nutritional food security. Shifting away from unsustainable high input-intensive crop production and monocultures towards more sustainable agro-ecological practices and diverse crop mix will yield improved production diversity and waste utilization to added value. Further, agro-ecological practices such as zero-budget and zero-waste natural farming, organic farming, and permaculture play an essential role in their impact on food and nutrition security and climate resilience. Similarly, organic farming, aquaculture, breeding, fisheries, marketing, permaculture, and social and economy have the potential to help farmers adapt to climate change and environmental conservation by planting crops, vegetables, fruit, viticulture, aquaculture, floriculture, livestock, aquaponics, hydroponics, vertical farming hardy, and restoring soil and water health, local food processing of biodiversity and feeding population in sustainable agriculture.

Thank you to all excellent authors for your valuable chapters and cooperative work. However, we appreciate that our book chapter project is going well because of you.

Finally, we hope this book will greatly benefit you, respected readers.

Indonesia – Turkey, 22nd July, 2022
Editor Team:
Ristina Siti SUNDARI
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BRIEF CURRICULUM VITAE OF EDITORS

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Korkmaz Bellitürk is an Associate Professor of Soil Science and Plant Nutrition Department of Agriculture Faculty at the Tekirdag Namık Kemal University, in Tekirdag, Turkey. He did his undergraduate degree at the Trakya University in Turkey in 1996 as head of the department, followed by a Ph.D project on hydrolysis of urea. He started at the Trakya University in 1996, focusing on plant mineral nutrition, and was a Research Assistant at the Faculty of Agriculture from 1996 till 2007. In 2007, he became Assistant Professor of Soil Science and Plant Nutrition Department, Tekirdag Namık Kemal University, Turkey. He was assigned to lecture for one week each within the context of Erasmus teaching staff mobility at Trakia Democritus University in Greece in 2011 and at the University of Technology and Life Sciences in Poland in 2013. He was assigned for 3 months between 11 July and 11 October at the University of Vermont in Burlington/Vermont, USA to take a part in a project called "use of soil earthworms in agriculture" in 2011. From 2014 to 2015, he worked as a postdoc researcher at the University of Vermont in USA, working on soil ecology, earthworms and vermicompost. After the postdoc he became Associate Professor of Soil Science and Plant Nutrition Department of Agriculture Faculty at the Tekirdag Namık Kemal University, in Tekirdag, in 2018, where he focused of phytoremediation, plant nutrition, soil and water pollution, soil ecology, organic farming, composting and vermicomposting. He conducts one of the bilateral cooperation projects signed between the Council of Higher Education-Turkey and Higher Education Commission-Pakistan. The universities involved in the project are Tekirdag Namık Kemal University-Turkey and University of Agriculture Faisalabad-Pakistan in 2019. He served as project head and researcher in 29 projects supported by TUBITAK, Trakya University, Tekirdag Namık Kemal University, Nevsehir Hacı Bektas Veli University, Bilecik Seyh Edebali University, TAGEM, University of Agriculture-Faisalabad and Yozgat Bozok University Scientific Research Projects Units. He has 145 articles (*Totally, 21 of* *them are the articles published in international periodicals cited by international science indexes [SCI-SCI-Exp.]*), 9 book chapters and 3 books on soil science, ecological management for soil quality, plant nutrition, soil-water pollution, ecologic agriculture, vermicomposting and fertilization topics as research articles and papers presented in domestic and abroad scientific meetings. He has been awarded many projects and scientific publication awards in his field of study. He has been editor-in-chief of the journal Rice Research since 2015. He has one national patent. He features on ISI's list of highly cited authors in the field of soil fauna, soil fertility and plant sciences since 2010. Link: https://www.scopus.com/authid/detail.uri?authorId=35811876500, https://orcid.org/0000-0003-4944-3497, Web of Science Researcher ID ABA-1887-2020,.https://publons.com/wos-op/researcher/3929063/korkmaz-belliturk/,

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CHAPTER 1

RESIDUAL EFFECT OF BIOCHAR ON BERSEEM YIELD AND YIELD ATTRIBUTES UNDER DOSAGES OF NITROGEN AND FARMYARD MANURE LEVELS

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1.1. Introduction

Forage plant production could be very vital for successful animal productivity. Trifolium is a larger genus within the Leguminosae family. Berseem (Trifolium alexandrinum L.) is Iran's maximum extensively grown clover (Sher et al., 2016). Berseem is thought to have an excessive capability for organic N fixation, and the persistent nitrogen is made to related plants via mineralized root and nodule nitrogen. Berseem, oats, Lucerne, barley, and shaft are key winter forage vegetation (Roy and Jana, 2016). Berseem is utilized in current decades and is famous for farmers due to its speedy increase, an excessive wide variety of harvests, and sparkling forage productivity with suitable quality and quantity. Berseem is the king of fodder because of its capacity to supply greater cuts and produce the best clean fodder yield. Because of the excessive populace pressure and unavailability of fodder, farmers normally exercise greater fertilizer utility to berseem (Daneshnia et al., 2016). Biochar is excellent grained charcoal excessive in natural carbon and largely proof against decomposition (Yao et al., 2017). It is constituted of pyrolysis of flora and waste feedstocks. Otherwise it needed to concern on changing rainfall pattern (Ashraf, 2021).

Biochar application has developed interest as a sustainable generation to enhance enermously weathered or degraded soils. It can enhance plant boom with the aid of using enhancing soil chemical traits (i.e., nutrient retention and availability) and soil bodily traits (i.e., bulk density, water protecting potential, permeability) and soil organic homes, all contributing to an extended crop productiveness (Xie et al., 2018). The net impact on the soil's physical properties relies upon the interaction of the biochar with the Physico-chemical traits of the soil and different determinant elements along with the climatic situations typical on the site and the control of biochar application (Wang et al., 2015). Adding natural manures might also enhance the fertility of the soil and crop productivity to convert the physicochemical properties of soil, including bioavailability of nutrients, water protection, cation exchange potential, soil pH, and microbial population (Utomo et al., 2018). In addition, biochar is especially recalcitrant to microbial decomposition and, as a consequence, ensures a long-term gain for soil fertility. Biochar impact the law and productivity function of the agricultural soil.

There are numerous reasons to anticipate that biochar would possibly lower the opportunity of nutrient leaching in soils and create stronger nutrients (Streubel et al., 2017). And also in limited soil or soiless (Sundari, et al., 2022) substitute with biochar. Recently using natural substances like fertilizers for crop productivity has obtained interest for sustainable crop productiveness. Organic matter is the existence of soil, and the practices that aid natural matter also favor sustainable productiveness (Sial et al., 2019). Incorporation of plant residues is a beneficial means to preserve organic matter content material and thereby enhance organic activity, enhance physical properties, and growth nutrient availability. Organic manuring with the aid of using manner of the direct application of traditional farmyard manure, mulching, crop residue, or green manuring has declined over the years because of various operational constraints (Pasley et al., 2019). Agricultural scientists are engaged in setting up an agricultural system that may decrease production value and preserve herbal resources. Therefore, the latest interest in manuring has re-emerged due to excessive fertilizer prices and the significance of biochar, green manure, farmyard manure, and different forms of manures retaining long-time period soil productiveness except for meeting the well-timed requirement of nutrients. Likewise, there is a positive interaction between the mixture of natural manures and urea as a nitrogen source (Oladele et al., 2019).

Nitrogen fertilization performs a vital function in enhancing soil fertility and growing crop productiveness. Nitrogen fertilization will increase grain yield (43-68%) and biomass (25-42%) in maize (Almodares et al., 2019). It contributes 18-34% growth in soil residual N. Sole residue incorporation or mixture with N fertilizer has nice consequences on plant growth and production and soil physicochemical properties (Khalid et al., 2017). Using natural substances in a mixture with inorganic fertilizers to optimize nutrient availability to flora is a tough challenge as natural substances have a variable and complicated chemical nature. This availability called for the information and understanding of the chemical composition, particularly the nutrient content material and C first-class natural substances and their interplay with inorganic nutrient sources. Unfortunately, there the little synthesis of the incorporated consequences of organic substances on net nutrient control (Xie et al., 2018). Numerous trials have compared the yields from a given quantity of inorganic fertilizer and natural material and their mixture, and in lots of conditions have produced better yields (Wang et al., 2013). It must now no longer be sudden that the mixture increases because greater total nutrients were added. Economically FYM 50% and Nitrogen 50% in 85,000 maize plants per ha resulted in a higher harvest index of 31.5% and the highest R/C ratio of 6.2 (Ahmad, et al. 2021a, 2021b)

Therefore, it is miles vital to evaluate the consequences of biochar and FYM on crop productiveness beneath field situations when it comes to agronomic practices at a given site because such studies are uncommon and are little recognized as approximately viable interaction consequences (Ulyett et al., 2014). For this purpose, a field test has been initiated of biochar, FYM, and chemical fertilizer N on crop yields and soil homes. Nitrogen is one of the maximum vital plant nutrients proscribed in soil and that sells vigorous plant vegetative growth. This paper reviews the effects of the impact of biochar, alone and in mixtures with FYM and fertilizer N, on soil organic matter and mineral N in a decided cropping system (Almodares et al., 2019). Nitrogen fertilization is one of the maximum essential agronomic practices, and consequently, there is various research carried out with nitrogen fertilizer. Nitrogen deficiency impacts the partitioning of assimilates amongst vegetative and reproductive organs and may affect the growth and improvement of the flora.

It improves diverse crop parameters like grain weight and yield (Mohammad et al., 2013). Its excess application might also lead to accommodations and make the plant vulnerable to diseases. Though the significance of inorganic fertilizer cannot be ignored, the non-stop application of inorganic fertilizer now no longer leads to soil degradation and increases production costs and diverse environmental issues related to heavy inorganic fertilization (Sher et al., 2016; Ahmad et al., 2022). The research was designed to keep in view the above facts to assess the residual and integrate the impact of biochar, FYM, and mineral nitrogen on berseem yield and yield additives under the agro-climatic circumstance Peshawar-Pakistan.

1.2. Materials and Methods

Field experimentation was executed to assess the residual biochar impact on berseem productivity under numerous nitrogen and farmyard manure rates at Agronomy Research Farm, The University of Agriculture Peshawar, from 2013–to 2014. The consequences of formerly provided biochar at 3 degrees such as 0, 25, and 50 t ha-1 have been studied in the test. In contrast, FYM carried out before sowing @5 and 10 t ha-1 on the time of sowing in mixture with nitrogen carried out in degrees (15 and 30 kg ha-1) in identical splits, 1/2 of at sowing and remaining after planting. A control turned into also covered withinside the test. Berseem seed of local variety "Pelosi Type" was sown on October 15th, 2013 @ 25 kg ha-1. The experiment was specified in a randomized complete block design with three replications having a plot size of 4. 5 m by 4 m.

Moreover, the field was plowed twice as much as 30 cm in-depth with the cultivator's assistance, followed by planking. Plowing was carried out carefully for non-disturbance of the preceding layout of the experiment. Berseem seeds were sewed in standing water (flooding), and the field was irrigated in line with the requirement of the crop. All other cultural practices have been carried out uniformly in every experimental unit.

Procedure for data recording

Emergence: Emergence m-2 was recorded by throwing 1m2quadrate randomly in 3 distinctive spots in every plot, after which the seedling numbers were counted. The data have been averaged to get emergence m^{-2}. **Weed density:** Weeds were measured at three spots in each experimental unit 45 days after sowing with the help of quadrate and were converted into the number of weeds m^{-2}. **Plant height:** Plant height was measured before the final cut. The ten randomly selected plants were measured from soil to the end of the plant in each plot after calculating the average change. **A number of seeds head $^{-1}$:** Seeds from ten randomly decided heads or bolls of every experimental unit have been hand threshed, counted, and transformed into an average number of seeds boll-1. **Thousand seed weight:** After counting the number of seeds head-1 at random from the sample of every experimental unit, the counted seeds were weighed and then transformed into a thousand seed weight. **Seed yield:** Seed yield was measured in kg ha^{-1}. Three distinctive spots have been harvested with the assistance of one m2 quadrate, and seed heads have been threshed. Seeds of every pattern have been weighed with digital balance and transformed into kg ha^{-1}. **Biological yield:** The dry forage yield was taken after every cut was introduced and transformed into kg ha^{-1} for recording biological yield data.

1.3. Results And Discussions

1. Emergence

A perusal of the data revealed that the effects of biochar, farmyard manure, and nitrogen application were not significant on the appearance of m^{-2} of berseem (Table 1). Planned mean comparison indicated that the contrast between control vs. rest and biochar vs. no biochar were non-significant. Similarly, all interactions were found non-significant. Though treatments' effects were not significant, high emergence was noted in no biochar plots compared to BC plots. Similarly, FYM @5 t ha^{-1} resulted in higher emergence. Likewise, a lower level of N (15 kg ha^{-1}) resulted in higher emergence.

2. Weeds density m^{-2}

Data perusal revealed that previously applied BC, FYM and N significantly influenced weeds density m-2. Biochar Plots had more weeds as contrasted with no BC density was higher where BC applied @50 t ha-1. FYM @10 t ha-1 application to plots had more weeds, and 5 t ha-1 had lesser weeds population. Likewise, as the commercial N treatment was increased from 15 to 30 kg ha-1, the density of the weeds was noted high.

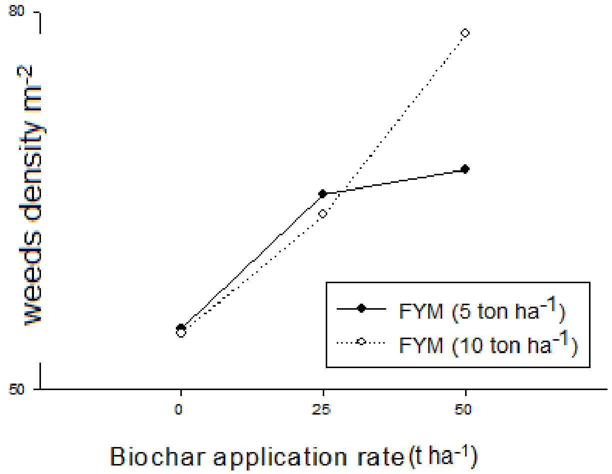

Figure 1. Interaction of BC and FYM for weeds density m^{-2}.

Comparison between fertilized and unfertilized plots exhibited that weeds density was higher in fertilized plots and lower in control plots. Fig. 2c shows that as the BC levels boost up from 25 to 50 t ha-1 along with 10 t ha FYM, the weeds' density reached a peak point. The dry biomass of weeds after 3rd cut was significantly affected by BC, FYM, and N levels. The contrast between control vs. rest and BC vs. no BC was significant, while all interactions remained not significant. Planned mean comparison indicated that the dry weight of weeds was higher (546 kg ha^{-1}) in plots where residual biochar (BC) was applied as compared to p without biochar (495 kg ha^{-1}). Fertilized plots resulted in higher (522 kg ha^{-1}) weeds dry biomass, and control plots resulted in lower (413 kg ha^{-1}) dry mass of weeds. Plots with BC @50 t ha^{-1}, incorporated FYM @10 t ha^{-1}, and N application @30 kg ha^{-1} resulted in higher dry biomass of weeds than 25 t ha^{-1} BC, 5 t ha^{-1} FYM 15 kg ha^{-1} N application.

Mean values of weeds' dry biomass after the fifth cut revealed that the remaining BC, FYM, and N rates impacted weeds' dry biomass after the fifth cut. BC x FYM x N and N x FYM communications were non-huge, while BC x N and BC x FYM were critical. Higher weeds dry biomass were examined in plots got BC @50 t ha^{-1}. Amended FYM@ 10 t ha^{-1} and N 30 kg ha^{-1} had higher dry biomass of weeds when contrasted with 5 t ha^{-1} FYM and 15 kg ha^{-1} N. mutual effect of BC and FYM showed that weeds' dry weight expanded in both 5 and 10 t ha^{-1} with a high degree of BC yet this increment was more with 10 t ha^{-1} FYM application (figure 1). Interaction of N and BC uncovered that weeds' dry biomass straightly improved 15 and 30 kg ha^{-1} with expanded in 50 t ha^{-1} BC, yet expansion in dry biomass of weeds was substantially more with N application @30 kg ha^{-1} (Figure 1)

3. Plant height

A measurable exagetation of plant tallness in Table 2 revealed that the past applied BC, FYM, and N significantly influenced plant stature. Short height plants (75.08 cm) were inspected in no BC plots, while long height plants (90.25 cm) were examined with BC @25 t ha^{-1} Incorporation of FYM @10 t ha^{-1} brought about higher plant tallness (86.72 cm) than 5 t ha^{-1} (82.78 cm). Higher plant tallness (88.33 cm) was kept in plots treated with 30 kg ha^{-1} N when contrasted with 15 kg N ha^{-1} (81.17 cm). Our findings are also supported by Utomo et al. (2018), who observe higher stature of plants with optimal doses of N while further increment in N leads to plant lodging. Similarly, Yao et al. (2017) reported the same findings for nitrogen application.

4. Number of heads m^{-2}

Heads m-2 mean data are presented in Table 2. Biochar, nitrogen, and FYM levels significantly impacted heads m^{-2}. Higher berseem heads m^{-2} were analyzed in plots where BC was previously utilized at @25 t ha^{-1}, followed by a high measure of BC with 50 t ha^{-1}. Besides, the high stockpile of farmyard manure 10 t ha^{-1} and N 30 kg ha $^{-1}$ brought about higher heads m^{-2} when contrasted with 5 t FYM ha^{-1} and 15 kg N ha^{-1} separately. Nitrogen and BC collaboration uncovered that number of seeds head^{-1} expanded in both the entire and half portion of N with expansion in BC from 0 to 25 t ha^{-1}. Albeit high measure of N 30 kg ha^{-1} supported heads m^{-2}yield more when contrasted with

15 kg ha^{-1} (Fig. 3). Xie et al. (2018) and Wang et al. (2015) found similar findings with N fertilization. They revealed that productive units significantly enhanced with nitrogen fertilization, but higher doses may decline the yield attributess and expand the vegetative growth.

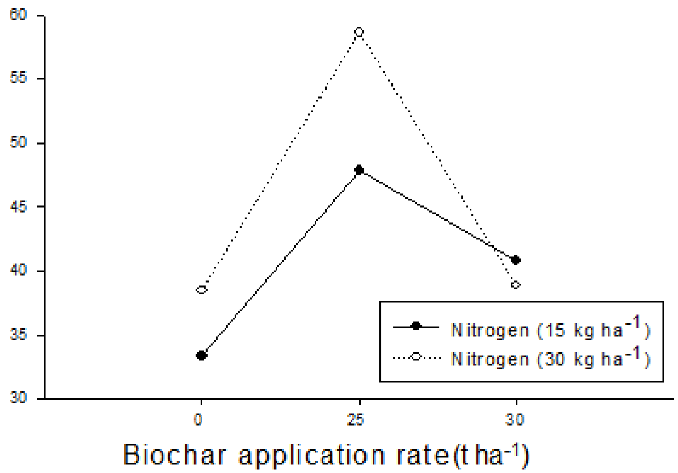

Figure 2. Interaction of BC and N for seed $head^{-1}$

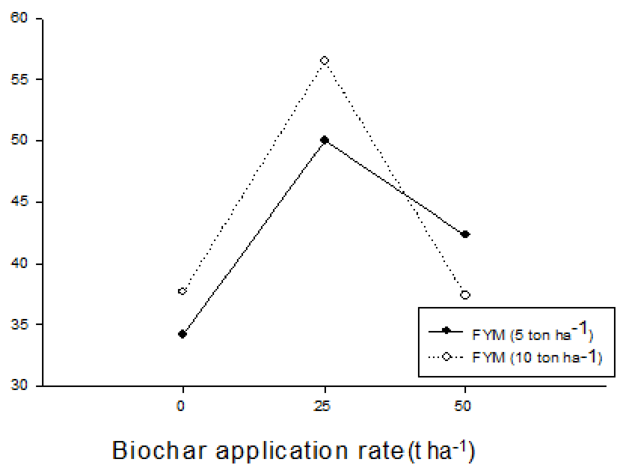

Figure 3. Interaction of BC and FYM for seed $head^{-1}$

5. Biological yield

Residual BC, FYM, and N fundamentally impacted biological yield. Biochar control plots created lesser biomass (40380 kg ha-1) of berseem while higher biomass (49211 kg ha-1) was kept in plots treated with 50 t ha-1 BC application. BC 50 t ha-1 plots had more organic yield than no biochar plots.

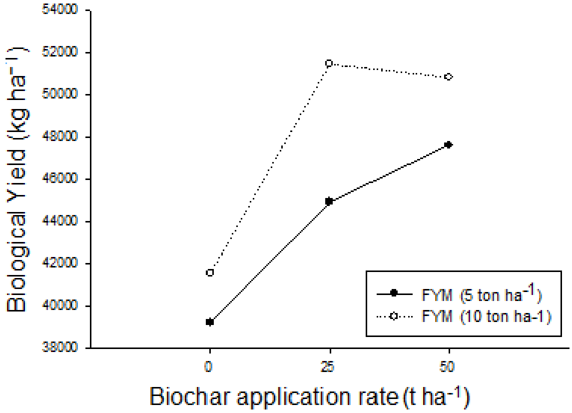

Figure 4. Interaction of BC and FYM for biological yield (kg ha^{-1})

Application of FYM @ 10 t ha-1 and N @ 30 kg ha-1 gave higher natural yield as connected with 5 t FYM ha-1 and 15 kg N ha-1 separately. The BC and FYM communication for biological yield showed that improving BC expanded natural product with 10 t ha-1 FYM than 5 t ha-1. However, further expansion in BC diminished biological yield (Fig. 4). Interaction between BC and N for biological yield (Fig. 5) demonstrated that rising BC upgraded biological yield directly with 15 kg N ha-1 than 30 kg N ha-1, where it declined with additional expansion in BC. Streubel et al. (2017) reasoned that biological yield increments with the mutual utilization of urea and organic manures.

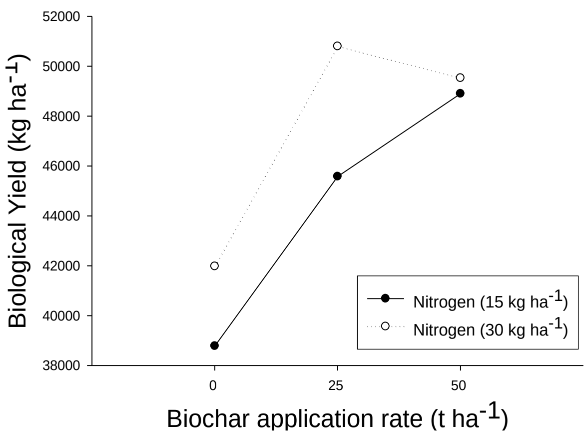

Figure 5. Interaction of BC and N for biological yield (kg ha^{-1})

6. Seed yield

Seed yield was affected by BC, FYM, and nitrogen. Treated plots brought about higher seed yield when contrasted with control. Lower seed yield (705 kg ha-1) was inspected in plots where no BC was practiced, while higher returns (914 kg ha-1) of berseem seed delivered by plots got BC with how much 25 t ha-1. FYM @5 t ha-1produced a lower seed yield (773 kg ha-1) as put next to each other with 10 t ha-1 (809 kg ha-1). A higher yield of berseem (805 kg ha-1) was kept in plots treated with N 30 kg ha-1 as adjusted to 15 kg N ha-1 (777 kg ha-1). Expanding seed yield biochar from 0 - 25 t ha-¬1 on the seed yield improved in 30 and 15 kg N ha-1. However, the increment was more with 30 kg N ha-1 (Figure 5a). Moreover, the communication of BC and FYM uncovered that rising the degree of FYM from 5-10 t ha-1 seed yield expanded with 25 t ha-1 BC (Figure 4). Sial et al. (2019) and Mhsen et al. (2010) came about that nitrogenous manures improved the yielding nature of berseem.

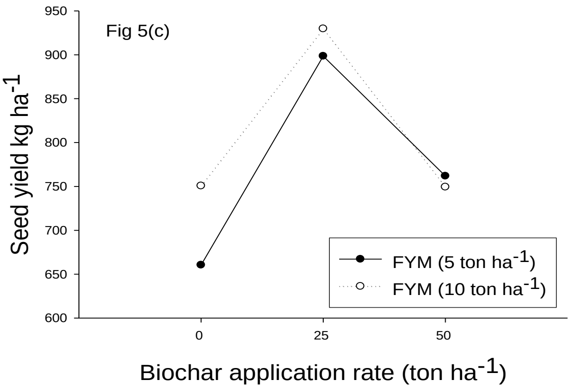

Figure 5. Interaction of BC and FYM for seed yield (kg ha^{-1})

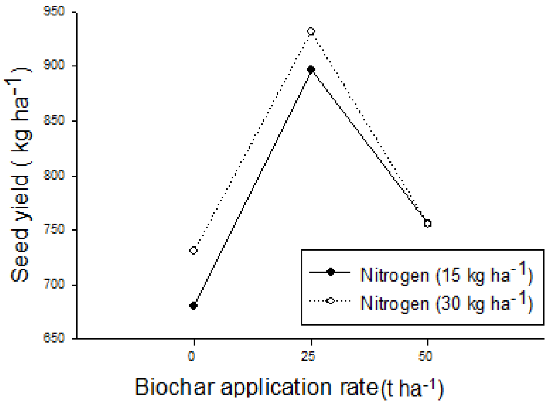

Figure 6. Interaction of BC and FYM for seed yield (kg ha^{-1})

7. Number of seed head^{-1}

The mean value in Table 9 showed that seed head^{-1} was significantly influenced by biochar and mineral nitrogen. Moreover, the contrast between control versus rest and biochar versus no biochar is likewise enormous. Already applied 25 t ha^{-1} BC brought about additional while fewer seeds head^{-1}were got from plots where no biochar was applied. Moreover, more seeds head^{-1}studied with FYM supply @ 10 t ha^{-1}. In like manner, N @ 30 kg ha $^{-1}$ contributed to expanded seeds head^{-1}.

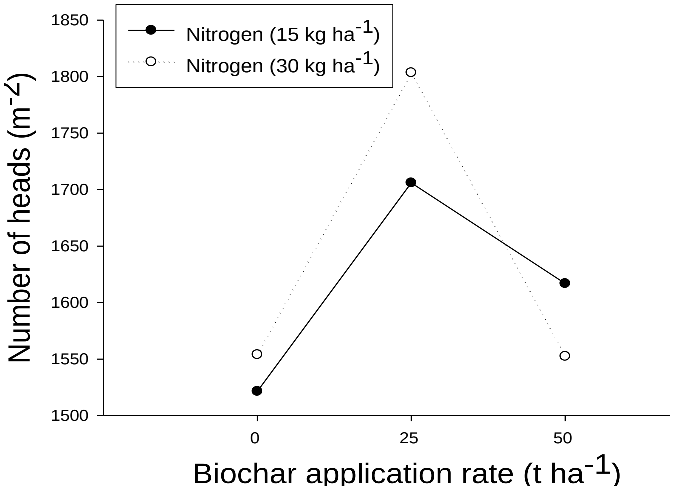

Figure 7. Interaction of BC and N for number of heads m^{-2}

Meanwhile, Seed head^{-1} expanded in the two levels 5 and 10 t ha^{-1} FYM application with BC application at the pace of 25 t ha^{-1}. FYM at the rate of 10 t ha^{-1} delivered more seeds head^{-1}(Fig. 7). The interaction among N and BC exposed that seeds head^{-1} upgraded in both (15 and 30 kg ha^{-1} N) with expanding BC from 0 to 25 t ha^{-1}. Higher seed head $^{-1}$ was delivered by 30 kg ha^{-1} N application when contrasted with N application at the pace of 15 kg ha^{-1} (Fig. 7). Shah and Ahmad, 2009, revealed that combined utilization of FYM and N supplements further develops seed numbers. Moreover, Pasley et al. (2019) and Sial et al. (2019) declared that the integrated use of nitrogen enhances seeds productivity.

8. Thousand seed weight

A measurable examination of the information revealed that 1000 seed weight was significantly impacted by past applied BC, FYM, and N. BC x N x

FYM and FYM x N were non-critical. The control versus rest and BC versus no BC contrast was critical. Planned mean examination showed that previously applied BC came about higher than 1000 grains weight when contrasted with no BC plots.

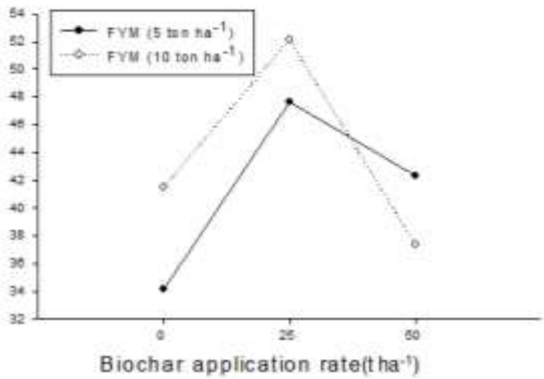

Figure 8. Interaction of BC and FYM for thousand seed weight (g)

In like manner, a comparison of treated plots with control uncovered that heavier 1000 grains were higher in fertilized plots while lower in unfertilized plots. Lower weight (4 g) of thousand grains was kept in no biochar plots, while higher (5 g) was acquired in plots with 25 t ha^{-1} biochar. FYM @ 10 t ha^{-1} brought about heavier 1000 grains (5 g) when contrasted with 5 t ha^{-1} (4 g). Low use of mineral N delivered a lower weight of 1000 grains (4 g). Higher thousand-grain weight (6 g) was examined in plots treated with 30 kg ha^{-1} N.

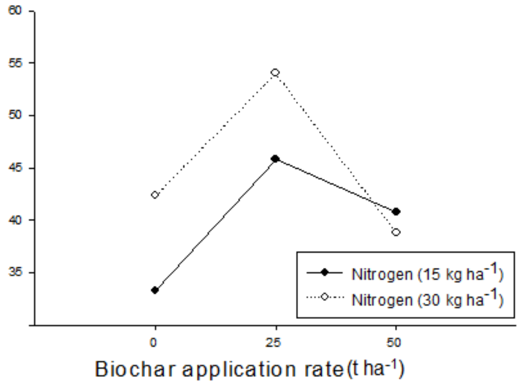

Figure 9. Interaction of N and BC for thousand seed weight (g)

BC, and FYM combined effect showed that Increasing biochar from 0 to 25 t ha^{-1}, 1000 grains weight expanded both in 5 and 10 t ha^{-1} FYM, yet the increment was more in 5 t FYM ha^{-1} contrasted and 10 t ha^{-1} (Figure 6a). A thousand grains weight increments with the expansion in biochar levels up to 25 t ha^{-1} with both 30 and 15 kg N ha^{-1}, yet the increase was more in 30 kg N ha^{-1} (Figure 9). Our present results outcomes are following Oladele et al. (2019). They also explored the heavier weight of the richer grainsntegrated organic and inorganic fertilization approaches.

1.4. Conclusion

Farmyard manure at 10 t ha^{-1} produced higher seed yield, biological yield, heavier grains, weed density, and fresh and dry biomass of weeds. Plots treated with 30 kg N ha^{-1} resulted in tallest plants, higher weeds density, fresh and dry biomass of weeds, higher biological and grains productivity, and heavier grains. It was concluded from the study that 50 t ha^{-1} BC, 10 t ha^{-1} FYM, and 30 kg ha^{-1} N enhanced yield and yield attributes.

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CHAPTER 2

DETERMINATION OF NUTRITIONAL STATUS OF OLIVE (*Olea europaea* L.) ORCHARDS GROWN IN BANDIRMA DISTRICT, BALIKESIR TURKEY, BY PLANT ANALYSIS

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2.1. Introduction

The olive, the oldest cultural crop, belongs to the *Oleaceae* family, the genus *Olea*, species *Olea europaea*, and subspecies *Olea europaea sativa* (Kiritsakis and Markakis, 1987). Olive grows under warm and rainy winter and dry summer conditions like hot weather (Bozdoğan Konuşkan, 2008). Olive is an essential crop in terms of nutrition. The color and shape of olive differ depending on the variety. Olive mainly consists of water and oil. Protein, cellulose, sugar, minerals, and hydrocarbons are also found in the chemical structure of olive. Factors such Asthe region where it is grown and its variety affects the chemical composition of olive (Vinha et al., 2005).

The rising consumption of olive oil is essential for our country. Olive oil and olive consumption are the most essential for human health. According to studies, olive oil ranks first in terms of heart health. Vitamin E in the content of olive is cancer preventive. Vitamins A, D, E, K and minerals such as calcium, phosphorus, potassium, sulfur, magnesium, iron, copper, and manganese in the content of olive are beneficial for bone growth. All technical requirements in establishing the olive orchards should be considered to obtain a high olive yield.

Plant variety and crop quality are important factors for optimizing the application time of N fertilizer. For example, late nitrogen fertilization in wheat cultivars significantly improves wheat bread quality by increasing gluten content in the grain. Thus, it is recommended to apply some nitrogen fertilizer under adequate soil moisture conditions a few months before the wheat harvest (Adiloğlu and Eraslan, 2012).

A study was conducted to determine the nutrition status of wheat (*Triticum aestivum* L.) in the Muratlı district of Tekirdağ with leaf analysis. Some plant nutrients were analyzed in leaf samples taken from 20 different wheat (*Triticum aestivum* L.) fields in the Muratlı district. When the analysis results were compared with the reference values, deficiencies were found in 5 % for K, 10 % for N, 25 % for Ca and P, 90 % for Zn, 100 % for Mg, and 20 % for Cu element (Çaktü, 2015).

The minimum temperature for growing an olive tree is -7^{0}C. The branches of young and old olive trees are negatively affected by cold temperatures. Olive should not be grown in areas where the temperature falls below 0 ^{0}C before olive harvest. In addition, olive cultivation should not be done in the areas with frost risk in March and April (Dokuzoğuz and Mendilcioğlu, 1971). High temperature, drying winds, and heavy rain at the pollination and flowering stage negatively influence fruit set in olive. The maximum temperature olive can resist 40 ^{0}C (Buldan and Çukur, 2003). In a study conducted in the Başiskele district of Kocaeli province, leaf analysis of macro and micronutrient elements was carried out on leaf samples collected from 20 collards (*Brassica oleracea var. Acephala*) garden to determine the nutritional status of collards (*Brassica oleracea var. Acephala*). According to the results, 40 % of leaf samples were deficient in N and Mg, 60 % in K, 75 % in Ca, 15 % in Fe, and 25 % in Zn and Mn. It was found that N, K, and Ca contents were high in 5 % of leaf samples and Fe content in 10 % (Yıldız, 2014).

The research aims to determine the nutritional status of olive plants (*Olea europaea* L.) with leaf analysis in the Bandirma District of Balikesir province and to provide fertilization by plant requirements in line with the determined plant nutrient deficiencies and excesses.

2.2. Materials and Methods

In this study, olive (*Olea europaea* L.) plant leaf samples were taken from 20 different olive orchards in the Bandirma District of Balikesir province, as stated in the study conducted by Jones et al. (1991). Some macro (N, P, K, Ca, and Mg) and some micro (Fe, Cu, Zn, and Mn) plant nutrient analyses were performed on leaf samples (Kacar and İnal, 2010). For each nutrient element, the data obtained were compared with the reference values, and the nutritional status of the olive plant was revealed in the research areas. Table 1 shows some information about the olive orchards from which samples were taken. On the other hand, some pictures are given from the orchards (Fig. 1, Fig. 2, and Fig. 3).

Figure 1. A view from researched olive orchards

Table 1. Some information about researched olive orchards

No	Location	Farmer names	Parcel no	Area (m^2)
1	Bıyıklı	Ertaç Yalçın	2872	2747
2	İnkaya	Mebruke Razi	6800	1175
3	Kalemlik	Ülkü Kılıç	3684	1999
4	Ergili	Sevgiser Şuvman	250	4550
5	Yeşilçomlu	Fatma Saraçoğlu	235	7550
6	Şirinçavuş	Kroman Çelik Sanayi A. Ş.	155	2417
7	Hıdırköy	Halit Dedeokayoğulları	216	3000
8	Hıdırköy	Nurten Eken-Cemil ve Erden Dönmez	314	788
9	Kuzguncuk	Birol Gürel	3472	2014
10	Narlık	Saadet Arı	4712	1125
11	Söğütlüçeşme	Cihan Güneş	6952	1500
12	Bezirci	Barış Olgun	130	1218
13	Ergili	Ahmet Engin	125	2500
14	Aksakal	Fikret Çakmak	273	3030
15	Doğa	İbrahim Yılmaz	255	1300
16	Dedeoba	Ali Çelik	188	76651
17	Mahbubeler	Recep Baytemur	231	4352
18	Eskiziraatli	Beşire Bingöl	152	1962
19	Dutlimanı	Sevgi Uzun	702	1700
20	Küçükkoru	Halil Karaböcek	321	9200

Figure 2. A view from researched olive orchards

Figure 3. A view from researched olive orchards

2.3. Results and Discussion

The result of a study on some macro elements contents of the olive plant is presented in Table 2**.**

Nitrogen (N) Content of Olive Leaf Samples

In this research, nitrogen contents of leaf samples were changed between 1.48 and 2.05 % (Table 2). According to Jones et al. (1996), a sufficient level of the nitrogen content of the olive plant is within the range of 1.50-2.50 %. When the nitrogen contents of leaf samples were compared to the critical values suggested by Jones et al. (1996), it was found that 1 sample was deficient, and 19 samples were sufficient. The results showed that 5% of olive plants were deficient in the research area, and 95% of olive plants were sufficient in N contents.

Phosphorus (P) Content of Olive Leaf Samples

In this research, the phosphorus contents of leaf samples were changed between 0.06 and 0.14% (Table 2). According to Jones et al. (1996), a sufficient level of the phosphorus content of the olive plant is within the range of 0.10-0.30 %.

Table 2. Some macronutrient element contents of olive plant, %

Sample No	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)
1	1.57	0.09	0.30	1.33	0.13
2	1.68	0.11	0.71	1.37	0.11
3	1.51	0.14	1.03	1.13	0.08
4	1.57	0.14	0.07	1.43	0.10
5	1.48	0.08	0.83	1.29	0.10
6	1.74	0.09	0.72	1.10	0.07
7	1.65	0.08	0.78	1.10	0.09
8	1.65	0.08	0.63	1.01	0.10
9	1.57	0.08	0.73	0.92	0.08
10	1.51	0.13	0.77	0.82	0.09
11	1.71	0.10	0.71	0.92	0.07
12	1.76	0.14	0.69	1.15	0.10
13	1.74	0.09	0.71	0.98	0.06
14	1.65	0.06	0.54	1.18	0.06
15	2.05	0.10	0.97	1.23	0.11
16	1.71	0.08	0.52	0.59	0.04
17	1.82	0.09	0.83	1.10	0.06
18	1.79	0.10	0.95	0.98	0.07
19	1.82	0.07	0.58	0.60	0.05
20	1.60	0.08	0.69	1.35	0.08
Max.	1.48	0.06	0.30	0.59	0.04
Min.	2.05	0.14	1.03	1.43	0.13

According to Table 2, when the phosphorus contents of leaf samples were compared to the critical values suggested by Jones et al. (1996), it was found that 12 samples were deficient and eight samples were sufficient. The results showed that 60 % of olive plants were deficient in the research area, and 40 % of olive plants were sufficient in P contents.

Potassium (K) Content of Olive Leaf Samples

In this research, the Potassium contents of leaf samples were changed between 0.30 and 1.03 % (Table 2). According to Jones et al. (1996), a sufficient level of the Potassium content of the olive plant is within the range of 0.90-1.20 %. When the Potassium contents of leaf samples were compared to the critical values suggested by Jones et al. (1996), it was found that 17 samples were deficient, and three samples were sufficient. The results showed that 85 % of olive plants were deficient in the research area, and 15 % were sufficient in K contents.

Calcium (Ca) Content of Olive Leaf Samples

In this research, the Calcium contents of leaf samples were changed between 0.59-and 1.43 % (Table 2). According to Jones et al. (1996), a sufficient limit value of the Calcium content of the olive plant is within the range of 1.00-2.00 %. When the Calcium contents of leaf samples were compared to the critical values suggested by Jones et al. (1996), it was found that seven samples were deficient, and 13 samples were sufficient. The results showed that in the Bandırma province, 35 % of olive orchards were insufficient, and 65 % of olive orchards were sufficient in Ca contents.

Magnesium (Mg) Content of Olive Leaf Samples

In this research, the Magnesium contents of leaf samples were changed between 0.04 and 0.13 % (Table 2). According to Jones et al. (1996), a sufficient level of the magnesium content of the olive plant is within the range of 0.20-0.60 %. When the Magnesium contents of leaf samples were compared to the critical values suggested by Jones et al. (1996), it was found that all samples were deficient. The result of a study on some microelements contents of the olive plant is displayed in Table 3.

Iron (Fe) Content of Olive Leaf Samples

In this research, the Fe contents of leaf samples were changed between 55-226 mg kg^{-1} (Table 3). According to Haspolat (2006), sufficient Fe content of the olive plant is within the range of 70-200 mg kg^{-1}. When the Fe contents of leaf samples were compared to the critical values suggested by Haspolat (2006), it was found that 1 sample was deficient, 1 sample was excess, and 18 samples were sufficient. The results showed that 5 % of plant samples were deficient, 90 % were sufficient, and 5 % were excess in Fe contents.

Zinc (Zn) Content of Olive Leaf Samples

In this research, the Zn contents of leaf samples were changed between 4.77 and 32.60 mg kg^{-1} (Table 3). According to Jones et al. (1996), sufficient Zn content of the olive plant is within the range of 25-100 mg $kg-^{1}$. When the

Zn contents of leaf samples were compared to the critical values suggested by Jones et al. (1996), it was found that 19 samples were deficient, and 1 sample was sufficient. The results showed that 95 % of olive plants were deficient in the research area, and 5 % of olive plants were sufficient in Zn contents.

Table 3. Some micronutrient element contents of olive plant, mg kg^{-1}

Sample No	Iron (Fe)	Copper (Cu)	Zinc (Zn)	Manganese (Mn)
1	106	385	7.52	24.60
2	89	140	8.15	26.60
3	104	57	8.20	16.80
4	226	136	10.00	21.00
5	142	54	6.24	24.00
6	73	35	4.77	27.00
7	113	45	6.01	28.46
8	113	129	6.09	26.00
9	119	26	9.55	22.99
10	85	89	8.68	20.44
11	55	142	7.06	18.84
12	96	138	11.00	23.86
13	94	21	18.66	17.24
14	137	24	5.67	17.06
15	119	80	23.40	53.50
16	187	8	10.00	12.10
17	99	145	32.60	27.00
18	86	45	17.70	30.60
19	127	7	7.30	14.37
20	116	37	16.00	43.00
Max.	55	7	4.77	12.10
Min.	226	385	32.60	53.50

Copper (Cu) Content of Olive Leaf Samples

In this research, the Cu contents of leaf samples were changed between 7-385 mg kg^{-1} (Table 3). According to Haspolat (2006), sufficient iron content of the olive plant is within the range of 6-18 mg kg^{-1}. When the Cu contents of leaf samples were compared to the critical values suggested by Haspolat (2006), it was found that two samples were sufficient, and 18 samples were excess. The results showed that 10 % of olive orchards were sufficient, and 90 % of olive orchards were excess in Cu contents.

Manganese (Mn) Content of Olive Leaf Samples

In this research, the Mn contents of leaf samples were changed between 12.10-53.50 mg kg^{-1} (Table 3). According to Jones et al. (1996), a sufficient level of Mn content of the olive plant is within the range of 25-200mg $kg\text{-}^{1}$. When the Mn contents of leaf samples were compared to the critical values suggested by Jones et al. (1996), it was found that 12 samples were low and eight samples were sufficient. The results showed that 60 % of examined olive orchards were deficient, and 40 % of olive orchards were sufficient in Mn contents.

2.4. Conclusion and Recommendations

Conclusion

The levels of some macro and micronutrients in the olive plant, cultivated by a large part of the population living in the Bandırma district of Balıkesir province, were examined by leaf analysis. The finding was that concentration of nitrogen varied from 1.48 to 2.05 %. This concentration showed that nitrogen was deficient in 5 % and adequate in 95 % of plants in the research area. According to these results, there is no need to apply especially nitrogen fertilizer to olive plants nowadays. It was observed that the phosphorus concentration in leaf samples ranged from 0.06 to 0.14 %. When phosphorus analysis results were compared to the critical phosphorus values, phosphorus deficiency was observed in 60 % of plants. Phosphorus fertilization should be done based on a soil analysis to reduce phosphorus deficiency in olive plants.

It was found that the potassium values of plants changed between 0.30 and 1.03 % in this research. According to this, potassium deficiency was determined in 85 % of the plants in the study area. Potassium fertilization should be done based on soil and plant analysis to reduce potassium deficiency in plants. It was determined that the calcium contents of plants changed between 0.59 and 1.43 %. According to this, calcium deficiency was determined in 35 % of the plants. Calcium fertilizers should be applied to the plants to meet their Calcium needs.

It was found that the content of magnesium varied from 0.04 to 0.13 %. In the case of magnesium content, all samples were found deficient. Magnesium leaf fertilization should be applied to all examined olive orchards to reduce plant potassium deficiency.

It was determined that the iron contents of plants changed between 55 and 226 mg kg^{-1}. The acceptable limit value of the iron content is between 70 and 200 mg kg^{-1}. It was observed that 5 % of analyzed plant samples were deficient, and 5 % were excess in Fe concentrations. In general, the iron content of the plants was found sufficient. Therefore, there is no need for iron fertilizers in the fertilization program nowadays. Copper concentration ranged from 7-385 mg kg^{-1}, 10 % of olive plants in the research area were found to be sufficient, and 2 % were excess in Cu content. Elevated copper concentrations can cause toxic effects in plants. The plant is driving some difficulties in absorbing iron. Therefore, chlorosis can be observed like in iron deficiency. The deficiency must be taken into account in the fertilization process.

It was determined that the zinc content of plants varied between 4.77 and 32.60 mg kg^{-1}. The acceptable limit value of the zinc content is between 25 and 100 mg kg^{-1}. According to this, zinc deficiency was determined in 95 % of the plants in the study area. Zinc leaf fertilization should be applied to orchards that determine zinc deficiency. It was observed that the manganese content in plants ranged from 12.10-53.50 mg kg^{-1}. The acceptable limit value of the manganese content is between 25 and 200 mg kg^{-1}. According to this, manganese deficiency was determined in 60 % of the research area. Manganese fertilization should be applied to examine orchards.

Recommendation

When the results of this research are generally evaluated, magnesium deficiency (100 %) takes first place among nutrient deficiencies, followed by zinc (95%). The deficiency of potassium element was in third place with a rate of 85%, and the deficiency of manganese element was in fourth place with a rate of 60%. Eliminating the deficiencies of these four nutrient elements must be considered in the fertilization program in the olive cultivation in Bandırma, Balıkesir.

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CHAPTER 3

ECONOMIC POTENTIAL OF *TERUBUK* (*Saccharum edule* Hasskarl)

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3.1. Introduction

Economic development, especially at the regional level, aims to improve the community's welfare. Efforts are being made to achieve this, including acceleration of growth in the agricultural sector. Meanwhile, the dynamics in the development of agricultural progress are currently faced with a global phenomenon that creates new competitive challenges. This challenge indeed demands each region to be able to compete and spur its development. The strategy to encourage regional competitiveness, especially in the economic sector, is through managing the potential of local-owned resources. For this reason, it is necessary to identify superior prospects, including agricultural commodities, products, and services in each region, so that they can be developed and become regional leverage.

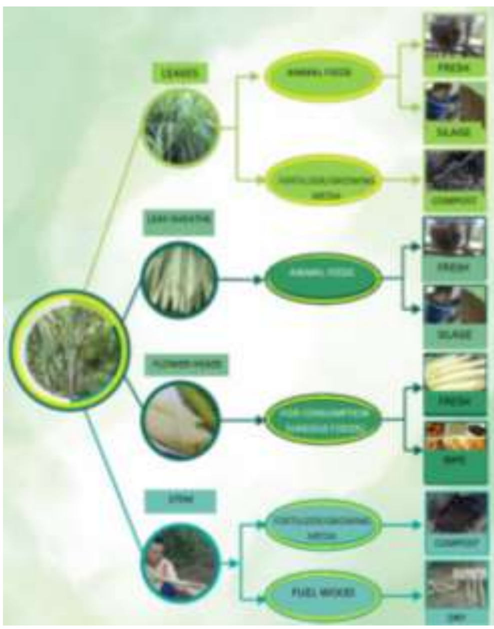

Figure 1. Industrial Tree of Terubuk
Source: Sukmawani et al. (2018), Copy Right No. 000119318

The potential and superiority of each region will undoubtedly vary according to its characteristics; they can come in the form of agricultural commodities in general (plants, livestock, and fisheries), products, or services. One of the potentials in the agricultural sector to develop is the commodity of Terubuk or *Saccharum edule* Hasskarl.

As an indigenous vegetable, Terubuk is one of the plants found in several areas, including in the Sukabumi Regency. Terubuk has been found for a long time in various regions in Indonesia as it has wide adaptability. The results of research by Sukmawani et al. (2017) showed that Terubuk is a vegetable plant with the economic potential to increase farmers' income. Farmer's income was later proven by the results of a follow-up study conducted by Sukmawani et al. (2018) that generated an industrial tree of Terubuk with all parts of the plant that could be used daily (Figure 1). Based on the industrial tree in Figure 1 above, apart from being edible, other parts of the plant can also be used as animal feed.

3.2. General Overview of Terubuk

Terubuk is another name for Trubus. In various regions, Terubuk is also known by different names. Some call it Turubus, Tebu Endog or egg sugar cane (Java), Tiwu Endog or Turubuk (Sunda), Sayor Lilin (Menado), Bunga Tebu or sugarcane flower (Sumatra), Sayur Trubus (Maluku), Idawaho (Ternate), didiliutu (Halmahera Utara), and others depending on the area. According to Sukmawani et al. (2016), Terubuk is also named differently in several countries such as duruka, Fijian asparagus/dule (Fiji), and pitpit (Melanesia).

Judging from its taxonomy, the Terubuk plant belongs to a family of sugarcane plants included in the Poales family, Saccharum genus, and Saccharum edule Hassk species. The shape of the Terubuk plant is similar to sugar cane with reddish-green segmented stems. Based on its classification, Terubuk is a vascular plant, so its propagation can be done vegetatively through stem cuttings.

Table 1. Nutritional Content of Terubuk Flower

No	Element	Content (%)
1	Water	90.20
2	Ash	16.94
3	Fat	4.18
4	Coarse Fibers	10.92
5	Protein	61.02
6	Carbohydrate	6.94

Source: Mangunwidjaja et al. (2014)

According to Kurniatusolihat and Nia (2009), propagation of Terubuk by cuttings consisting of 3 segments can increase the number of shoots and flower weight. In addition, Terubuk plants are characterized by unusual inflorescences; they do not have perfect flowers, so they do not produce seeds. Thus, another solution for the propagation of Terubuk, according to Arsela, P (2011), is the tissue culture method. The most edible part of the Terubuk plant is the flower; it has nutritional content, as presented in Table 1.

In addition to the nutritional content listed in Table 1, Andarwulan, Nuri, and Rh Fitri Faradilla (2012) in their research stated that Terubuk also contains vitamins such as Phosphorus, Calcium, Iron, Vitamin A Activity, Thiamine (Vitamin B1), and Ascorbic Acid (Vitamin C). Meanwhile, Pentury et al. (2017) conducted a study on the nutritional content of Terubuk flowers in fresh and processed conditions, as shown in Table 2 below.

Table 2. Nutritional Content of Terubuk Flower before and after Processing

No	Element	Before Processing	After Processing
1	Water content	88,64%	77,34%
2	Fat	1,44%	11,81%
3	Protein	4,40%	3,77%
4	Ash content	1,25%	1,66%
5	Carbohydrate	4,25%	5,37%
6	Coarse Fibers	0,63%	1,07%

Source: Pentury et al. (2017)

Based on nutritional value and vitamin content, it can see that Terubuk contributes positively to health. Although there has been no further specific research on the benefits of Terubuk for health, at least the content of nutrients and vitamins in Terubuk is sufficient evidence that it is suitable for consumption. Terubuk is an annual plant (perennial) that has fibrous roots and segmented stems like sugar cane but is not branched. Terubuk leaves are elongated ribbon-shaped with fine hairs on the surface. The flowers of the Terubuk plant are compound. These flowers are harvested when they are still young (buds) and consumed either fresh or processed further.

Terubuk plant is mainly found in areas with friable soil; it is easy to plant, has high adaptability, and is suitable when planted on land with a soil pH of 5-6 and planting height between 1-1500 m above sea level. Having this high adaptability makes Terubuk plants easy to cultivate. They do not require too much attention to grow well and produce. Maintaining the land planted by Terubuk is also easy: just get rid of nuisance plants and bury them in the ground to get compost. Fertilizing the Terubuk plant does not take too much effort either: simply use drum fertilizer of about 10 tons for a hectare. Terubuk should be planted in a monoculture system with a spacing of 1.5 m x 1 m or 1 m x 1 m for optimal growth

Figure 2. Terubuk Plant

The age of the Terubuk plant until it produces flowers ready to harvest is 5 -10 months after planting, depending on the plant's growth. Meanwhile, the productive age of the Terubuk plant is around 2-3 years and can be extended by rejuvenating the plant, such as through pruning, fertilizing, and soil hoarding. Criteria for ready-to-harvest plants include the distance between the more tenuous leaf arrangements. Harvesting can be done by cutting the buds of flowers still covered with leaf sheath. The harvesting is better carried out by taking the entire leaf sheaths to protect the Terubuk flower and maintain longer shelf life.

3.3. Economic Potential of Terubuk

Although it is a potential crop, Terubuk has not yet been specifically cultivated as the primary commodity by farmers. Meilani, EH et al. (2017) conducted research on "Agribisnis Terubuk Sebagai Komoditas Potensi Unggulan Lokal Kabupaten Sukabumi" (Terubuk Agribusiness as a Local Leading Potential Commodity of Sukabumi Regency) stated that Terubuk planting in Sukabumi Regency is usually carried out with an intercropping system; some even plant Terubuk only as an intercrop between other major plants. Many people also plant Terubuk as a hedge in rice fields, ponds, or yards so that the yields are easy to pick and can be used for daily consumption.

Terubuk is worth being developed as a primary or side commodity by farmers since it has economic value. According to research conducted in Sukabumi Regency, Terubuk flowers are not sold in kilograms but in a bunch consisting of several Terubuk flowers. Terubuk is marketed not only in the traditional market but has also entered the modern one. The research of Siddiq, Syahrul, et al. (2020) concluded that the perception of most consumers in the current market stated that this Terubuk vegetable was attractive. The selling price of Terubuk is also quite good, around Rp. 50,000 per bunch, where each bunch consists of 10 Terubuk flowers. This price is the selling price at the consumer level, while the selling price at the farmer level varies depending on the size of Terubuk, starting from Rp. 1000 per flower up to Rp. 5000 for three Terubuk flowers (Figure 2).

Figure 2. Terubuk Flowers are ready for the market

The selling price of Terubuk flowers, which is relatively high, tends to be stable and is not affected by seasons or specific days. During the time of research conducted in Sukabumi Regency from 2016 to 2021, the prevailing price of Terubuk did not change much due to the high demand but low supply, for there was not much Terubuk available. The lack of Terubuk quantity is reasonable because, as previously stated, Terubuk is not the main crop cultivated by farmers.

Table 3. Analysis of Terubuk Farming per Hectare

No	Description	Quantity (unit)	Unit Price	Total	Remark
I	**Fixed Costs**				
	Ground lease	1 ha	3.000.000	3.000.000	
	Tools depreciation				
	Hoe	Six units	200.000	1.200.000	17.000/year
	Total fixed cost			**3.017.000**	
II	**Variable Costs**				
	Seeds	9600	500	4.800.000	
	Manure	5 quintal	230.000	1.150.000	
	Soil hoeing/plowing	5 people	25.000	625.000	125000 x 5
	Seeds planting	5 people	25.000	625.000	125000 x 5
	Fertilizing	5 people	25.000	125.000	
	Watering	5 people	25.000	125.000	
	Weeding	5 people	25.000	125.000	
	Hoarding	5 people	25.000	375.000	125000 x 3
	Harvesting	5 people	25.000	125.000	
	Transporting	5 people	25.000	125.000	
	Total variable cost			**8.200.000**	
III	**Total cost**				
	Fixed cost			3.017.000	
	Variable cost			8.200.000	
			Total cost	11.217.000	
IV	**Receipts**				
	Production	9600	2000	19.200.000	
V	**Revenue (IV-III)**				
	Receipts			19.200.000	
	Total Cost			11.217.000	
				7.883.000	
VI	**R/C Ratio**			1,7	
VII	**BEP of Production**			2633	piece
VIII	**BEP of Receipts**			5.266.036	Rupiah
IX	**BEP of Price**			1168,4375	Rupiah/stalk

Source: Primary data, 2016 (processed)

Thus it is not widely available in the market. The high and stable selling price of Terubuk proves that Terubuk has the economic potential to increase farmers' income. The following table presents the results of farming analysis on Terubuk plants based on research conducted in Sukabumi Regency, Indonesia.

The results of the Terubuk farming analysis are supported by a study conducted by Sangadji (2018) in Tidore Island which concluded that Terubuk farming is feasible to be developed with an R/C ratio above one and an average profit of Rp. 989,000 in a single production. Terubuk farming analysis presented above is only from its flower, excluding the by-products that can be obtained from other parts of the Terubuk plant. In addition to the flowers, the other parts of the Terubuk plant are used to increase the added value obtained by cultivating Terubuk. Research conducted by Chaniago, Ramadhani, et al. (2015) proved that Terubuk has potential for animal feed. The feed can help overcome the problem of meals, especially forage-based ones, which many farmers face.

The results of research by Sukmawani et al. (2018) also concluded that Terubuk waste could be used as animal feed and organic fertilizer (compost). Their results are supported by silage trials using Terubuk waste raw materials conducted by Miftahunnisa, and Aulia (2018), which prove that Terubuk waste as animal feed is made into silage can increase the weight of cattle. Based on the result of research by Chaniago (2015), it is stated that an average of 11,300 kg of leaf wet biomass is produced from 1 ha of Terubuk plant. Such an amount is sufficient to feed four cows within 90 days. Furthermore, Chaniago (2015) proved that cattle fed with Terubuk-based feed twice a day (morning and evening) as much as 7.5 kg has gained weight about 0.03 kg/head/day.

The utilization of Terubuk waste as an alternative feed can be applied during the dry season to overcome the limited availability of forage. As an alternative feed, Terubuk plant waste must be preserved first by turning it into silage to maintain its quality. According to Moran (2005), hay is the result of fermenting forage that has been held by acids intentionally added or naturally produced during the storage period.

Since Terubuk has potential as a vegetable for consumption and its waste for alternative animal feed, this plant is perfectly suitable to be developed in an integrated manner. The results of the study by Sukmawani Reny and Miftahunnisa (2021) have proven that the integration of Terubuk farming with sheep and ducks can improve the community's economy by getting more income from livestock and plants raised (meat, eggs, fertilizer, Terubuk flowers, and Terubuk plant waste). The implementation of an integrated farming system of animals and Terubuk crops will increase farmers' income in three ways: (1) increasing the selling price accompanied by an increase in quality, (2) reducing production costs through efficiency, and (3) obtaining crop yields from more than one product.

Another potential added value of the Terubuk plant is its waste utilization as compost material, especially on parts that are not consumed and cannot be used as animal feed ingredients, such as stems and roots, which have complicated character. In addition, the leaves and leaf sheaths can also be used as compost if they are not used for animal feed. The Terubuk can be implemented to support the zero-waste campaign. The tremendous economic potential described earlier will provide maximum added value if it is implemented by properly considering aspects of input, output, and production processes. Input relates to human and natural resources, output refers to food products (agriculture and livestock) and organic waste, and the production process refers to time and the environment.

3.4. Conclusion

Terubuk is not a popular commodity and is not widely known in the community. With its economic potential, Terubuk deserves to be developed by farmers as a commodity cultivated either in monoculture, intercropping, or integrated with livestock. As a potential vegetable source, a well-managed Terubuk development will provide added value for farmers or ranchers.

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CHAPTER 4

SUSTAINABLE AGRICULTURE PRODUCTION IN UPSTREAM WATERSHED: SOCIO-ECOLOGICAL APPROACH

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4.1. Introduction

Sustainable Agriculture Production (SAP) is very strategic in achieving the Sustainable Development Goals (SDGs), especially providing sufficient food and reaching zero hunger for everyone. A global sustainable development platform is implemented in all economic activities. Demand for the production and consumption of sustainable products in the global market is increasing. Nowadays, demands for sustainable production are part of a global standard that is believed to answer sustainability challenges at the production level (economic, social, and environmental).

Land and environmental damage have implications for the emergence of critical land because of erosion and landslides. The rate of soil erosion on agricultural land in Indonesia with slopes of 3-15% is high, reaching the range of 97.5-423.6 tons/ha/year (Abdurachman, 2008). Many agricultural lands have more than 15% slopes so the erosion rate can be very high, especially in areas with high rainfall. The degradation of agricultural land is a serious problem. Land degradation costs around US$40 billion annually worldwide, not considering the hidden costs of increased fertilizer use, loss of biodiversity, and loss of unique landscapes (WMO - World Meteorological Organization, 2020).

Land and water have a close interactive relationship, but the two resources have different characteristics. Water has the characteristics of mobility or flow, variability, and diversity, making it difficult to claim ownership. Water can flow across administrative boundaries, both within a country and between countries, so water is often referred to as common-pool resources; its use is not exclusive, but users can compete. According to Law No. 11 concerning Irrigation, "Water" is all water contained in and or derived from water sources, both above and below the surface of the land, not included in this sense water found in the sea; "Water sources" are places and containers of water, both above and below the ground surface.

Furthermore, the notion of a watershed is a land area that is a unit with a river and its tributaries, which functions to accommodate, store, and drain water from rainfall to lakes or to the sea naturally, which limits land. It is a topography and boundary separator at sea to water areas still affected by land activities. A Watershed can also be interpreted as a spatial unit consisting of abiotic elements (soil, water, air), biotic (vegetation, animals, and other living organisms), and human activities that interact and depend on each other in a unified ecosystem. A unified ecosystem means that if the linkages have been established, the management of forest, land, water, communities, and others must pay attention to the role of these ecosystem components (Indonesian Law Decree No. 7/2004).

Watershed management must be carried out through a system that can provide high land productivity and sustainability and improve community welfare (Sudaryono, 2002). Watersheds must be managed sustainably by balancing economic, ecological, and social aspects. Many transboundary problems, such as inter-district water resource management problems, are not appropriately handled (Suradisastra, 2004).

The community movement in maintaining and preserving watersheds is very dependent on the level of participation and the tendency of community attitudes in watershed management activities (Radjabaycolle & Sumarjo, 2014). The national policies that form the basis for regions to form watershed forums are Minister of Forestry Regulation No.P.39/Menhut-II/2009 concerning Guidelines for Formulating Integrated Watershed Management Plans and Minister of Forestry Regulation No.P.42/Menhut-II/2009 concerning General Patterns, Integrated Watershed Management Standards and Criteria.

However, according to (Slamet, 2015), managing the watershed system is not easy because it faces many conflicts of interest, so any approach taken will have general cost and benefit consequences for the parties involved. Commons research theory assumes the most considerable difficulty in managing watersheds is in social organizations/institutions. Building collective action is easiest to start from the micro watershed level, but hydrological management demands a scope of work at the macro watershed level. Potential trade-offs between the two occur (Fisher et al., 2008). Therefore, at the watershed (macro-watershed) scale, institutional arrangements are needed to increase interactions between sub-watershed groups (micro-watershed) members of the watershed.

The success of sustainable production depends on land tenure within the property rights. At the same time, the property rights in natural resource management brought implications for maintaining sustainability. The certainty of land tenure rights will legally guarantee sustainable management practices as long-term agricultural production investments. The property right is the basic need in designing the precise rules of the constellation of mutual trust and cooperation among institutions, actors, and natural resource users. This difference in management rights results in jurisdictional uncertainty in farming, including investment in sustainable production activities.

Most cash-crop commodities are near production and protection forest and watershed catchment areas. The development of cash-crop production in the upstream area requires conservation principles (Banuwa et al., 2008). Appropriate conservation technologies should be developed on plantations, including partial weeding, ridging, sediment pits, end trenches, and shade plants/multi-strata systems (Agus et al., 2002). The combination of plantations with various shade plants is known as agroforestry systems.

Sustainable farming will enhance the environment's ability as an "indirect" service provider in the form of carbon storage, protection of watersheds, replenishment of the groundwater layer, and habitat for biodiversity (Hope et al., 2005). Agroforestry in coffee farming is one of the sustainable adaptive management efforts to address the risk of damage to forest ecosystems (Bernard et al., 2014; Buongiorno & Zhou, 2015; Eakin et al., 2014; FAO, 2014; Fitriani et al., 2018; Fitriani et al., 2018; Fitriani & Kuswadi, 2021; Foran et al., 2014; Fu, 2009; Kuswadi & Fitriani, 2021).

The right to access natural resources, including forest management, has implications for the efforts to utilize and maintain sustainability. Land rights jurisdiction is the first-order condition in maintaining sustainable farming production in upstream watersheds (Fitriani et al., 2020). Sustainable production will guarantee the ecological system's function. The threat of social unsustainability faced by communities in the upstream watershed. The still-high poverty rate and pre-prosperous communities around the forest showed that cash-crop production does not fulfill the adequate income to support a prosperous economic life. Poverty and inequality occur in the rural economy. Limited sources lower the production and income, also unemployment turn as causes poverty conditions (Fitriani et al., 2017). The root cause of obtaining property rights led to uncertainty in natural management rights. Complex problems are related to the low institutional performance of CFM. The limitations of jurisdiction, game rules, and social capital are still weak in realizing trust and cooperation, and the quality of human resources in adopting sustainable production techniques are still not synergized. Information on internal and external factors supporting community institutions to achieve sustainable goals is minimal.

Generally, the formulation of the problem of this paper is to answer the question of what and how the sustainability of agriculture production in the upstream watershed should establish and consider the social and ecological aspects. The discussion will trigger the establishment of ecological services in the upstream watersheds. Furthermore, the specific objectives of this study are

(1) to explore farming production systems in the upstream watersheds to meet the ecological requirement for environmentally sustainable, and (2) to assess the social sustainability performs that the criteria for social sustainability can be met.

4.2. Sustainable Agriculture Production in Upstream Watershed

The sustainable agriculture production upstream is explored through the agriculture system the farmer practically implements. Discussion of sustainable production starts from the property right on natural resources, sustainable agriculture and sustainable production literacy, and sustainable production at the practical level. At the same time, the explanation of sustainable production at the practical level is the representation of sustainable production that meets ecological sustainability. The last social sustainability assessment will discuss the equality of income distribution.

1. Property rights in natural resources

A Watershed, according to Indonesia Government Regulation No. 37/2012, is a land area that is a unit with a river and its tributaries, which functions to accommodate, store, and drain water that comes from rainfall to lakes or the sea naturally. Land and water have a close interactive relationship, but the two resources have different characteristics. Water has the characteristics of mobility or flow, variability, and diversity, making it difficult to claim ownership. Water can flow across administrative boundaries, both within a country and between countries, so water is often referred to as common-pool resources; its use is not exclusive, but users can compete.

The upstream watershed is a water catchment area included in the conservation and protected forest areas. Therefore, the upstream watershed needs to be managed sustainably by balancing economic, ecological, and social aspects. Indonesia's watersheds and forest regions are destroyed, then the ecological function declines and worsens. Good governance in watershed and forest management is needed. The initial form of policy to manage the state forest and natural resources with participatory community involvement were the Community Forest Management (CFM) (Minister of Forestry Decree No.622/1995) and No. 677/1997, which provided the land forest use rights to the community. The Ministry of Forestry has issued Decree No.52/2007 concerning the Community Forests and No.49/2008 concerning Village

Forests. The Decree prevents land encroachment and ensures the flow of economic benefits from the existence of forests to local communities. The policies are seen as one of the efforts to reduce the rate of deforestation in Indonesia. The regulation gives local communities the right to access and manage non-timber products for the sustainable protection of forests.

Good governance in watershed management must have management capabilities to improve and maintain the sustainability of natural resources in meeting the community's needs. Good governance in watershed management is needed because bad governance could worsen the damage to natural resources. Social actors will strongly influence decisions and choices of sustainable agricultural practices (Bernard *et al.,* 2014; Eakin *et al.*, 2014)**.** The characteristics of good watershed management (Ntabe *et al.,* 2015) require conditions such as (1) it must consist of a participatory nature in the sense of opening up opportunities for good contact and interaction; (2) It should have a polycentric organization, consisting of several stakeholders who have of authority in the organization; (3) It is accountable to the community and the holders of authority above it; (4) It is deliberative in the sense of providing opportunities for its members to debate, mediate and negotiate; and (5) have a multi-layered management structure in the sense of containing broad representation, and also (6) fair in the distribution of unexpected benefits and risks.

The main problems in upstream watershed management lay in the conceptual state's approach to controlling the upstream watershed area. It assumes that individual farmers in the practice of using land directly cause conflict with the social goal of protecting the upstream watershed area. Forests are assumed to be the only whole land for watershed protection, and planting trees is the best way to protect and restore watersheds from damage. Responsibilities of government seem often just motivated by partial achievement such as biodiversity conservation, not integrated action to protect watersheds. The forestry department uses state forests as a political image, profit extraction, and retention of political power. On the other side, millions of forest-dwelling farmers who do not have legal access threaten the sustainability of upstream watersheds and the protection of forests (Swallow et al., 2001).

The history of the Community Forest Management (CFM, Indonesian term called Kelompok Hutan Kemasyarakatan/HKm) was first issued in 1995 through the Decree of the Minister of Forestry No.622/1995. Recognition of CBM was very slow until 1997, then the next Decree No. 677/1997issued to strengthen forest rights use to communities, well-known as Community Forest Management Rights (CFMR). In 2001, Decree No. 31/2001 gave flexibility to the community as the leading actor in forest management. Then, the Regulation No. P.13/2010 issued the right of Forest Management to empower local communities. CFMR implements restrictions in protected forest areas and production forests. The forest is not burdened with rights or permits for forest products to become a source of livelihood for the local community. The CFMR is granted for 35 years and is extended according to the results of the evaluation every five years. The CFMR extension is submitted to the Governor three years before the permit expires. Then the management of forest areas through partnerships is regulated in Regulation No. P.39/2013 and No. 47/2013 about the Forest Utilization in Certain Areas. Forest utilization activities in partnership should deal with the third parties (local communities, local government corporations and private, Cooperatives, MSMEs) in the context of partnerships and opening business opportunities.

Community and public participation in sustainable management of protection forests and watersheds area was a new direction for forest sustainability policies in Indonesia. Forestry agencies conduct long-term planning to expand community access through a partnership program. Partnership program in Community Forest Management is part of efforts to minimize deforestation and land degradation and achieve a prosperous forest function.

Farmers with CFMR on land management rights have more opportunities than other land tenures. Differences in land management impact farmers' decisions about the type of plant and the conservation technology requirement. Investing in natural resources sustainability is linked with the authority among stakeholders in watersheds management synergistically. The status of landholders will determine the willingness of coffee growers to follow the scheme of providing environmental services. The land tenure status changes could enhance the farmer's participation in following the environmental service scheme more than other land tenures. The existence of farmers with partnership and CBFM scheme on different land tenure on upper Sekampung has a strategic position to minimize the deforestation and recovery watersheds destruction. Forestry agencies, correspondingly in implementing the forest management strategy, elaborate the community participation. For instance, the local involvement community in the revitalization strategy for the restoration of the Sekampung watershed (54,283 ha) and the Seputih watershed (12,290 ha) with sustainable agriculture production, primarily through the sustainable agroforestry practiced (Fitriani et al., 2018a).

Land rights are fundamental land management decisions and long-term investments (Klemick, 2011). This pathway is the most likely to lead to sustainable ecosystem management (Poudel et al., 2016) and is linked as a critical norm in rural area management (Eisenberg, 2016). Property rights affect environmental sustainability efforts, although the relationship between property rights and environmental services is very complex (Swallow et al., 2010). The farmers' income sources are the prerequisite to sustainable agricultural production activities in upstream watersheds. There is a significant difference in income based on land tenure among coffee farmers. A significant difference between the income of private land, community forest base management right holder (CFBM), and rent-land. The average income of private land farmers is higher than CFBM and rent-land farmers (IDR 4.4 million > IDR 2.9 million > IDR 2.7 million) (Fitriani et al., 2018c).

2. Sustainable Agriculture Production

Agriculture is managing natural resources to produce physical commodities with the help of technology, capital, labor, plantations, and or livestock agriculture, including food crops, horticulture, and agroecosystems. Sustainable agriculture is an agricultural business that utilizes and simultaneously conserves resources to produce optimally harvested products using renewable production facilities with reasonable input costs, meeting social and environmental criteria. Sustainable agriculture is a philosophy of values and farming systems. Values reflect an awareness of ecological and social realities and a commitment to respond appropriately to that awareness. The procedures, design, and management of conservation of all resources to maintain and increase farm profitability are critical points of sustainable farming practices. Nutrient and water cycles, energy flows, soil organisms, and natural pest control to produce nutritious, healthy, and safe food from contamination are at the core of the biological agricultural production process.

Sustainable farming systems can maintain productivity and resource benefits to be socially supportive, commercially competitive, and environmentally friendly in a sustainable manner. Sustainable agriculture also refers to an integrated system of plant and animal production practices, integrated farming, and agroforestry that maintains natural biological cycles and controls, maintain the economic viability of agricultural operations, and improves the quality of life of farmers and society. Indonesian Law No.

22/2019 concerning the Sustainable Agricultural Cultivation system through better regulation of efforts to meet human needs, sustainable production of agricultural commodities, and maintaining a sustainable living environment. Sustainable agriculture seen from agroindustry should give added value to activate economic circle for communities (Saepulloh, et. Al., 2021 and usndari, et. al., 2017)

The study of sustainable agricultural development begins with the global paradigm of sustainable development goals (SDGs), the development platform for countries worldwide. The direction and design of development programs in Indonesia are also in line with the SDGs targets. Sustainable agricultural development is the target of the SDGs linked with the goals of eradicating hunger (goal 2), sustainable consumption and production (goal 12), and the preservation and sustainable use of terrestrial ecosystems (goal 15).

Agriculture can be a significant source of growth for agriculture-based countries, reducing poverty and improving the environment. Making smallholder agriculture more productive and sustainable through increasing productivity, profitability, and sustainability of smallholder agriculture is the leading way out of poverty. The laws and regulations that form the basis of sustainable agricultural development policies in Indonesia are:

1. Law Number 41 of 2009 concerning the Protection of Sustainable Food Agricultural Land;
2. Law no. 22 of 2019 concerning Sustainable Agricultural Cultivation Systems
3. Government Regulation No. 25/2012 concerning Information Systems for Sustainable Food Agriculture.
4. Minister of Agriculture Decree No 07/2012 concerning the technical guidelines for criteria and requirements for areas, lands, and land reserves for Sustainable Agri-food production;
5. Regulation of the Minister of Agrarian Affairs and Spatial Planning No. 19/2016 concerning determination of sustainable agri-food land in areas that have not formed a regional spatial plan.

The objectives of the SDGs at the practical level are manifested in the discussion of the theme of agricultural production, agroecosystem unity, and assessment of the achievement of sustainable indicators in an ecological, social, and economic inclusive review. Food production technology and sustainable ecosystems are critical points in sustainable agriculture. The assessment focuses on the policy and evaluation of the fulfillment of sustainability indicators in the interdependence of environmental, social, and economic sustainability. The final part, as a closing, includes a discussion on best practices for sustainable agricultural development. Good practice in integrating crops and livestock, integrated farming, agroforestry, and permaculture farming systems represent the implementation of sustainable agriculture in Indonesia. Sustainable agriculture in Indonesia is simplified as an agricultural business for optimal yields while preserving agricultural resources and the environment. The operationalization of this objective is carried out in the following activities:

a. The production process takes place efficiently for excellent quality products
b. Actions to conserve agricultural resources and the environment in every stage of the production process.
c. Availability and ability to access technology for quality conservation of agricultural and environmental resources

3. Sustainable production: agroforestry practices

Cash-crop commodities in upstream watersheds and protection forests are coffee, cocoa, pepper, rubber, and palm oil (Fitriani et al., 2018b). The empirical study in two main upstream watersheds in Lampung, which implemented the CFMR, which involved 408 coffee farmers, revealed that the coffee farmers derive their source of income from various commodities, mainly were coffee, pepper as intercropping crops, and shade trees. The average contribution of coffee farming attaint to 24% of the total farm income. The farmers with private land tenure are the highest compared to another. The diversity of income sources in the upstream watershed from various plant vegetation is essential in maintaining land cover as a water catchment area. These farming practices are called coffee agroforestry (Fitriani et al., 2020; Kuswadi & Fitriani, 2021a). The practice of coffee agroforestry is an adaptation of sustainable production in the upstream watershed.

Coffee farming in the coffee agroforestry system is the proprietary land management that meets the criteria for sustainability and provides long-term socio-economic benefits. Coffee farming carried out by farmers in different land management conditions meets the criteria for socially sustainable.

Meanwhile, the external factor that influences the successful performance of coffee production is the market, through commodity price incentives, both at the local, regional, and global levels. The commodity market is developing towards a buyer's obsession (global consumer desire) which requires sustainable production of commodities. International standards institutions develop sustainability principles to minimize environmental risks and tackle global climate change. Complex issues refer to excess dependencies, transaction costs, and vulnerabilities that threaten producers (especially the poorest). Several studies have shown that farmers' participation in coffee certification is more due to economic incentives to obtain premium price incentives. However, further investigation still needs to investigate whether the price incentive in the environmental service scheme becomes a central external factor in mobilizing community participation in realizing sustainable coffee production performance.

The performance of sustainable coffee farming is essential as part of efforts to improve the structure of revenue, income, expenditure, and welfare of coffee farmers, most of whom are still facing problems of poverty and economic inequality. The incentives for GAP coffee actors can be formulated in a payment scheme for environmental services. Parties who have implemented the coffee GAP appropriately are entitled to incentives or compensation for their hard work and efforts to ensure environmental sustainability in the upstream area of the Sekampung watershed by the beneficiary in the downstream area. Compensation payments for the provision of environmental services are an alternative to improving new sources of income for farmers who run the coffee GAP well. Incentives and premium pricing approaches tend to be more effective in achieving conservation and development goals.

Agroforestry was categorized as dense when ground-truthing indicated it had an average of 144 trees with a diameter (DBH) > 30 cm and 844 DBH trees ranging from 5 to 30 cm, respectively; the middle class had 42 trees, and 742 trees were found for the second diameter category (Markum et al., 2013). With this basis, the condition of vegetation density in coffee farming lands is in the middle-class agroforestry density criteria because the ratio of the median density of coffee: intercropping: MPTS is 2508: 142: 84 trees. Almost all coffee farmers have coffee plantations that are planted in a mixed garden pattern (96.25%), with shade plants (MPTS1, 44%) and with various crops (MPTS2 56%) (Fitriani et al., 2018c).

Coffee farming with a combination of shade provides an overview of the biodiversity performance of complex vegetation in middle-class agroforestry density. Understanding which tree species to choose and how to manage them for different socio-ecological contexts underlies farmers' choices in planting shade trees (Barrios et al., 2017). This fact is relevant to (Yulilistyarini, 2013) that non-timber MPTS are mostly found as mixed agroforestry systems in multi-strata coffee agroforestry systems. This was also found in coffee farmers in Pulau Panggung District, Tanggamus (Fitriani et al., 2018).

The sustainable coffee farming system is described by the presence of other trees as shade trees and various intercropping plants. Coffee farmers classify the planting of trees on their plantations as protection trees, well-known as multipurpose tree species (MPTS). They also cultivate pepper and banana as the main intercropping crops in coffee fields. This condition shows that coffee farmers can optimize their land use by combining coffee plants with other crops and carrying out productive activities outside the agricultural sector.

Soil conservation activities are essential to reach sustainable agriculture production. Production activities in water catchment areas must apply soil conservation principles. Conservation practices carried out by coffee farmers in the research area fall into mechanical technology and soil bioengineering categories. The farmers stated that they had implemented soil conservation on their land. Land conservation activities are carried out as a combination of ditch, mounds, and terraces according to the contours of the land. The soil bioengineering practices implement shade trees, mulch, manure, and multiple cropping plant (Kuswadi & Fitriani, 2021b).

Local communities called Ditch as Roark. It is a small hole measuring about 50 cm long, 50 cm wide, and 50 cm high. Roark is also a place to accumulate plant residues. This action is carried out based on the benefits of improving plant root aeration and increasing production. Roark accumulates litter and topsoil transported by surface runoff to be relatively rich in nutrients. Coffee farmers in the research area, apart from doing work, also make excavations that are technically conservation called dead-end canals. This excavation is a rorak with a length of 1 to 1.5 m. If one canal is filled with plant residues and soil, another canal is made on the other side of the coffee plant. Conservation techniques that are suitable for coffee-based agricultural land are (Agus et al., 2002) partial weeding- Natural plant strips (NPS) - like cover crops and partial weeding, ridging, tied ridging, sediment pit, dead-end trench, shade plants/multi-story systems, and the combination of various techniques.

As the 8th-year coffee plant gets bigger and taller, the value of plant protection against the soil will increase. Its effectiveness in resisting erosion will resemble the forest. Multi-strata treatment effectively suppresses erosion tolerably on almost any slope and length. Thus, erosion management treatment is mechanical (engineering), mostly needed when the coffee plants and shade plants are still young. However, some farmers believe mechanical conservation can improve soil fertility through litter accumulation, root improvement, and a further increase in coffee production.

Furthermore, land conservation using shade plants on coffee farms was carried out by 96.76% of coffee farmers. They operate the coffee farming system with agroforestry in the upstream watershed. Shade plants are widespread among coffee farmers, as well as in other locations in coffee production centers in Indonesia. The shade plant species vary widely (Agus et al., 2002); it is called: (a). Shade (protective) plants of the same type that form a simple agroforestry system, namely a combination of coffee and one type of protective plants, such as Gamal/quickstick (*Gliricidia sepium*), December tree (*Erythrina subumbrans*), lamtoro (*Leucaena leucocephala*) or cinnamon (*Cinnamomum burmamii*)). (b) Protective plants that are diverse and form a complex agroforestry system (complex agroforestry or multi-strata system), for example, coffee plants with two or more of the following plants: candlenut (*Aleurites muluccana*), jengkol bean (*Pithecellobium jiringa*), petai*/sting bean/bitter bean/sator bean (Parkia speciosa*), cinnamon (Cinnamomum verum), durian (Durio zibethinus), avocado (*Persea Americana*), jackfruit (*Artocarpus heterophyllus*), cempedak (*Artocarpus integer*), etcetera.

Coffee with multi-strata shade trees can be achieved gradually. Farmers start with a simple system; over time, they add to the diversity of plants in their coffee plantations. The stratified canopy of the system causes this system to resemble a forest which conditions only a small portion of rainwater that directly hits the ground surface. Most of the rainwater first falls on the plant's leaves before reaching the ground, so the impact power (kinetic energy) is significantly reduced. In addition, in multi-strata systems, especially complex ones, the number of leaves that fall and protect the soil surface from rain is greater.

The high density of coffee trees is mainly planted by farmers in Upstream Sekampung watersheds (Pekon Datar Lebuay dan Sinar Jawa, especially in Cita Laksana, Talang Tengah, Ciherang, and Sukoharjo). Farmers responded positively to strengthening the sustainable coffee farming program with agroforestry. Coffee farmers are familiar with and familiar with the term environmental services. They realize that agricultural production activities in the upstream watershed must be aware of preventive and rehabilitative measures to secure land capability. The farmers' willingness to provide sustainable agroforestry practices on their land.

Coffee farming with agroforestry is essential in developing sustainable production management that provides better vegetation cover in the upstream watershed. Increasing community participation in a sustainable coffee production system is an integral part of a long-term plan that ensures the availability of environmental/ecological services upstream of the watershed. The certainty of land management rights greatly influences farmers' preferences for better types of agroforestry. The interaction of mechanistic understanding and innovation adoption drive can help select the right technology to ensure sustainability (Meijer et al., 2015). The expansion of the coffee area must be managed carefully through the delegation of land management rights responsible for maintaining sustainability. The spread of new coffee areas must avoid the trade-off of sacrificing biodiversity and conservation areas/national parks (Jezeer & Verweij, 2015).

4.3. Social Assessment

The social sustainability assessment relates to the quality of life of those working and living in agriculture and the surrounding community. The main goals of national development are to enhance society's quality of life. Development is a physical reality and a people's determination to strive as hard as possible—through social, economic, and institutional processes—to achieve a better life. Unfortunately, at the beginning of 2021, the poverty rate in Indonesia increased, exacerbated by the Covid 19 pandemic. In March 2021, the poverty rate reached 10.14 percent, or as many as 27.54 million people, or an increase of 1.12 million compared to March 2020.

Meanwhile, the Open Unemployment rate in February 2021 was recorded at 6.26 percent. There are 19.10 million people (9.30 percent of the working-age population) affected by Covid-19. Consisted of unemployment due to Covid-19 (1.62 million people), Non-Work Force due to Covid-19 (0.65 million people), temporarily not working due to Covid-19 (1.11 million people), and residents working who experienced a reduction in working hours due to Covid-19 (15.72 million people), 27.54 millions are below the poverty line until the first quarter of 2021.

Based on the Human Development Index (HDI) in 2020, there was a slowdown in growth compared to previous years. Indonesia's HDI in 2020 is 71.94. The decline greatly influenced this slowdown in the average per capita expenditure. This indicator fell from 11.30 million IDR in 2019 to 11.01 million IDR in 2020. Meanwhile, in terms of education, in 2020, children aged seven years hope to enjoy 12.98 years of education or almost equivalent to the length of time to complete education up to Diploma I. The average length of schooling for residents aged 25 years and over 8.48 years in 2020. Regarding health, babies born in 2020 expect to live up to 71.47 years, 0.13 years longer than those born in the previous year (Badan Pusat Statistik, 2021).

The impact of development in improving welfare can be made through a study of income distribution. The size distribution measures the various incomes received by individuals and families. The availability of new sources of income is a solution for the availability of jobs and reducing rural unemployment. Farmers' household incomes will increase, so people's welfare will be better, poverty will decrease, and the economic gap in rural areas can be narrowed. Voluntary transactions for environmental services through the provision of incentives from users of environmental services to providers can take place if and only if the provider of environmental services can guarantee the stock and flow of environmental services on an ongoing basis (which is a conditionality).

Social sustainability relates to the quality of life of those working and living in agriculture and the surrounding community. Quality of life includes equal revenue or income for different stakeholders in the agricultural production chain. In situations of high unemployment, sustainable agriculture promotes the sharing of agricultural value-added to more members of society through more available labor and will increase social cohesion and equity. Social sustainability assessment related to income distribution could regulate by the Gini coefficient, Loren's curve, and *Theil index*. Gini coeficient (Gini ratio) formulate as follow (Hayami, 2001):

$$G = \Sigma \Sigma \mid yi - yj \mid / 2n^2u, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Gini Coeficient operationalize formulate as follow (Widodo, 1990):

$$GC = 1 - \sum_{1}^{n} . f_1 (X_{i+1} - X_i)(Y_i + Y_{i+1}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

GC = *Gini Coeficient*

X_i = Proportion of cumulative number of households in class i

f_i = Proportion number of households in class i

Y_i = Proportion of cumulative number of households in class i=

- If divided by 5 classes:
  20% poorest class, 20% second class, 20% third class, 20% fouth class, and 20% of richest
- If divided into three classes:
  40% poorest class, 40% moderate, 20% richest

Inequality determination used the World Bank clasification and Oshima (1976):

a. G<0,4 = low
b. <0,4<G<0,5 = moderate
c. G>0,5 = high

Social sustainability assessment of sustainable farming practice upstream was carried out using the Gini Coefficient, Lorens Curve, and Theil's Index. The Gini coefficient is an indicator that shows overall income inequality. Based on the case in the upstream Sekampung watershed in Lampung, which is implementing coffee agroforestry as an upstream land use management, the Gini coefficient value for coffee farmers as a whole is 0.42 (Figure 1). The Gini coefficient for coffee farmers with the highest property rights reached 0.52, followed by HK farmers at 0.48 and non-partner farmers reaching 0.49. The Gini coefficient value for coffee farmers is higher than the Gini coefficient for the population of Lampung. In September 2016, when the research was conducted, the Gini coefficient for the Lampung population was 0.358, with conditions in urban areas of 0.384 and rural areas of 0.330. The value of the Gini coefficient can be seen in the following figure.

The average Gini coefficient for coffee farmers (0.42) is not much different from the national Gini ratio, which is 0.403. The results of the Gini coefficient calculation based on coffee farmers' income are in the classification range <0.4 <G <0.5, which means they have a moderate inequality value or the difference in income between coffee farmers in the moderate inequality category. The income shows that the proportion of coffee farmers at high-income levels is more significant. Moderate inequality can occur due to differences in land area, with a reasonably high variation (least 0.25 ha, widest 5 ha, with an average of 1.37 ha).

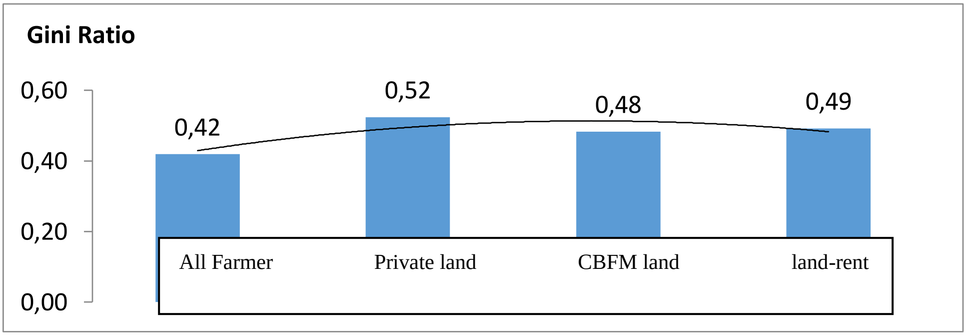

Figure 1. Gini Ratio of coffee farmers in the study area

The condition of land use, which has a reasonably high variation, causes production, productivity, price differences, and coffee farming income to vary, causing a gap in farmers' farming income. In addition, it can also occur due to inequality in infrastructure and economic development in the research area. Furthermore, the income distribution analysis is strengthened by the Lorens Curve, which relates the proportion of the population to the proportion of income received (Figure 2).

The Lorenz curve for private coffee farmers has the smallest area because the curve is close to the population proportion curve. The curve shows that other activities besides coffee farming carried out by private property farmers can shift the Lorenz curve closer to the diagonal line, which means improving the condition of income distribution inequality among property rights coffee farmers. Business activities other than coffee farming also show improvements in land productivity, labor, and the agricultural sector.

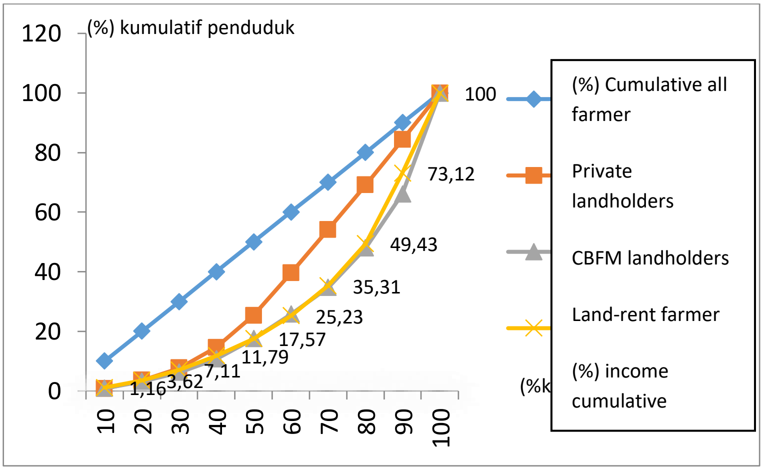

Figure 2. Loren's curve of coffee farmers in the study area

The more productive the allocation of labor owned by farmers and the more business activities in the agricultural sector will improve the structure and distribution of farmers' income. Activities in the agricultural and non-agricultural sectors can alleviate the unequal distribution of household incomes (Fitriani et al., 2022). While CBFM right holders and land-rent farmers have a wider area than the Lorenz curve of property rights farmers, they differ slightly in the highest 20% income proportion. The curve means that the proportion of income between CBFM right holders and land-rent farmers is not much different. Inequality can also occur due to differences in age, education, employment, gender, etcetera (Daryanto & Hafizrianda, 2010). Furthermore, Theil Index produces the following conditions.

Table 1. Value of Theil Index of coffee farmers

Group	Inequality	Theil Index
	Inequality within groups	0.18
Private	Inequality among groups	(0.36)
	Inequality within groups	0.21
CBFM	Inequality among groups	(0.37)
	Inequality within groups	0.78
Land rent farmer	Inequality among groups	(0.34)

The calculation results show that the T value in the coffee farmers with the private rights group is 0.18, and for CBFM farmers is 0.21. The T-value indicates that both proprietary coffee farmers and HKm and non-HKm/non-partner coffee farmers show relative equality or, in other words, do not indicate any inequality within the group because if the T value = 0 means perfect equity. Meanwhile, the entropy T value of coffee farmers was 0.36 and 0.37, and 0.34 was relatively more prominent than the T value in the group. The high difference in the total group inequality index is partly due to the relatively large variation in income levels over the difference in average ownership. Theil index value of Lampung Province in 2016 was 0.13. Assessment of social indicators shows that coffee farming contributes better income to 60% of the proportion of coffee farmers. The proportion of the population (40%) with the lowest 40% income is tiny (±11%). Therefore, the Gini coefficient and Theil index show values of moderate inequality and close to equity. Thus, coffee farming carried out by farmers in different land management conditions meets socially sustainable criteria, which means that coffee farming activities carried out by farmers in the upstream Sekampung watershed can socially demonstrate the fulfillment of equitable income distribution.

4.4. Conclusion

1. Ecologically, sustainable production in the upstream watershed is characterized by the agroforestry pattern in coffee farming. Coffee agroforestry in the upstream Watersheds met as the medium-class density of agroforestry. Coffee farming in the upstream Watersheds fulfills the criteria for being environmentally sustainable.

2. The assessment of social sustainability indicators showed that the income distribution among coffee farmers does not indicate an imbalance within the group, so the criteria for social sustainability can be met.

4.5. Policy Implications

Promoting sustainable coffee farming systems as sustainable agriculture production is the answer to providing environmentally sustainable production. The development of sustainable coffee farming needs to be fully supported by appropriate and strong policies integrated between relevant ministries/agencies/agencies, communities, and third parties in the global coffee value chain system. As an academic paper, the performance of sustainable coffee farming upstream of the Sekampung watersheds is essential to be the basis of regional policies in institutionalizing sustainable production and establishing good governance in sustainable watersheds management. Therefore, coordination is needed at the national, regional, and local levels involved, including University and intermediary, to meet the parties' agreement on the sustainable watersheds management scheme. Third parties (intermediaries) play an essential role in driving the process of empowering farmers in sustainable production.

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CHAPTER 5

MARKETING STRATEGY OF AGRICULTURAL COMMODITY FOR FINANCIAL IMPROVEMENT

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5.1. Introduction

Commodities are among the most diverse trade goods because they consist of various types. Agricultural commodities are not only in the form of farm products such as rice and wheat. According to the Food and Agriculture Organization of the United Nations, agriculture has a broad meaning, including animals and plants and using natural resources. According to the Regulation of the Minister of Agriculture of the Republic of Indonesia Number 18 concerning Guidelines for the Development of Agricultural Areas Based on Farmers' Corporations, agricultural areas consist of food crops, horticulture, plantation, and livestock commodities sub-sectors.

Examples of agricultural commodities of each entity ranging from plantations, livestock, and food crops. Food crops are plants with high carbohydrate content that can be used as staple foods. Examples of food crop commodities are rice, corn, soybeans, and cassava or cassava. Examples of horticultural commodities are chili, shallots, garlic, leeks, cabbage, potatoes, bananas, durian, mango, oranges, ornamental plants (such as orchids, gladiolus flowers, and chrysanthemums), as well as medicinal plants (such as turmeric, aromatic ginger, and Curcuma zanthorrhiza). The plantation is an agricultural sub-sector that requires large areas of land, planting media, and suitable ecosystems to cultivate many plants The creative economy sector is one of the key sectors that is the focus and hope for accelerating the recovery of national economic activity and growth (Sundari, et al., 2021, 2022).

Examples of plantation commodities are sugarcane, coffee, tea, tobacco, cocoa, quinine, cinnamon, cashew, cloves, nutmeg, pepper, sugar palm, vanilla, castor, lemongrass, vetiver, candlenut, cotton, kapok, palm oil, roselle, coconut, and rubber. Indonesian Export Commodities Livestock and Fisheries Livestock Livestock commodities are agricultural activities that raise animals, breed them, and use them for human needs. Examples of livestock commodities are dairy cattle, beef cattle, buffalo, goats, sheep, ducks, and local chickens.

5.2. Marketing Strategy

There are several experts' opinions regarding strategy; among others, according to Stephanie K. Marrus, strategy is a process of determining the plan agricultural sector has not been optimally exploited. The agricultural sector is one sector that has a significant contribution to the economy in Indonesia, which can be seen in the agricultural sector's contribution to national income and employment in Indonesia. Regarding national income, the agricultural sector's contribution to gross domestic product (GDP) was 12.54 percent in 2018, while at the level of employment, the agricultural sector contributed 30.46 percent in 2017. The agricultural sector itself consists of several sub-sectors. , namely food crops and horticulture, plantation crops, animal husbandry, fisheries, and forestry.

All creation in the heavens and on earth is a gift from Allah SWT, including the agricultural sector. Everything that grows on Earth is His gift, and He wills over everything on this earth. Therefore, humans are obliged to be grateful and grateful. One of the signs of gratitude and gratitude that humans can do is pay zakat, including its relation to zakat in the agricultural sector. Jumhur Ulama expands the scope of agricultural products to four commodities with other crops with the exact 'Allah (legal cause). Abu Hanifah argues that zakat on agricultural products is on everything planted: hubbub (seeds), fruits, and vegetables. Imam Malik and Imam Shafi'i argue that zakat is obligatory on all staple foods eaten and stored. Therefore, according to Imam Malik and Imam Shafi'i, staple foods other than wheat, such as corn, rice, and tubers, must be paid zakat.

Along with the times, the majority of Ulama agree that all commodities in the agricultural sector can be used as objects of zakat after fulfilling certain conditions. The difference lies in categorizing these commodities into agricultural or commercial zakat. Agricultural zakat is zakat with a nishab of 5 wasaq, with a zakat rate of 10 percent for rain-fed and 5 percent for irrigation systems, and is paid at harvest time without any haul.

On the other hand, commercial zakat is imposed on retail businesses that have exceeded the nishab and haul. The object of commercial zakat is calculated from current assets minus short-term liabilities. The nishab for commercial zakat is 20 dinars or 85 grams of pure gold, reaching 2.5 percent. As previously explained, the agricultural sector consists of several sub-sectors: food crops and horticulture, plantations, livestock, fisheries, and forestry. Each sub-sector has its method of calculating zakat. The following sub-chapter will explain the methods for calculating zakat in the agricultural sub-sector, ranging from food crops and horticulture to the forestry sub-sector.

5.3. Agricultural Financial Management

Finance is a business function responsible for obtaining funds for the company, managing finances within the company, and planning expenditures in the form of assets (plant, equipment, machinery). Financial management is working the resources owned by the company to achieve its goals and objectives (Griffin and Ebert, 2004; Nickels et al., 1996). What is the concept of agricultural financial management? To answer this question, you need to understand three keywords attached to the concept of agricultural financial management such as (1) management, (2) finance, and (3) agriculture.

According to Pinches (1995), finance is a word that describes the availability of financial resources for governments, companies, or individuals and the management of all resources. This discussion pays special attention to the second aspect, namely financial management. They further explained that what is meant by financial management is managing and financing (financing) resources for companies using money and considering prices as external factors determined by the market.

Financial activities have also involved many interrelated functions, as stated by Siegel and Shim (1991) and Brigham and Houston (2007), including 1. Obtaining funds 2. Using funds 3. Monitoring performance 4. Solving problems occur, both now and in the future. According to Kadarsan (1995), finance is related to the following. 1. Demand for capital 2. Supply of capital 3. Regulation and use of capital 4. Control of capital. The two financial concepts described by Siegel and Shim (1991) and Kadarsan (1995) above have the same meaning. The two financial concepts presented include finding, using, and monitoring funds used to finance company activities.

Furthermore, understanding finance is necessary to know about financial goals. There are several corporate financial goals, as stated by Siegel and Shim (1991), Brigham and Houston (2007), and Van Horne and Wachowicz (2001), namely as follows. 1. Maximizing profit 2. Maximizing shareholder wealth 3. Maximizing managerial rewards 4. Social responsibility. Modern financial theory has used the assumption or requirement that the main goal in business is to maximize the wealth of shareholders or debt securities issued by the company, which means maximizing the company's share price. The other financial goals mentioned above also influence company policy but have a lower priority than maximizing share price. The higher the share price, the wealth of shareholders will increase. In the traditional view, economists emphasize the financial goal of maximizing profit. However, currently, the purpose of maximizing profit is not enough, especially for large-scale companies and companies that have gone public. Maximizing the welfare of shareholders (owners) by providing adequate rewards from the share of profits generated is the goal of maximizing profit.

Thus, three critical decisions are the most important in financial management: investment, financing, and profit distribution. Investment decisions involve decisions to procure assets according to company needs, in this case, related to allocating capital or funds to procure assets needed to achieve profit maximization targets. Financing decisions include decisions to meet funding needs. Financing decisions are a consequence of investment decisions.

Therefore, financing decisions must refer to and pay attention to the results of investment decisions related to the amount, time, and source of financing. The decision to distribute profits (also known as dividend policy) shows that after management can allocate resources in the form of investments to achieve maximum profit, it is crucial to determine the allocation of these profits to shareholders appropriately.The ability to generate maximum profit that is not followed by the ability to distribute earnings to shareholders will result in shareholders withdrawing from the company. In studying agricultural financial management or in managing business activities, you need to master the vocabulary of financial terms. According to Siegel and Shim (1991), the benefits you can get from learning financial terms are 1. Understand financial information 2. Know how to use the information effectively 3. Communicate clearly about quantitative aspects of performance and results. Knowledge of finance and how to apply it successfully is one of the most important things to learn about financial management. Knowledge of finance is beneficial for you in planning, problem-solving, and decision-making.

The average financial manager spends time planning, setting goals, and developing courses of action to achieve company goals. If you are a financial manager, you must handle and master broader production, marketing, finance, and personnel (human resources) plans. Each of these plans requires financial knowledge, thus allowing for better communication between departments within the company. For example, the company's budget, in this case, the financial plan, communicates its overall goals to the leaders, namely managers, so that they can know what the company expects of itself and the economic parameters that guide it. You must be able to identify problems in the proposed budget before it is passed and provide suggestions or recommendations on the budgets that are prepared.

Your failure to understand the budget indicates that you will fail in achieving company goals. After you know about the concept of finance, then the following concept is about agriculture. Agriculture refers to agriculture in a broad sense which includes agriculture (plants), animal husbandry, forestry, and fisheries. Why is agriculture, in a general sense, necessary to discuss? You can get the answer by listening to the following description. In developing countries, the agricultural sector is one economic development sector with a relatively significant role. You may ask how to measure the part of the agricultural sector in economic development? Measure the role of the agricultural sector in economic growth can be seen from the contribution of the agricultural sector's Gross Domestic Product (GDP) to the total GDP.

If it is a concept of financial management, what about the concept of agricultural financial management. Kadarsan (1995) states that agricultural finance is related to financial matters in the agricultural sector. Furthermore, agricultural financial management is financial management in business activities related to the agricultural sector, including planning, use, and supervision of capital used to finance agricultural sector business activities. Meanwhile, Kadarsan (1995) added that agricultural financial management includes companies outside the agricultural sector, but their activities involve the agricultural sector, such as agro-industry, agro-tourism, and economic institutions that support the agricultural sector activities, such as banks. The financial institution is a subsystem in the agribusiness system. The examples and illustrations in this module cover all subsystems in agribusiness.

According to Krisnamurthi (2001), the agribusiness system is a series of interrelated subsystems, namely upstream, downstream, farming, and supporters. Agribusiness is the concept of an integrative system consisting of subsystems. Agribusiness consists of a collection of units/business actors in each subsystem. In the following, each subsystem will be explained as follows. 1. Up-stream agribusiness subsystem: economic activities that produce (upstream agro-industry) and trade in primary agricultural production facilities. Example: fertilizer industry, medicine, seeds/seedlings, agricultural machine tools, and others. 2. Farming subsystem (on-farm agribusiness): the primary agricultural and cultivation sectors. 3. Downstream agribusiness: economic activities that process primary agricultural products into processed products, both in ready-to-cook/ready-for-use, ready-to-consumer forms and trading activities in the domestic and international markets. International. Example: postharvest, packaging, storage, processing, distribution, marketing, retail. 4. Supporting service subsystem: supporting institutions and activities, for example, banks and financial institutions, transportation, extension, agribusiness information services, research and development, insurance, and others.

The party who has a close relationship with financial management, in general, is the financial manager. The financial manager's responsibilities will describe the activities in financial management. The most critical responsibility for financial managers is planning the procurement and use of funds to maximize company profits (Weston and Brigham, 1990). Financial obligation shows that a financial manager is decisive in procuring funds for the company by looking at the various alternative funding sources.

In addition to seeking funding sources, a financial manager is also very decisive in using funds to achieve company goals. Furthermore, Weston and Brigham (1990) explained several details of activities related to financial management, namely as follows: 1. Forecasting and financial planning Financial managers must interact with other managers to predict the company's future and establish a joint plan to determine the company's future position. 2. Decision-making in investment and financing following the long-term plan, financial managers must provide capital to support growth. Successful companies usually get high levels of sales, which requires additional investments in land, factories, equipment, and current assets (assets) necessary to produce goods and services.

The financial manager must help determine the optimal level of sales growth, make decisions on specific investments to be carried out, and determine the type of funds used to finance these investments. A financial manager must consider decisions about using internal or external funds, such as from debt. 3. Coordination and financial control The financial manager must work closely with other field managers so that the company operates as efficiently as possible. All business decisions have financial implications, and all managers in finance and other fields must consider this. For example, marketing decisions will affect sales growth which in turn causes changes in the need for investment.

Thus, marketing decision-makers must consider how managers' actions affect and are influenced by factors such as availability of funds, policies regarding inventory, and utilization of company (factory) capacity. 4. Interaction with capital markets. Financial managers must deal with money markets and capital markets as it is known that every company often needs additional funds. For example, the company may need to build a new factory or expand agricultural land to meet market demand, or it may develop into other business fields. If the company wants to grow its business and requires Rp. 200 million funds, the available capital is only Rp. 50 million, so it needs funding from other sources. The need for additional funds can be met from own funds (company owners) or other sources outside the company. Generally, own funds are insufficient to meet investment needs, so the money market or capital market becomes an alternative source of funding that needs attention. The description of funding sources will be discussed in detail in the module that discusses funding sources.

As Weston and Brigham (1990) explained regarding activities in financial management, according to Kadarsan (1995), five factors must be a unique rationale in financial management. Decisions related to finance are as follows. 1. Determine the amount of capital required by the company. 2. Determine the flow of capital investment that has many alternative uses. 3. Determine the source and composition of finance to be used. 4. Determine strategies to eliminate and reduce the company's financial risks and uncertainty factors. 5. Determine the form of the company's legal entity.

5.4. Government Strategy in Financial Inclusion of The Agricultural Sector

The Coordinating Ministry for Economic Affairs is intensively integrating economic activities and inclusive finance in the agricultural sector, especially for millennial farmers, to accelerate national economic recovery and improve people's welfare. (https://www.merdeka.com/uang/strategi-governmental-push-inclusion-keuangan-sector agriculture.html). Several state-owned companies carry out programs to increase financial inclusion in the agricultural sector, such as those by PT Bank Mandiri Tbk, PT Telkom Indonesia Tbk, and PT Pupuk Indonesia. The low-interest People's Business Credit (PBC=KUR) program is one of the government's efforts to increase farmer financing. As one of the state-owned banks, Bank Mandiri has distributed KUR since 2008, with an outstanding until March 2021 reaching Rp46.2 trillion to 1.94 million debtors.

Financial inclusion is also carried out through increasing access to banking through Mandiri Agen, which serves banking transactions such as account opening, cash deposits, cash withdrawals, transfers, and payments or purchases. Specifically for support in the government's program for Farmer Entrepreneurship, Bank Mandiri has also provided CSR in the form of constructing an Integrated Rice Processing Center (SPBT) in Pamarican District, Ciamis Regency in 2018, which has been operated to provide benefits to farmers. Plus the support for access to capital with KUR, the Kartu Tani program for suggestions for purchasing subsidized fertilizers, and integrated coaching and training. Through the integrative Agree scheme from PT Telkom

Indonesia, farmers can optimize production results through good supply and demand management, facilitate the distribution of subsidies, and encourage farmer regeneration by giving birth to millennial farmers. To complement this synergism, PT Pupuk Indonesia (Persero) also provides complete upstream-downstream agricultural assistance in on-farm and off-farm activities through the Agrosolution program.

In on-farm activities, Agro Solution farmers get quality agro-input products such as non-subsidized fertilizers and medicines, as well as technology escort and technical guidance. Meanwhile, off-farm activities take the form of access to capital, insurance, and off-take guarantees for harvests. Through this program, Pupuk Indonesia increased crop yields from an average of 5 to 6 tons per hectare to 8 to 10 tons per hectare. "Support for digitalization in agricultural ecosystems can elevate the livelihood and economic level of farmers and facilitate the development of integrated agricultural services," said Deputy for Macroeconomic and Financial Coordination as Secretary of the National Council for Financial Inclusion (DNKI) Iskandar Simorangkir at the FGD Synergy Programs Supporting Financial Inclusion for Millennial Farmer. To date, there have been 13 piloting locations for the digitalization of the national agricultural ecosystem, and it is hoped that the number will increase. Therefore the program has objectives to improve farmer welfare and develop the agricultural sector can be achieved soon.

President Joko Widodo, as Chairman of the National Council for Inclusive Finance (DNKI), emphasized that he prioritized the expansion and ease of access to formal financial services through digital financial services for all levels of society, especially the beneficiary groups of micro and small enterprises (UMK), farmers, fishers, and low-income communities following the mandate of Presidential Decree No. 114 of 2020 concerning the National Strategy for Financial Inclusion (SNKI).

In 2020, the financial inclusion index in Indonesia had reached 81.4 percent, higher than in 2019, which reached 76.19 percent. Financial inclusion is in line with the various efforts DNKI has made to achieve the financial inclusion target of 90 percent by 2024. When viewed from the employment structure in August 2020, 29.76 percent of workers worked in the agricultural sector. However, only about 8 percent are young farmers (millennial generation). When viewed from the age structure, the Indonesian population is dominated by the millennial generation (25.87 percent) and generation Z (27.94 percent). (https://www.merdeka.com/uang/strategi-governmental-push-inclusion-keuangan-sector-pertanian).

5.5. Systems in Agricultural Product Marketing Strategy

A strategy needs a series of stages that synergize with the system in the economic and agricultural sectors. Knowing the existing system will make it easier to determine the marketing strategy for the resulting product and also applies to the system in the marketing strategy of agricultural products. A system is a group of items or parts that are interconnected and regularly interrelated in forming an integrated whole. The system can be interpreted as the marketing system as a collection of institutions that carry out the task of marketing goods, services, ideas, people, and environmental factors that influence each other and shape and influence the company's relationship with its market.

In marketing, the group of interrelated and interrelated items includes 1. Combined organizations that carry out marketing work. 2. Products, services, ideas, or people that are marketed. 3. Target market. 4. Intermediaries (retailers, wholesalers, transportation agents, financial institutions). 5. Environmental constraints (environmental constraints). The most straightforward marketing system consists of two interrelated elements: the marketing organization and its target market. The elements in a marketing system are similar to those in a stereo radio system. The agricultural product marketing system is an interrelated part from the planting process to distributing agricultural products to final consumers in the hope that farmers will receive compensation for money or income from these agricultural products.

This marketing system is expected to be able to create a strategy for marketing agricultural products. Marketing strategy is making decisions about marketing costs, marketing mix, and marketing allocation concerning expected and competitive environmental conditions. In marketing strategy, three main factors cause changes in marketing strategy: 1. Product life cycle. The strategy must be adapted to the life cycle stages, namely the introduction stage, the growth stage, the maturity stage, and the decline stage. 2. The company's competitive position in the market. The marketing strategy must adapt to the company's role in the competition, whether to lead, challenge, follow or only take a small part of the market. 3. Economic situation. The marketing strategy must be adjusted to the economic situation and the outlook, whether the economy is in a prosperous situation or high inflation. (Yulianti: 8).

5.6. Agricultural Commodity Marketing Strategy for Financial Improvement

Financial improvement requires a linkage and synergism in monetary policies to fulfill financial inclusion, including in the agricultural sector. The financial improvement involves government intervention in services for farmers in marketing agricultural products so that they have high prices or at least not below the standard, which can later cause losses because they have lower prices than the Price of financing and maintenance of these agricultural products. There must be a facilitator from the government and the need for assistance from experts in carrying out the skills of agricultural commodity marketing strategies given to farmers. The government's role as a facilitator of marketing strategy can provide an official forum that becomes a place for farmers to make it easier to sell agricultural products with standards that do not cause losses. Meanwhile, the role of experts from educational institutions is to provide literacy-related marketing strategies for farmers in carrying out agricultural systems to realize personal and community financial improvements. So, it can give added value for any commodities (Sundari, et al., 2016). The following is a plan that must be prepared to reach so that marketing strategies are practical and efficient.

1. Promotion

In the marketing strategy of agricultural products, promotion is needed to introduce agricultural products to potential consumers and explain directly the quality of farm products that have been produced. Promotion is essential so that consumers who initially do not know can get information related to products that may initially be considered the same as other products. It turns out that this product has much better quality than other agricultural products.

2. Creativity

Creativity in marketing methods involves marketing efforts and strategies to make it seem unique and different and finding new ways to pursue marketing activities so that they can run optimally. There are many creative ways that people do today. One of them is utilizing worldwide internet facilities to market business products.

3. Consistency

Consistency in all marketing areas can help reduce marketing costs and increasing the effectiveness of brand creation.

4. Planning

In the marketing strategy for agricultural products, it is necessary to have good planning related to market share, selling prices, and the shape of the packaging of these agricultural products. Because all businesses must have a goal of wanting maximum results to create economic opportunities for others, planning is closely related to the vision, mission, and goals that have been determined by a business or business community, and agricultural products are no exception.

5. Budget

Calculating the marketing budget is a challenging part and requires accurate calculation results. The funds needed for marketing can be prepared from the allocation made. Usually, small businesses make budgets with less accuracy, resulting in waste.

6. Branding

Branding is how consumers receive products and the companies that make those products. Sometimes small businesses forget the need for a brand or recognition of images, logos, and even products that small businesses produce.

7. Customer Relationship

Proper management of customer relationships is one of the essential things to creating loyal and consistent customers. Remember, a business can be destroyed if the wrong marketing strategy is chosen.

Building a business and developing it requires a serious effort. The serious and, at the same time, the critical part that can bring our business success lies in how to manage business finances. It takes discipline and sufficient understanding to collect money in any business. Here's how to manage business finances effectively in a business:

1. Record All Expenses

The way to manage business finances is to record all expenses in detail and as well as possible. Suppose we can't do this well; developing whatever type of business we do will not be easy. One of the essential things that will make it easier for us to record all expenses is to keep all evidence of costs while running a business. It would be better to document proof of income because every incoming income measures every ordinary expense. The difference in the numbers that occur will be seen as a bright spot. The main goal of recording all expenses is to cover any discrepancies in the numbers. The difference in numbers is a natural thing, the money that has been spent is usually not following the existing evidence of expenditure. The expenditure can be done by looking at proof of income. That way, all financial movements can be appropriately tracked if you have a record of all costs incurred.

2. Making Financial Projections

The following way to manage business finances is to make financial projections. The economic forecast in question is to imagine in the future what expenses will need to be made for business purposes. We can determine the period, for example, in the next six months. What are the expenses that will occur during the six months? Every week/month, buy agricultural seeds that run out. The second month buys additional equipment to support agriculture. The third month of multiplying complementary agricultural goods. The fourth month of expanding agricultural land. In the fifth month, opening a branch of agricultural land. The sixth month of promotion to develop buyers

Making financial posts is essential. The first post we can focus on for monthly and weekly needs, and the next post for other interests following predetermined requirements. This step is an essential tip for managing business finances, especially for business development, so it is more organized with a clear vision and mission.

3. Keep Personal and Business Finances Separate

It is important to remember and note that for every novice business person, one factor that makes business finances a mess is the mix of personal and business finances. If in normal and stable business conditions, the unifying of personal finance and business finance may not be felt immediately. However, if in a crisis and emergency, the mix of personal finances and business finances will make the business go bankrupt and fall apart.

Therefore, the wisest way to manage business finances is to separate in advance which is personal money and which is money for the business. For example, in how to manage small business finances, personal finances will be difficult to track because the movement of money into small businesses is languid. One of the main goals of separating personal and business finances is to follow the trend of finances. In the basic principles of accounting and money management, separating personal and business money is fundamental. To be able to do how to manage finances in a company, especially for every entrepreneur who wants to develop a business, finances should not be mixed and messy. Create two financial accounts for the personal use of your name and identity, and for business, finance uses your business name. Save money for business development in a business account and money for daily needs in a personal account. Therefore, everything can be appropriately tracked and run well.

4. Pay All Bills On Time

It must be mandatory to pay all bills on time, so we can know the profit earned. It Must pay bills on time in manage business finances. Because the invoice has not been paid, the profit obtained is not pure. Profits can be calculated on a net basis when all bills and arrears have been paid off. In the way of small business financial management, there are terms gross profit and net profit. Gross profit is income that has not been deducted from expenses, including bills. The net profit is the pure profit that we get.

5. Calculate Income and Profit in Detail

Tips on how to manage business finances next are to calculate income and profits in detail. This section is not much different from the point in number one, which is to record all expenses. The difference is in expenditure and income. In these tips on how to manage business finances, calculate every income that has been obtained. Cut by every obligation to be paid, then we will get a pure count of our profit. That way, we can find out how much our income and profits are in detail. That way, we can continue managing business money to achieve business success. Therefore, a good entrepreneur is an entrepreneur who can wisely record every financial flow that occurs.

6. Minimize Travel Costs

Tips on how to manage business finances well next are to minimize the expenses. One of the expenses that we can minimize is the cost of travel.

Traveling, especially for business purposes, is essential. However, spending money on a business is also important. Especially in running a culinary business, the importance of observing ingredients and experimenting with food tastes requires us to travel. However, we can outsmart the cost of the trip. That way, we can manage the finances of agricultural businesses well.

7. Pay Attention to Contract Agreements with Third Parties

We often enter into business agreements with third parties in managing business finances, especially during business development. Partners in managing a business are essential to make our business progress and develop. Especially in today's online-based digital world, business development collaborates and relies on various parties to work together. Therefore, managing a business must organize better in understanding and paying attention to business contracts. The business contract can also overcome the ominous possibility that occurs, namely the occurrence of fraud from an adverse third party. With the employment contract, we have strong evidence to sue and compensate for all our losses.

8. Monitor Financial Cash Flow

One way to manage business finances that we must do in a very disciplined and responsible manner is related to the supervision of financial cash flows. If you think about it, just monitoring financial cash flow is effortless. We need to separate where the money is for business interests and where the money is for personal interests. However, in practice, monitoring financial cash flow is complex. The difficulties encountered are usually related to self-discipline and responsibility in supervision. The smooth flow of finances will affect the smooth running of a business.

9. Use Profits to Grow Your Business

Profit is the profit we get from the business we run. Getting very high profits from business results is something that every entrepreneur covets, but unfortunately, many entrepreneurs are immediately tempted to use profits for personal gain. In fact, in a good way of managing business finances, profits should not be used directly for personal interests. A wise entrepreneur will save the profit first and then use it as capital to develop the business being run. The profit earned, be it big or small, is diverted to develop the business. We have to pass several stages to use earnings for personal purposes. One indication is when we feel a business is running steadily.

10. Look at Ownership of Assets, Capital, and Accounts Payable

In running a business, we may be busy doing business development. Expand business capacity, widen customer reach, and create various programs for our business interests. And frequently, every entrepreneur forgets one important thing: to take note of everything he owns. Observing the ownership of assets, ownership of capital, and also debts owned is an essential thing. Before we master managing business finances, we must be very aware of asset ownership. Because assets are our principal capital to run a business, do not let us sacrifice the assets we already have in the name of business development. Many entrepreneurs pawn the assets they already have, such as buildings or equipment, to get additional money for business purposes. Observing assets, capital, and accounts payable is fundamental so that we can carry out how to manage personal and business finances. Before making developments in how to manage the finances of a startup business, we must continue to update the list related to asset ownership, capital, and accounts payable. This way, we can find out what we have and haven't finished.

11.Consultation with an Expert Mentor

Don't hesitate to consult with a mentor who is an expert in managing business finances. Consultation from experts will be very significant in improving business performance, especially for those of us who intend to grow our business even more prominent. For those who have run how to manage the finances of a small trading business, and want to move into more significant trading business, consulting with a mentor is a tip for managing business finances to be more organized. The presence of a mentor can also be better for educating our entrepreneurs mentally. Mentoring with this expert can also measure how well our mental development as entrepreneurs is. Knowing how far our cognitive development as entrepreneurs can help us go beyond our limits to become even better is essential.

12.Use Software to Manage Finances and Sales

The last tip on how to manage business finances is to use special software to manage the finances of a business. During the development of digital technology today, there are many software or applications to manage finances. Especially for those of us who are beginners, the use of financial software and applications is crucial. So how to manage small business finances can be arranged, and the business will develop slowly. The use of software to manage finances is also critical to minimize the occurrence of recording errors that lead to unwanted things. Both paid software or applications that we can freely download are available for use. It's just that, use the one that fits and is comfortable for us. It is better to be accompanied by a mentor or financial expert when using the software or application.

5.7. Conclusion

The strategies needed in marketing to increase finances are (a). Choose the consumers you want to target. (b). Identify consumer desires. (c). Define the marketing mix. Strategies for financial improvement are (1). Determine the amount of capital required by the company. (2). Determine the flow of capital investment that has many alternative uses. (3). Determine the source and composition of finance to be used. (4). Determine strategies to eliminate and reduce the company's financial risks and uncertainty factors. (5). Determine the legal entity form of the company.

5.8. Implication

The implication of marketing strategies in the context of increasing finances can be carried out by all farmers with various agricultural commodities. In the process of implementing the strategy, it is necessary to have assistance from the government and parties directly involved with agricultural activities. Because actually farmers are heroes of natural resources for all mankind.

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CHAPTER 6

GENOME-WIDE ASSOCIATION STUDIES IN SUSTAINABLE LIVESTOCK BREEDING

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6.1 Introduction

Single nucleotide polymorphisms (SNPs) are the common variations throughout the genome in farm animals. Last few decades, many genes or associated genetic markers have been detected that affect crucial traits in livestock (Meuwissen et al., 2001; Dekkers, 2004). Major genes related to economic characters in livestock have been identified by genomic scans and animal genetic mapping methods. The emergence of the high-throughput genotyping and sequencing technologies make possible and affordable the genotyping of hundreds of thousands of SNPs. SNP chips have facilitated to benefit the genome-wide association studies (GWAS) in defining molecular markers related to complex quantitative traits such as meat production, milk yield and quality, wool production and quality, This progress altered the selection efficacy for the characters which are hard to improve using classical selection methods (Dekkers, 2004; Gökçek, 2020).

These genome-wide studies offer new potential for marker-assisted and genomic selection (Goddard and Hayes, 2009). The contribution of genomic selection or marker-assisted selection to animal breeding programs could make them more effective and increase the acquisition of selection in many livestock species worldwide (Meuwissen et al., 2001; Goddard et al., 2010; 2016; Gholizadeh and Esmaeili-Fard, 2022). This chapter summarizes the genome-wide association studies performed on livestock species such as sheep, goats, cattle, and chickens worldwide.

6.2. Methodology of GWAS

In genome-wide association studies, morphological data should be obtained from animals. The methodology of GWAS step by step is shown in Figure 1. This morphological data could be obtained using some measurements or observation. Afterward, the same animals with morphological data must be genotyped with different chips. The animals have been genotyped with the SNP chips or whole-genome sequencing.

Various methods are applied for quality control of raw genotypes. Firstly, individuals with low call rates (<0.90-0.97) should be discarded from additional statistical analysis. Secondly, SNPs that have a low call rate (<0.90-0.97), a minor allele frequency < 0.01, and significant deviations from Hardy-Weinberg equilibrium (< 0.00001) should be excluded. PLINK 1.9 and

GenABEL are used for quality control analysis (Aulchenko et al., 2007; Chang et al., 2015).

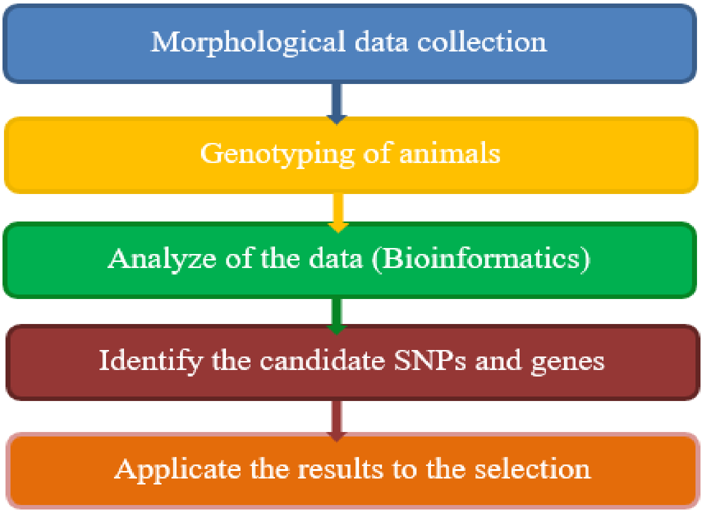

Figure 1. Methodology of GWAS

The Bonferroni correction can perform to adjust for the identification of multiple SNP loci. An SNP, chromosome-wise significance, and genome-wide significance level referred to when the raw P-value was equal to or lower than 0.05/N (N is the number of SNP loci analyzed in the research). Visualization of the correlation data in quantile-quantile plots and Manhattan plots are analyzed by SNPEVG software (Wang et al., 2012).

6.3. Genome-wide association studies in cattle

In dairy cattle, the accuracy of genomic prediction goes forward to 0.7 for somatic cell count, longevity, and fertility and 0.8 for economical production traits (Wiggans et al., 2011; Lund et al., 2011; Meuwissen et al., 2016). Nevertheless, the accuracy of genomic predictions in beef cattle is 0.3 to 0.7, which is lower than in dairy cattle (Van Eenennaam et al., 2014). Researchers have carried out many GWAS and reported markers associated with quantitative characters in cattle (Purfield et al., 2019a; 2019b; Keogh et al., 2021). Keogh et al. (2021) identified two SNPs such as rs110344317 and rs110240246, located on the genomic regions of the *MSTN* and *LCORL* genes, respectively, in Limousin and Charolais breeds, related to live-weight, carcass weight, and cull-cow weight. Buzanskas et al. (2014) have found that ten SNPs were significantly related to long-yearling weight, weaning weight, and birth weight in M.A. (Charolais X Canchim X Zebu) and Canchim cattle using

GWAS. In this study, they revealed an SNP rs43421095, which is within the *dipeptidyl-peptidase 6* (*DPP6*) gene, was significantly related to birth weight trait. Also, on BTA 4, an SNP rs43421095, which has a pleiotropic effect, was found to correlate with birth weight and weaning weight traits. An SNP rs29011435, close to the *MARCH3* and *LMNB1* genes, was significantly related to the long-yearling weight trait.

Pedrosa et al. (2021) have revealed many genes associated with milk traits such as; *TMEM160, SAE1, ARHGAP35, ZC3H4, NPAS1, ZMIZ1, LDB2, ABI3, PPIF, SERPINB9* and *SERPINB6* for lactation persistency; *SPIDR, GABRA2, ZNF131, NIM1K, DCHS1* and *GABRG1* for milk yield; *EXT2, OLFML2A, ETV6, GOT1, POLD1* and *NR6A1* for fat gain; the *KCN* gene family, *LRRC26* and *DPP6* for fat percentage; *ODAM, CDC14A, HSTN* and *RTCA* for protein yield; and *LALBA, HERC3, CCL28, HERC5* and *NEURL1* for protein percentage in North American Holstein cattle using GWAS. Prakapenka et al. (2021) have reported that inter-chromosome epistasis effects of milk fat percentage are related to the Chr14 region, including the *DGAT1* gene, which has the regulatory role for Chr14 in Holstein cattle. *MEPE, PKD2, HERC3, SPP1, ABCG2, IBSP, CSN1S2, ODAM, CSN1S1, CSN2,* and *LOC526979* genes have the crucial effects on intra-chromosome epistasis of milk protein percentage in this breed. They have found that the *SLC4A4-GC-NPFFR2* gene region significantly affects protein and milk yields.

Ilie et al. (2021) reported an SNP rs110749552 located within the *HERC3* gene correlated with somatic cell score in Romanian Brown and Romanian Spotted cattle breeds. The population structure is shown as pairwise scatter plots in Ilie et al. (2021)'s study and is shown in Fig. 2. Also, three genes such as *LUZP2, MEGF10,* and *AKAP8,* were associated with somatic cell scores in studied breeds. Nine SNPs that are located close to known genes *CLHC1, GATA6, SATB2, SPATA6, EPS8, COL12A1, IL12A, RAMAC*, and *ANKRD55* have been identified correlated with somatic cell scores in Romanian Brown cattle; three SNPs that located to near the *ZDHHC19, MMP7,* and *DAPK1* genes have been identified correlated with somatic cell score in Romanian Spotted cattle.

Wolf et al. (2021) found sequence variants correlated with non-return after 56 days, calving-to-first service interval, and three candidate genes as *ARHGAP21, ZNF462,* and *MARCH11* related to health and fertility in German Black Pied cattle using GWAS due to whole-genome sequence data. They have revealed five SNPs within the *ARHGAP21* gene related to post-partum anestrus trait in tropical beef cattle (Fortes et al., 2014) on BTA 13 or within a region downstream of the gene correlated with the calving-to-first service interval.

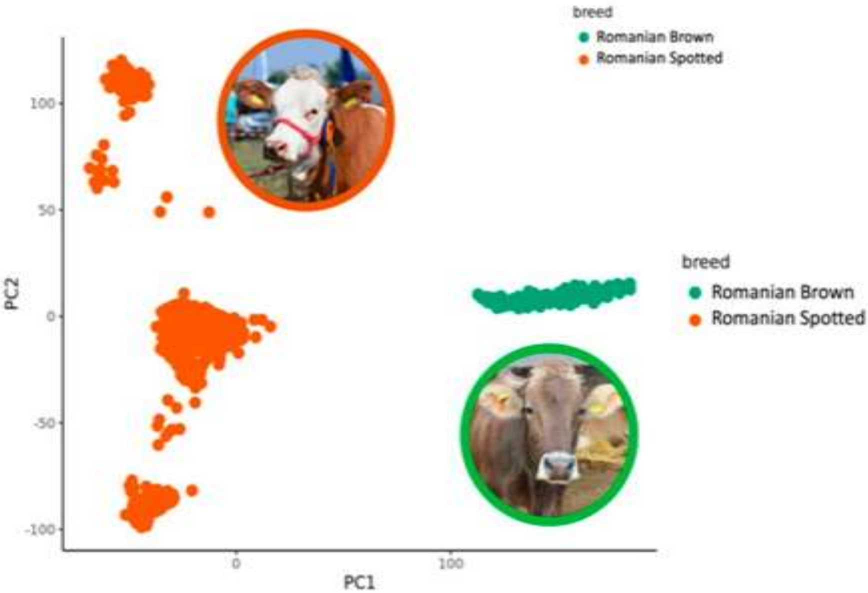

Figure 2. Population structure from the PCA (principal component analysis) of the SNPs and Romanian Brown, Romanian Spotted cattle (Ilie et al., 2021).

Also, they reported that *CLDN8* and *RBFOX1* genes are the potential candidate genes correlated with somatic cell scores in this breed. Santana et al. (2015) have defined thirty significant SNPs on chromosomes 2, 8, 12, and 17 and many genes such as *DMRT2*, *LNX2*, *IFFO2*, *TRNAG-CCC*, and *MTIF3* correlated with residual body weight gain in Nellore cattle breed using GWAS. Braz et al. (2021) have revealed that ecoregion-specific G × E SNPs might play an essential role in the adaptation and resilience of beef cattle to different environments. Ecoregion-specific genomic predictions should be generated to define livestock best adapted for divergent backgrounds.

6.4. Genome-wide association studies in sheep

Many GWAS for quantitative characters in sheep have been carried out in the last decades and successfully revealed various genetic markers (Demars et al., 2013; Gholizadeh et al., 2014; Benavides and Souza, 2018; Calvo et al., 2021). Gholizadeh and Esmaeili-Fard (2022) have found 29 significant relations for litter size by meta-analysis of GWAS in six sheep breeds. The result of protein-protein interaction analysis could determine hub genes like *GRIA2, PLCB1, RPTOR, CASK,* and *PLCB4* that have an essential role in cell growth, cell adhesion, and cell proliferation, and autophagy pathways. Also, they confirmed the role of the *BMPR1B* gene in prolificacy traits with GWAS analysis. Besides that, they defined that some SNPs dispersed on chromosomes express various genetic backgrounds underlying mutations of prolific traits in each breed. In another study, Demars et al. (2013) have determined a region around the *BMP15* gene located on chromosome X and revealed two non-conservative variations called $FecX^{GR}$ and Fec^{XO} related to ovulation rate and litter size in the two sheep breeds. Gholizadeh et al. (2014) defined some SNPs (within the *DYNC2H1* gene) on chromosomes 10 and 15 as related to litter size in Baluchi sheep breed with GWAS analysis. Benavides and Souza (2018) have found a causal SNP related to the *GDF9* gene variation in the Vacaria sheep population.

Smołucha et al. (2021) identified a causal SNP in the *EPHA6* gene connected to litter size in the Polish Mountain sheep breed using genome-wide association analysis. Esmaeili-Fard et al. (2021) have defined *NTRK2* as a novel gene related to litter size in the Baluchi sheep breed. Xu et al. (2018) reported that candidate genes such as *MMP2, FBN1, BMPR1B, SPP1, FLI1,* and *MMP15* related to litter size in low and high prolific sheep breeds with GWAS. Calvo et al. (2021) have found that the $\mathrm{FecX^{GR}}$ allele has genome-wide significance related to prolificacy trait in Spain's Rasa Aragonesa sheep breed. They also defined a novel SNP in the second exon region of the *BMP15* gene called $\mathrm{FecX^{RA}}$ (c.1172C > T) that caused an amino acid change from threonine to isoleucine (T400I). They have revealed the significantly altered prolificacy of 0.52 ± 0.05, 0.42 ± 0.05, and 0.32 ± 0.01 in $\mathrm{FecX^{GR}}$, $\mathrm{FecX^{RA}}$, and $\mathrm{FecX^{R}}$ heterozygous ewes.

Sutera et al. (2019) have found nine SNPs correlated with milk production characters in Italy's Valle del Belice sheep breed. They have revealed that rs398340969, within the *DCPS* gene, was related to protein and milk yield. Also, the rs425417915 and rs417079368, located within the *TTC7B* gene and the *SUCNR1* gene, respectively, were related to fat percentage and protein percentage, as shown in Fig. 3. In another study, Marina et al. (2021) have investigated the milk traits such as milk yield, protein yield, fat yield, fat percentage, protein percentage, and milk somatic cell count and also cheese-making properties such as rennet clotting time, cheese yield, dried curd yield, curd firmness curd-firming time and individual laboratory cheese yield in Churra and Assaf sheep breeds. They have found that *PTHLH* and *LALBA* genes were associated with the protein percentage and individual laboratory cheese yield traits in the Churra breed. In the Asaf breed, *the SLC2A2* gene and the *SCUBE2* and *NRP1* genes were related to the milk and cheese-making traits.

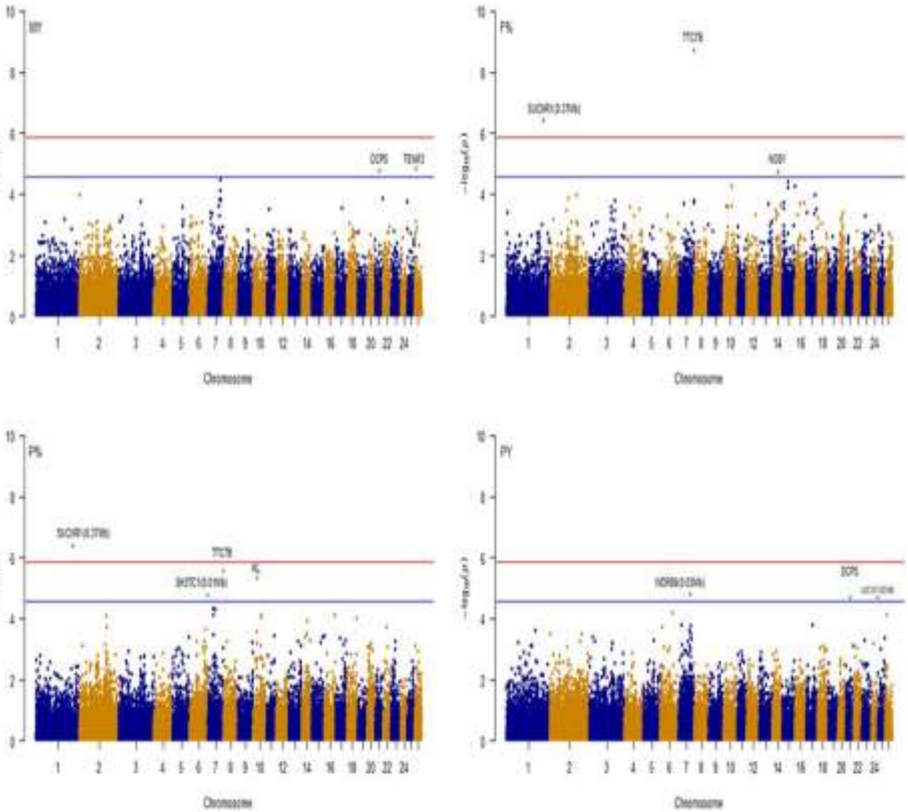

Figure 3. Manhattan plots of GWA analysis milk production characters and SNPs in Valle del Belice sheep (Sutera et al., 2019).

Ghasemi et al. (2019) have reported that the three significant SNPs located on chromosome 1 as rs423491318, which is close to a member of the RAS oncogene family (*RAB6B*) gene, rs405981386, which is close to serotransferrin (*Tf*) and rs421198841 which is within the GRB10 interacting GYF protein 2 (*GIGYF2*) correlated with birth weight in Lori-Bakhtiari sheep breed of Iran. Similarly, Zhang et al. (2013) have found five candidate genes (*RIPK2, MEF2B, RFXANK, TRHDE, and CAMKMT*) related to post-weaning gain in sheep by GWAS. They also reported six genes (*SMC2*, *GRM1*, *MBD5, POL*, *RPL7, and UBR2*) that affect the post-weaning gain trait.

6.5. Genome-wide association studies in goats

Several recent studies have been carried out with quantitative traits in goats using GWAS and successfully revealed various genetic markers (Scholtens et al., 2020; Islam et al., 2020; Gu et al., 2022). Gu et al. (2022) have found that the fifty-three significant SNPs and forty-two candidate genes (such as *PSTPIP2*, *CCL19*, *C7orf57*, *SIPA1L*, *FIGN*, *SGCG*, and *FGF9*) correlated with body conformation traits using GWAS of Dazu black goats which is a Chinese meat goat breed. They have reported that forty SNPs within or close to twenty-eight genes (*UBAP1*, *RPP25L*, *CNTFR*, *CCL19*, *TLR4*, *CCL21*, *BRINP1*, *FGF9*, *CDK5RAP2*, and *SGCG*) which are located on chromosome 8 and 12 associated with cannon circumference from whole-genome sequencing data. Also, they have found eleven significant SNPs (*SUN3*, *MANEA*, *C7orf57*, *ENSCHIG00000020259*, *CBLN4*, *DOK5*, *ENSCHIG00000022146*, *ENSCHIG00000008494*, *CDH9*, *CDKAL1*, *EDEM1*, and *SOX4*) within the chromosomes 4, 20, and 22 correlated with chest depth, and it is shown in Fig. 4. Similarly, Zhang et al. (2021) reported twenty-one SNPs on *MAPK3, LRP1B, LDB2,* et cetera. Genes were correlated with birth weight traits in Inner Mongolia Cashmere goats.

Islam et al. (2020) have reported sixty-six genomic regions related to reproduction traits in the Chinese Arbas Cashmere goat. They have identified significant candidate genes as *KISS1*, *WNT10B*, *KHDRBS2*, *PPP3CA,* and *SETDB2* genes related to fecundity traits. Nazari-Ghadikolaei et al. (2018) have revealed the significant correlations with coat color close to or within the *RALY*, *ASIP*, *ITCH,* and *AHCY* genes located on chromosome 13 for brown and black coat color and the *PDGFRA* and *KIT* genes located on chromosome 6 for white coat color in Iranian Markhoz goat by GWAS. They also found important candidate genes such as *POU1F1* associated with mohair quality, *MREG* correlated with mohair volume, *DUOX1* related to yearling fleece weight, and *ADGRV1* associated with grease percentage. Similarly, Martin et al. (2017) have reported a significant SNP located on chromosome 13 within the ASIP gene, which is related to coat color trait in the French Saanen goat breed.

Scholtens et al. (2020) have revealed that forty-three SNPs located on chromosomes 19 and 29 are correlated with somatic cell score, fat, protein, and lactation milk yield in New Zealand dairy goats (Alpine, Nubian, Saanen, Toggenburg) using GWAS. The two SNPs located in the intron of the *ASGR2* gene were correlated with four milk traits using GWAS. Other SNPs within the intron of the *DLG4* gene and close to downstream of the *ELP5* gene were related to protein yield, milk yield, and fat yield. They also found that two SNPs within the *MYH10* gene were correlated with somatic cell scores.

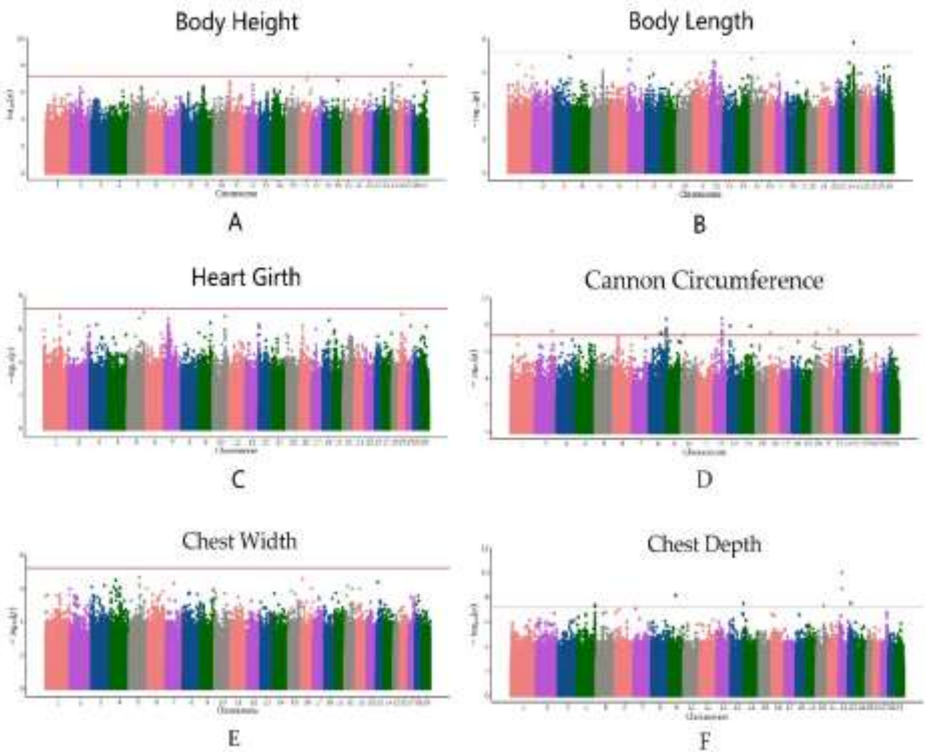

Figure 4. Manhattan plots of the body height (A), body length (B), heart girth (C), cannon circumference (D), chest width (E), and chest depth (F) for each SNP in Dazu black goats (Gu et al., 2022).

6.6. Genome-wide association studies in chickens

Several GWAS for quantitative traits such as growth, meat, and carcass traits in chickens have been carried out in recent years (Guo et al., 2017; Pertille et al., 2017; Huang et al., 2018; Moreira et al., 2018; Zhang et al., 2020). Zhang et al. (2020) identified seven significant genes such as *LMBR1*, *PLIN1*, *IL16*, *SHH*, *FGF7*, *SLC16A1*, and *IGF1R* on chromosomes 2, 4, 8, 10, and 26 that are correlated with abdominal fat content and weight. *TCF21* gene on chromosome 3 was revealed as a significant candidate gene for testis development and growth. They also reported that six candidate genes act as *TNFRSF1B*, *PLOD1*, *MTHFR*, *NPPC*, *SLC35A3*, and *EPHB2* play significant roles in bone development. In another study, Gu et al. (2011) identified twenty-six SNPs related to body weight traits by GWAS in chicken. They have found that for late growth for weeks 7–12, the GGA4 region of chicken chromosome 4 had many significant SNP effects, and in this region, *the LDB2* gene had a significant correlation with body weight (7–12 weeks) and with average daily gain (6–12 weeks).

Table 1. Significant SNPs were identified for studied traits in the Russian White chickens (Kudinov et al., 2019)

Trait	SNP	Position (bp)	Candidate / nearest genes
day-old chick-down color	rs314384321	123,194,966	*SLC7A13*
	rs15150566	122,907,241	*RALYL*
	rs15151359	124,071,457	*MMP16*
	rs16116752	119,793,622	*ZFHX4*
	rs14243963	122,016,783	*IMPA1*
	rs16455118	91,252,525	*DYSF*
	rs317256404	12,113,970	*PLEKHM3*
extraembryonic fluid yield	rs16209462	556,300	*SPPL2B*
	rs13730111	121,679,302	*ZNF704*
	rs316856766	123,425,663	*CA2*
	rs15630281	1,302,350	*PRKCD*
	rs315166929	1,006,316	*LOC107054345*
first egg age	rs317931060	178,102,549	*FGF9*
body weight	rs15619223	76,404,421	*LCORL*
egg weight	rs14201361	68,512,817	*KIAA1468*
	rs14200974	68,304,144	*PHLPP1*
	rs14439117	24,250,433	*TLL1*

Kudinov et al. (2019) have defined many SNPs close to genes associated with day-old chick down the color, the yield of extraembryonic fluid, age at first egg, body weight, and egg weight traits in Russian White chickens by GWAS, and it is shown in Table 1. In broilers, Moreira et al. (2018) identified twenty-two QTLs for carcass fat content and abdominal fat traits, and *INSR, CHST11*, *GPD2*, and *NR4A2* genes were correlated with fat deposition.

Li et al. (2018) have reported that the *GGA1* gene region (170Mb) is a significant region for small intestine lengths. Four SNPs rs313207223 within the *RB1* gene, which is a negative regulator of cell proliferation, rs312737959 within the *CKAP2* gene, which is a marker for proliferation and rs312771221, rs15494052 within the *SIAH3* gene, which is a regulator of multicellular organism development were associated with small intestine lengths.

Habimana et al. (2021) have found that four significant SNPs rs14123335, rs314702374, rs13792572, and rs74098018 near *PBX1*, *MRM1*, *GPATCH1*, and *MPHOSPH6* genes located on chromosomes 19, 11, and 8 significantly correlated with body weight in Rwanda indigenous chicken by GWAS and it is shown in Fig. 5. Also, four SNPs as rs13910430, rs737507850 rs314787954, and rs13623466 close to zinc finger, *ZBED1*, *CDC16*, *GRB2*, *GRAP2*, and *MX1* genes on chromosome 1 were significantly associated with Rwanda indigenous chicken's antibody response to Newcastle disease.

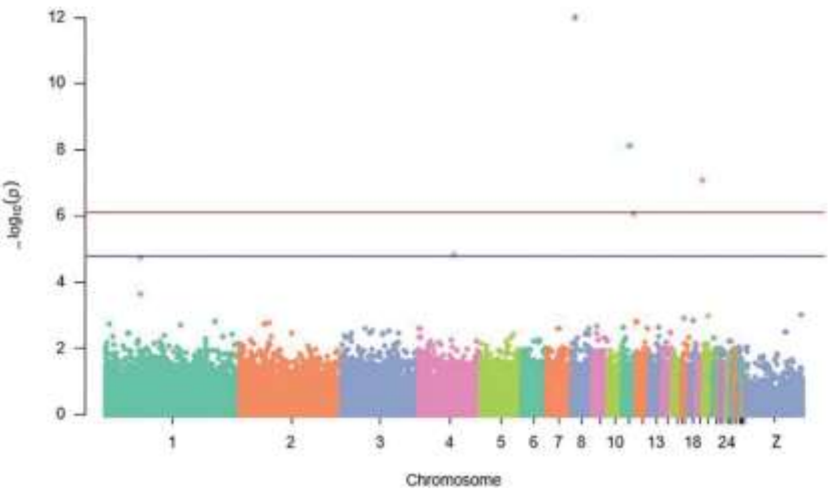

Figure 5. A Manhattan plot for significant SNPs correlated with body weight in Rwanda indigenous chicken (Habimana et al., 2021).

In another study, Dou et al. (2022) have found 113 QTNs and genes such as *ACTA1*, *TAPT1*, *IGF2BP1*, *LDB2*, *TGFBR2*, *PRKCA*, *GLI3*, *INHBA*, *SLC16A7*, *BAMBI*, *GPR39*, *APCDD1*, *and GATA4* were associated with growth traits in broilers. Similarly, Mebratie et al. (2019) reported eleven QTL and twenty-one SNPs correlated with body weight traits in commercial broiler chicken. Five QTL and SNPs were reported related to feeding efficiency traits by GWAS. They revealed that SNP, rs14042911 is within chromosome 12 in *the PTPRG* gene, pertaining to body weight (BW36 days). Also, SNPs rs16617885 and rs14073523 within the *CACNA1H* gene correlated with BW36. They have found that *the KDM6A* gene is a candidate gene linked to feeding intake traits. In Chinese Yancheng chickens, Jin et al. (2015) have reported that the four genes, such as *GLI3*, *FAM184B*, *MIR15A*, and *KCNIP4*, were closely correlated with body weight.

6.7. Conclusion

Many genome-wide association studies for quantitative traits have been performed in livestock species. These studies aimed to increase the accuracy of prediction for economic traits. The prediction can increase with the use of high-density SNPs for the QTL, and if the cost of DNA testing continues to fall, it will be more efficient to generate larger reference populations for using genomic selection. Genomic selection has many advantages for QTL that are hard to select for traditionally. The improvements in the technology in this field may also decrease the costs of genotyping and phenotyping economical traits in livestock and may increase the use of genomic selection in livestock.

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CHAPTER 7

WORTH AND NUTRITIOUS BANANA PSEUDOSTEM'S WASTE LEADS TO ZERO HUNGER

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7.1. Introduction

Many countries where banana trees can grow use bananas as a nutritious fibre food and calm the nerves because they contain lots of potassium, folic acid, and gelatin, which can be used as capsules. Despite this, it is still scarce to use the banana pseudo-stem as food that can be used as food that can relieve hunger because banana pseudostem is considered waste, something that is not valuable and then often piles up into garbage. Whereas overseas, banana pseudostem is a source of nutritious food with a high price, in Indonesia, it is still wasted. Indonesia has a wealth of banana plants of more than 1000 edible cultivars (Dwivany et al., 2021), 537 accessions of bananas, and 3042 clumps (Poerba et al., 2016).

The plant parts that can be used include leaves, fruit, heart, weevil, stem, or often banana pseudostem. Bananas pseudostem produced are far more than the bananas themselves and until now are still waste that has not been utilized optimally. Before being used as a diversified food and feed material, the banana tree trunk was made of rope, shade for planting, humidity, art, paper, and textiles, and could be decomposed into compost, liquid fertilizer, and others. The high fiber in bananas can cleanse the digestive system, prevent kidney stones, control stomach acidity, and help treat diabetics and anemia. (Devri et al., 2020, Widyastuti, 2019).

Pseudostem Pisang contains steroid, triterpenoid, alkaloid, flavonoid, tannin, dan saponin (Wibowo & Prasetyaningrum, 2015), and the nutritional composition it contains are water (92.50%), crude protein (0.35%), carbohydrates (4.60%), and rich in minerals such as calcium 122 mg, phosphorus 135 mg, iron 0.70 mg, potassium 213 mg, (Devri et al., 2020) and (Dhalika, T., Budiman & Ayuningsih, B., 2011). Banana pseudostem has unique nutritional composition and secondary metabolites contained in banana stems. So this community service is carried out to increase the repertoire of knowledge, skills, and technology in making the most of the banana stem, especially for fulfilling family nutrition to achieve SDGs 1 and 2 and to be an inspiration for the business.

7.2. Material and Method

Utilization of Banana Pseudo-Stem Waste into Nutritious Food

The activity begins with a pretest on understanding the banana pseudostem. Then counseling on the importance of family food security, the ins and outs of the banana pseudostem, the benefits of the banana pseudostem, and recognizing the types of banana pseudostem that are good for processing into the food diversification products. This diversification of food made from banana pseudostem will be processed into *urap*/salad, curry, and chips. All raw and complementary materials are taken from urban farming activities, so almost all of them are available in the yard.

Figure 1. Banana Plant and Pseudostem

1. Pseudostem Crispy

About 12 pieces of banana pseudostem weigh about 1 kg after slicing. Ingredients for marinade: Water, Salt to taste, and whiting. Ingredients for marinating: mushroom broth or chicken stock or beef stock, Salt, Water, Pepper, and Baking soda. The ingredients for coating are wheat flour, tapioca flour, rice flour, instant crispy seasoning flour (if any), powdered broth, and salt. When finished, you can add seasoning toppings, such as seasoning flour, topping with roasted corn flavor, cheese flavor, roast beef flavor, *Balado* flavor, and others.

Implementation: Prepare water to soak the sliced banana pseudostem. Add water whiting solution and salt. Stir evenly and set aside. Then take a banana tree about of a tree down (we will make the rest for animal feed), which is about 1.5–2.0 m long, and cut it into 3-4 pieces so that it is not too long. The outermost layer of the banana pseudostem is not used. The banana pseudostem used is layer 3 to layer three from the center. The middle one is used as a curry ingredient.

Figure 2. Raw matter of Banana Pseudostem for Crispy

Take a piece of banana pseudostem, peel both sides, and take the middle part, which is in the form of a grid. Then cut according to taste or lengthwise about 3-4 cm. The outside of the banana pseudostem is peeled by adjusting it using a sharp knife so that the inner sheet of the banana pseudostem is seen in the form of checkered net fibers like the texture of Taro.

Then cut into pieces according to taste for practice; here, it is 3 x 5 cm. Put it directly into the soaking water immediately after it is cut so that the black sap does not come out. Set the rest until the available materials are used up. After soaking, wash thoroughly with running water. Wash gently, so the texture does not crumble until it is free from whiting and the water becomes clear. Then squeeze and drain.

Furthermore, it is marinated by mixing all the ingredients of the banana pseudostem that have been squeezed earlier and stirring gently. Let stand until the flavors infuse for about 30 minutes. While waiting, prepare the flour coating for the chips. Then mix it evenly on the sliced banana pseudostem. Set aside. After being marinated, separate the sliced banana pseudostem from the marinated water, drain and squeeze it until it is rough along the lengthwise direction to keep the texture intact and from clumping together. Drain.

Figure 3. Raw matter of Banana Pseudostem for Crispy (marinated in lime clam)

Figure 4. Sliced Banana Pseudostem for Crispy

Prepare cooking oil and heat it. Then roll each piece of banana pseudostem in the flour coating so that it separates and does not stick. All the banana chunks are stirred until they are coated with flour. Then fry in hot oil on medium heat. Once the chips are stiff, transfer to medium or low heat so the oil does not clump or settle down. When the banana chips are almost ripe or look golden white, turn up the heat again. Then fry on high heat for about 1-2 minutes at the last minute. Then lift and drain.

2. Spicy Curry of Banana Pseudostem

The banana pseudostem in the process of making curry is as follows: Condiment prepared is one pcs of star anise, three pcs of cardamom, five cloves of flowers, three bay leaves, and three stalks of lemongrass. Seven large red chilies, seven shallots, seven garlic cloves, 3 cm turmeric, 2 cm ginger, and 5 cm galangal must blend. 100 ml beef broth, 100 ml coconut milk, 700 ml water, and vegetable oil for frying. Raw matter of 05. kg banana pseudostem center (the soft part in banana pseudostem) is cut 3 cm in length.

Figure 5. Raw matter of Banana Pseudostem for Curry

Step by step, making banana pseudostem curry is straightforward, from sauteing the ground spices until fragrant. Enter the condiment salam, lemon grass, flower lawing, cardamom, and cloves until everything is soft and the smell of curry can be smelled. Then add the banana pseudostem, stir until slightly soft, and add the beef broth and coconut milk. Stir again until the banana pseudostem is cooked. Remove and serve on a container to be ready to eat as complete nutritional food without expensive costs, avoiding malnutrition, food insecurity, and eradicating poverty and hunger.

Figure 6. Cooking Banana Pseudostem Curry

2. Pseudostem Salad (*Urap*)

The ingredients for making banana pseudostem urap include banana pseudostem, kecombrang, roay beans, bokor lettuce, chayote, mushroom broth, candlenut, kencur, chili, cayenne and sizeable red chili, shrimp paste, garlic, onion, grated coconut, sugar, and salt. All ingredients for a healthy lifestyle are delicious without added flavoring. All the raw materials are sliced, and the spices are mashed. The grated coconut is roasted until it is brownish yellow. Add the blended spices, mix well, add sugar and salt, mix well, and Enter. Stir until cooked, then add other vegetables in the yard, namely bokor lettuce, pumpkin, and torch ginger (Etlingera elatior). The ingredients for making banana pseudostem curry include banana pseudostem. The middle part is cut into 4 cm, mushroom broth, onion, garlic, chili, candlenut, cardamom, flower lawing, candlenut, coconut milk, turmeric, and ginger. The crushed spices are galangal, lemongrass, and kaffir lime leaves.

Figure 7. Raw Matter Banana Pseudostem for Salad (*Urap*) and Grated Coconut

Figure 8. Processing Condiments and Spices of Salad (*Urap*)

The mashed spices are sauteed until fragrant. Add lemongrass, kaffir lime leaves, galangal, sugar, and salt; give coconut milk and enough water; stir until it blends with the spices, add the banana pseudostem and stir until cooked. Pseudostem banana curry is ready to be served.

7.3. Discussion

Many people do not know that banana stem waste can help humans escape hunger. They know that banana plants can only be used for their fruit to eat. The rest is garbage to be thrown away. KWT partners Mekar Sari and Harum Manis were enthusiastic about the results in community service activities. The previous partners had never used banana gizzards for food. In addition, some asked about the toxic content in banana pseudostem because they were worried that the partner had never processed banana pseudostem. At times like this pandemic, food diversification with food processing (Azis et al., 2019) especially neglected local food sources, is very important. Food diversification will strengthen household food security (Food Sovereignty as a Base for Realizing National Food Security, 2016), especially with abundant raw materials in Indonesia, such as banana plants.

Processing such as making *urap* (salad), curry, and chips will lead to additional use-value, economic value (Sundari et al., 2017), and higher consumer preferences (Sundari et al., 2018; Sundari, Umbara, et al., 2019; Sundari & Umbara, 2019), as well as partners, provide positive attitudes and behaviors (Sundari et al., 2020; Sundari, Fitriadi, et al., 2019) towards this diversification of food made from banana pseudostem. This food diversification will benefit if a value-added analysis is carried out (Syaputra et al., 2014). Utilizing technology according to people's tastes, situations, and conditions through processing and other resources will be very profitable (Kotler, 2013, 2011, 2012a, 2012b; Kotler & Keller, 2016).

In making chips, the function of soaking in salt water is to remove toxins from the banana pseudostem, while the content of the betel solution is to remove the sap, thereby eliminating the bitter and rough taste. In addition, the texture becomes more robust with a savory taste so that it becomes mor-crunchy when fried later. With the proper technique for managing the size of the fire, the Gebog chips are not prone to being greasy. Gradually fry all that is left over. After frying, if it has cooled a bit, you can put it in an oil draining machine to separate the banana chips and the oil. Another way can be entered into the digital air fryer machine by standing up. Put it in the water Fryer machine with a temperature of 180 0C, and turn it on for about 5-7 minutes. That way, the results of the chips can be dehydrated and free of oil.

Alternatively, use a low-temperature oven (130 °C) for about 20 minutes. Another way, for an economical way, is to wrap it in large crackle plastic covered with tissue or multi-layered HVS paper. Do not use newsprint or those with writing on it. It is feared that the carbon will migrate to food that can harm health in the long run. The crackle is tied tightly and then stored for at least 24 hours. That way, the oil will usually be absorbed in the paper, so the chips can be rougher and not quickly rancid.

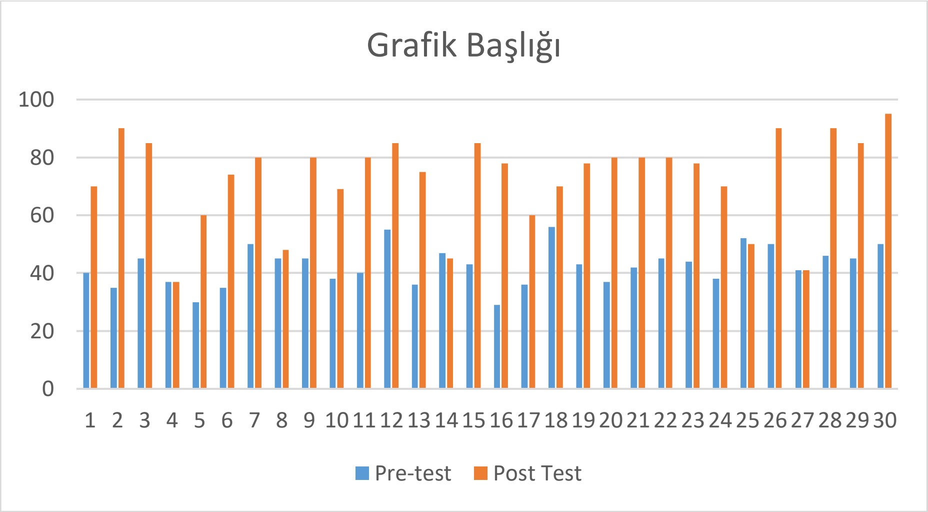

Figure 1. Pretest and Postest Citizen Understanding about Banana Pseudostem

The processed salad (urap) is delicious; some even plan to cook banana pseudostem for daily family consumption. As well as with banana pseudostem curry, partners assess that it does not feel like eating banana pseudostem like eating meat because it tastes good. The chips produced are also exciting and delicious. Partners say these chips want to be used as a home-based snack business to earn additional income. The results of the pretest and post-test evaluations of the women's farmer groups of Mekar Sari and Harum Manis can be seen in the following table.

The analysis results show differences in understanding and skills that are very real before and after being given counseling, assistance, and the implementation of processing banana pseudostem waste into various delicious preparations full of nutrition. This service activity dramatically increases the insight and skills of partners and can develop these products for Micro, Small, and

Medium Enterprises activities that will launch the wheels of the community's economy and improve public welfare and health. There is a need for broader socialization with other partners so that people can use the banana pseudostem in addition to the fruit and leaves, which are known to be helpful as a daily meal full of nutrition.

Figure 9. Salad (Urap) Pseudostem Dish

Figure 10. Pseudostem Curry

Figure 11. Pseudostem Crispy

7.4. Conclusion

Waste treatment that had been neglected for a long time turned out to provide significant benefits for partners and the community in order to strengthen the pillars of family food security, save household expenses, help protect the environment, meet nutritional needs, empowering household, become entrepreneurial or business opportunities.

7.5. Implication

Utilize the banana pseudostem, a food diversification program that can be made to alleviate poverty, and food insecurity, fulfill family nutrition and entrepreneurship. the policy should make by the authorities, which can be disseminated to the public through the community and non-governmental organizations for welfare. we are ready to extent

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CHAPTER 8

RICE STRAW COMPOST IN SUSTAINABLE AGRICULTURE

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8.1. Introduction

Rice which its cultivation has a history of more than thousands of years is the most produced third cereal in the world after maize and wheat. It is one of the major sources of human diet and has nearly 757 million tonnes of production in 164 million hectares in the world by 2020. Besides, total population of the world was 7.4 billion in 2015 however; the projections show that it will be 16% more by 2030 (FAOSTAT, 2022). As a result of the increase in population, the requirement of the world will be 50% more rice in 2030 with respect to that in 2015 while nearly in 30% less arable land than now (Swaminathan, 2016) meaning more rice straw will be generated after harvest.

According to the statistics, workers employed in agriculture is 26 % of the total (UN, 2022) and the projection of the rural population ratio to the total will decrease more than 6% by 2030 when compared to the data in 2015 (FAOSTAT, 2022) which means a potential decrease in the population of workers in agriculture inspite of the increase in the quantity of rice and rice straw. An additional 100 million tonnes of rice is estimated that will be required by 2035 in the Asia-Pacific region (Swaminathan, 2016). In this case, sustainable recycling management of rice straw will be needed more.

Asia is the biggest producers of rice. As seen in Figure 1, top ten rice producers are also in Asia with the average of 90 percent in overall between the years 2015 and 2020. Nevertheless, undernourishment and sustainability problems are still being reported. According to United Nations (UN) report on world hunger**,** the largest number of undernourished people live in Asia even roughly 63% of world’s hunger was in Asia in 2017 (WHO, 2019; UN, 2022). Among the sustainable development goals of UN adopted by United Nations Members States in 2015, Goal 2 (SDG2) on zero hunger and Goal 12 (SDG12) on responsible consumption and production are directly related topics with undernourished people, food loss and waste, sustainability in agriculture and use of resources especially in rice growing regions of Asia.

Food losses starting with pre-harvest, harvest and post harvest includes transport, storage and processing operations whereas retail and public consumption is referred as food waste rather than food losses (Durán-Sandoval et al., 2021; Fabi and English, 2019). Not only rice itself but also rice straw can be considered to be wasted during the harvest and post harvest because there is a huge lack of recycling or reuse of it. Rice straw is generally disposed of by burning in the field which gives harm to the soil and its flora as well as causing air pollution via greenhouse gas emissions (Singh et al., 2021; Rashad et al., 2010; Ratnakumar et al., 2019).

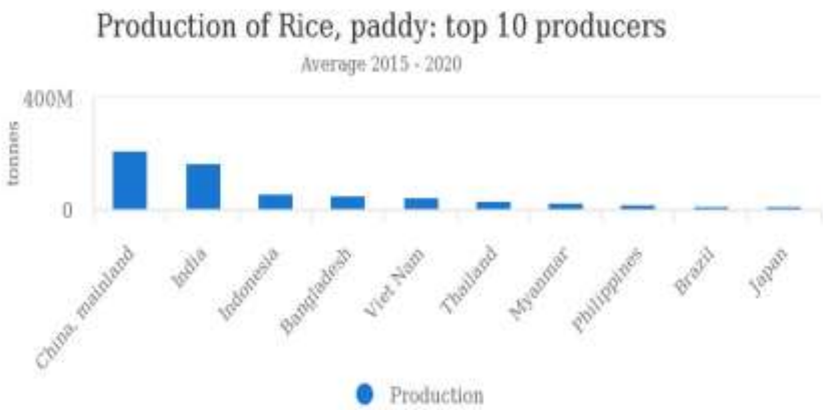

Figure 1. Top 10 producers of rice between the years 2015 and 2020. (FAOSTAT, 2022).

Surely, there are other management methods of rice straw except for burning. Some of these are papermaking, animal bedding, livestock feed, energy production, mushroom production, incorporation and mulching, composting and using as construction material and composites (Sözübek and Öztürk, 2022). Among these methods, utilization of rice straw by composting and turning it into fertilizer is valuable in terms of recyling, reuse and reducing the straw waste, as well as reducing greenhouse emissions caused by burning of the straws in the field.

8.2. Characteristic of Rice Straw

After rice harvesting, large quantities of rice straw remain in the field. The quantity of rice straw is directly related to both the cutting height and the production yield of rice that is also vary with the factors such as the type and chemical properties of the soil, fertilizer application and wheather (Van Hung et al., 2020). In the expression of the straw biomass, generally straw to grain ratio is used and this ratio is mainly between 0.7 and 1.5 (Kausar et al., 2010; Wageningen, 2013). Rice straw amount can also be calculated according to the following equation generally valid in Asian countries (Gadde et al., 2009).

$$Q_{RS} = P_{RR} \text{ x } SGR$$

where Q_{RS} is the quantity of rice straw (kt a^{-1}), P_{RR} is the production of rough rice (kt a^{-1}) and SGR is Straw-to-Grain Ratio.

Rice straw mainly includes lignin, cellulose and hemicellulose as a complex structure and this lignocellulosic structure makes the decomposition difficult (Chakma et al., 2016; Ratnakumar et al., 2019; Zhang and Cai, 2008). Lignin is a complex biopolymer composing from aromatic monomers. Both the tight bonds with cellulosic components and the functional groups being carried by lignin that is in charge of its recalcitrant and heterogeneous structure makes resistant to microbial degradation (Xu et al., 2021; Liu et al., 2019).

Silica and ash are also other components of rice straw. Silica that have roles in the protection of plant cell wall, carbohydrate and phenolic synthesis as well as grain yield is amended with urea and ammonia to fissure the silicified cuticular layer however they do not dissolve silica like sodium hydroxide (Van Soest, 2006). The resistant lignocellulosic structure and silica content of rice straw generally limits its use. (Ratnakumar et al., 2019)

Table 1: Composition of Rice Straw

Moisture (%)	**Silica** (%)	**Ash** (%)	**Cellulose** (%)	**Hemicellulose** (%)	**Lignin** (%)	**Reference**
12.8			38.6	19.7	13.6	(Zhu et al., 2005)
	8.3	12.4	33.7		19.9	(Gu et al.,2013)
		11.33	32.15	28.00	19.64	(Shawky et al., 2011)
6.9		11.8	33.9	25.6		(Jin and Chen, 2007)
			33.69	35.02	15.20	(Shan et al., 2008)
	6.8	11.2				(Agbagla-Dohnani et al.,2001)
		18,8	38.3	28.0	14,9	(Zhang and Cai,2008)
	6.67		36.29	20.67	9.42	(Bhattacharyya et al., 2020)
5.4		16.2	33.4	16.2	8.9	(Ma et al., 2009)
		10.2	32.0	29.9	18.8	(Murakami et al., 2012)

The physical and chemical properties of rice straw also affect the content of the compost. Carbon to Nitrogen ratio (C:N), pH, moisture, macro and micro nutrients, heavy metal content are the most analyzed properties as well as lignin, cellulose, hemicelluloses, ash, silica and protein content analysis of rice straw. Lignin, cellulose and hemicellulose content of rice straw is 8-20%, 30-45% and 15-40% respectively whereas moisture, silica and ash content is 5-15%, 5-15% and 10-20% respectively according to the studies given in Table 1. C:N ratio of rice straw is mainly between 40 % and 60%. C:N ratio is an important criteria for the initiation of composting. In order to supply optimum initial C:N ratio, rice straw is generally mixed with other wastes

.

8.3. Rice Straw Compost

Composting is a microbial and anaerobic process in which decomposion reactions take place after mixing the substrates. Soil elements are transported to other places after harvesting and little amounts are return to the soil by some amendments like incorporation or mulching. In order to put these element to the soil again, chemical fertilizers are used and often surplus chemical fertilizers disrupt soil balance and hence affect plants, soil and underground waters (Savcı, 2012). Despite the chemical fertilizers, organic fertilizers like compost, decompose slowly and in the correct time of plant need promoting sustainable agriculture.

Rice straw can be composted by itself but mainly by mixing other substrates such as manure, slurry, food wastes, green wastes, sewage sludge or other wastes with or without inoculants mainly due to its difficult degradation. In order to maintain a better agricultural sustainability via composting rice straw, optimum initial ratios of substrates for composting can be determined according to the results of analyses of physical and chemical properties of rice straw.

8.4. Compost Preparation

The factors that affect the overall composting stages can be counted as the size of substrate, porosity and aeration, C:N ratio, moisture, temperature, pH and other substrates or inoculants (Nakhshiniev et al., 2014; Rashad et al., 2010). Decreasing particle size increases the surface area thus decomposition rate increases. However, smaller particle size can also reduce the porocity by compacting the substrates and inhibits the required aeration for composting. In that case, anaerobic conditions form accompanying odor problems. Optimum porosity for composting is 35-50 % in order to supply a balance between temperature, moisture, CO_2 and O_2 during the composting process. If the porosity is above 50%, it leads the temperature remains low because of heat lost (Bernal et al., 2009). Rice straw generally were cut or sieved for 2-3 cm sizes in the studies and it is possible to come across researchs grounding and sieving the rice straw to get smaller sizes e.g. 2 mm for composting of rice straw by fungi (Zhou et al., 2015; Kausar et al., 2010; Zhao et al., 2016).

C:N ratio is the major effect on the beginning of composting process. The reasonable range for raw materials to be composed is 20:1 to 40:1 whereas, preferred range is 25:1-30:1 (Rynk et. al., 1992). Although the initial C:N ratio of the compost near 50:1 is suitable for a rapid composting progress (Sharma et al., 2014), this ratio is often below 40:1 in many of the studies. If this ratio is too high then, degradation time elongates and if too low then, nitrogen is easily mineralised into NH_3 (Nghi et al., 2020).

Initial moisture content is adjusted by adding water in the range of 40-70% (Ma et al., 2022; Goyal and Sindhu, 2011; Jusoh et al., 2013; Georg, 1993). During the composting stages, optimum moisture content should be remained in the range of 50-65%. Moisture content exceeding 65% have the similar affect with smaller particle size. Exchanging pore air with water causes anaerobic conditions (Nghi et al., 2020). On the other hand, if moisture content is below 40%, activity of bacteries is blocked (Fogarty and Tuovinen, 1991). Sometimes, a pretreatment is applied to accelerate the degradation for instance, moistening by urea solution of 0.1% blent with small quantity of cow dung (Sodhi et al., 2009).

Rice straw compost is prepared by mixing the substrate with other agricultural wastes or manure or various inoculants or combinations of these. Compost is turned over in definite periods. This turning over application makes a good aeration and controls both temperature and moisture. Moisture content is kept constant during the composting period such as 50-60 days (Sodhi et al., 2009).

8.5. Composting Stages and Compost Maturity

Carbon in organic compounds in rice straw is mineralised into CO_2 by fungi, bacteria or other microorganisms and nitrogen is mineralized into NH_3 while H_2O is another product meaning moisture. During these exothermic reactions, temperature of media increases and both pathogenic microorganisms and weed seeds are destroyed (Bernal et al., 2009). Although there is no accepted definite index worldwide, stability and maturity of the compost reflects its quality required for use as a fertilizer or soil conditioner in agriculture (Nakhshiniev et al., 2014; (Zhou et al., 2015). Volume reduction and degree of lignocellulusic degradation as well as the change in pH, temperature and C:N ratio are the measurable indicators that can be evaluated the stability and maturity status of the compost (Zhou et al., 2015; Nghi et al., 2020). Among these, the measurement of pH and temperature is relatively simpler.

Compost is accepted to reach its stability and maturity state if degradation rate and CO_2 emission speeds down and temperature stay constant after decreasing close to ambient temperature (Jusoh et al., 2013; Lannan et al., 2013; Fialho et al., 2010). Besides, seed germination test performed for the evaluation of phytotoxicity is also an indicator for the maturity of the compost (Ng et al., 2016; Goyal and Sindhu, 2011). Maturation indicates the existence of the humic substances comprising of humic acid, fulvic acid and humin (Zhao et al., 2016; Ywih Ch'ng et al., 2018). Amino acids are among the factors of humus formation; moreover they modify bacterial functions (Ma et al., 2022).

Although pH values ranging from 6.7 to 9.0 promotes microbial activity positively, pH of 5.5-8.0 is accepted optimal value where fungi prefer acidic pH values and bacteria prefer close to neutral pH values (Bernal et al., 2009; Fogarty and Tuovinen, 1991). Finally, pH coming back close to neutral values indicates humus formation (Fogarty and Tuovinen, 1991).

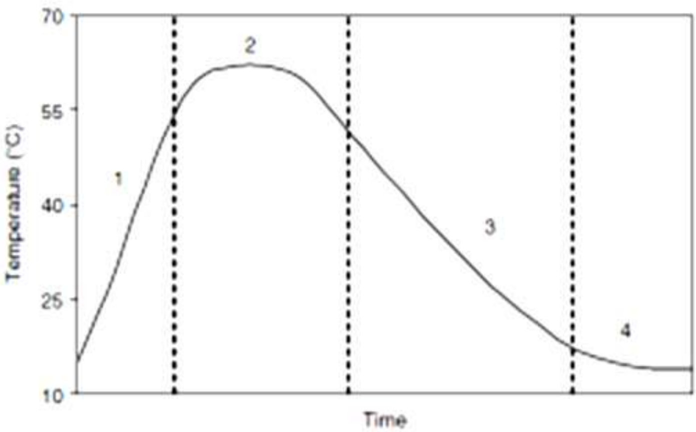

Figure 5. Changes in Temperature with Time in Stages of Composting (Shilev et al.,2007). (1=mesophilic stage, 2=thermophilic stage, 3=cooling stage, 4=maturing stage)

The change in temperature gives the idea about the stage of maturation during composting. In a typical composting, temperature changes follow each other in the order of mesophilic, thermophilic, cooling, and maturing stages as given in the Figure 5 (Nghi et al., 2020).

The first stage is mesophilic stage in which temperature increases quickly but not above 50^0C. Bacteria are dominant in the beginning of composting (Bernal et al., 2009) and in this stage, mesophilic bacteria species is dominant but its dominance decreases with increasing temperature up to nearly 40 °C (Nghi et al., 2020). Mesophilic bacteria quickly breaks down the biodegradable compounds causing heat release, thus a rapid rise in temperature is observed (Shilev et al.,2007). After 40 ^{0}C, thermophilic bacteria become dominant instead of mesophilic bacteria (Nghi et al., 2020). Fungi coexist in all stages but are dominant at moisture below 35% and are not active at temperatures above 60 ^{0}C (Bernal et al., 2009).

The second stage is the thermophilic stage, which the temperature attained to its maximum value (Fialho et al., 2010). Temperature first increses to 55 ^{0}C that pathogens are destructed then, at 60 ^{0}C, sanitation takes place which weed seeds and parasites are destructed (Shilev et al., 2007). Nghi et al. (2020) states that according to Haug (1980), the composting temperature has to be above 55 °C for three consecutive days to kill the pathogens The compost temperature reaches 60 °C in a couple of days or up to 10 days according to substrates and other physical variables (Jusoh et al., 2013; Shilev et al., 2007). In this stage, microorganism activities peak resulting the maximum organic material degradation (Zhao et al., 2016) and high temperatures fasten the degradation of complex carbohydrates such as cellulose and hemicellulose (Shilev et al., 2007).

Even so, the temperature should not exceed 65 °C in order not to inactivate the useful microbe otherwise a decrease in the rate of degradation is observed (Shilev et al., 2007). Therefore, temperature should be adjusted not to exceed that temperature by proper aeration and turning over the compost (Nghi et al., 2020; Shilev et al., 2007).

After the exhaustion of these compounds, a gradual decrease in the temperature occurs in the third stage which is cooling stage (Shilev et al., 2007) followed by the last stage called maturing stage. The temperature decreases then, remains constant close to ambient temperature in 60 to 90 days of composting (Jusoh et al., 2013; Fialho et al., 2010). Dominant microorganism in this stage is actinomycetes and fungi which can decompose the resistant polymers (Bernal et al., 2009). Additionally, mesophilic microorganisms occur again in maturing stage that is also known as curing (Shilev et al., 2007). Thereby, humus is formed after maturing stage (Nghi et al., 2020).

C:N ratio is a favourable indicator for the determination of maturity stage of the compost (Ywih Ch'ng et al., 2018; Kausar et al., 2011). Initially, carbon content of the substrates are high, with lossing of carbon compounds, decrease in C:N ratio is in prospect (Nakhshiniev et al., 2014). Composts used for fertilizing is desired to be stable in the soil and not to continue degradating, thus the C:N ratio lower than 25 is accepted for maturity and stability for many countries (Topal and Topal, 2013). Similarly, Ywih Ch'ng et al. (2018) reports that C:N ratio below 20 indicates the maturity of the compost, stated by Brady and Weil (2002). Even, a C:N ratio of 15 or below being more prefable, stated by Jimenez and Garcia (1989) is reported by Nakhshiniev et al. (2014). When C:N ratio is low e.g. green wastes, microbial decomposition causes ammonia formation, thus increasing pH and ammonia volatilization, on the contrary, high C:N ratio means more substrate to degrade and limitation of nitrogen decreases pH which inhibits microorganisms thuswise, composting process slows down (Fogarty and Tuovinen, 1991; Bernal et al., 2009).

8.6. Studies on Rice Straw Compost

Crop residues, especially rice straw is degradated hardly and slowly due to lignocellulosic structures. In order to overcome this elongated process, crop residues are generally mixed with animal wastes for compost formation which are mainly used as biofertilizers (Jusoh et al., 2013). The nature, structure and composition of the organic substances and their decomposition by microorganisms affect the maturity of the compost and both the time elapsed for composting and the quality of compost hinge upon microorganisms (Kausar et al., 2016). For that reason, adding inoculants, mainly effective microorganisms (EM), are frequently encountered case. The ratios of the substrates to each other is changed in order to obtain acceptable initial C:N ratios.

Rice straw can be composted either alone or in combination of animal manures and/or green wastes, again and/or effective microorganism. Although rice straw itself is already responsible for the odor absorption in the compost (Rynk et. al., 1992), in the case of composting rice straw alone, besides elongated degradation period, odor and undesired microorganismal activities may arise. Hence, generally co-composting is preferred and sometimes rice straw is moistened by urea solution resulting reduction in N loss (Omar et al., 2016).

The term EM was first developed by Japanese horticulturist Dr. Teruo Higa in 1970s (Jusoh et al., 2013; Sharma et al., 2014). EM refers to bacteria, fungi and actinobacteria where the combination of microorganisms for instance, lignocellulolytic fungi, cellulolytic bacteria, lactic acid bacteria, yeast, and photosynthetic bacteria that fasten the composting (Kausar et al., 2011; Sharma et al., 2014). EM increases both macronutrient and micronutrient content of the compost when compared with control (Jusoh et al., 2013).

Studies on composting of rice straw in terms of substrate ratios, additional inoculant, composting period and C:N ratio of the compost are summerized and given in the Table 4. As can be seen in the table, studies are performed mainly co-composting of rice straw with animal manures and green wastes with or without EM. Animal manures are generally rich in N, decomposes quickly and need amendments with high C content (Rynk et. al., 1992). Odor problem may arise in composting of poultry manure despite the low odor potential of goat manure (Rynk et. al., 1992). Besides, reduction in lead and cadmium content of the compost is reported in a study of co-composting of rice straw with chicken and donkey manure (Karanja et al., 2019).

After moistening of unchopped rice straw with 0.1 urea solution, increase of humic substances in RS+cattle dung and RS+consortium of fungi by 34% and 27 % when compared with RS compost alone is obtained in a sudy of Goyal and Sindhu (2011). Another study of composting sewage sludge with crop straws including rice straw reveals that more hemicellulosic structure and smaller C:N ratio of the straw causes faster the rate of organic matter thus more humic substance formation in the compost (Zhao et al., 2016).

Also, inoculants fasten the increase in temperature and the degradation of lignocelluloses so that C:N ratio decreases more quickly accompanying higher volume loss of the substrates compared to the control without inoculants (Zhou et al., 2015).

Table 4: Brief information about some of the studies on composting of rice straw

Ratio of Substrates	EM /Inoculant	Composting Period	C:N ratio of Compost	Reference
RS+chicken manure(1:1)	Fungal consortium *A.niger+T.viride*	6 weeks	initial: 29.25 maturity:15.33 control:19.83	(Kausar et al., 2010)
RS+chicken manure(1:1)	Lignocellulolytic actinobacteria %10 (v/w)	6 weeks	initial: 29.3 maturity:18.1	(Kausar et al., 2011)
RS+chicken manure(2:1)	-	49 days	initial: 29.25 maturity:10.55	(Ali et al., 2006)
RS+chicken manure (10:1)	-	62 days	initial: 58.67 maturity:10.84 control:23.75	(Karanja et al., 2019)
RS+chicken slurry+zeolite+ urea(20:1:1:1)	-	55 days	initial: 33.8 maturity: 15	(Omar et al., 2016)
RS+poulty droppings(8:1)	EM consortium	60 days	initial: 60:1 maturity:15:1	(Sharma et al., 2014)
RS+dairy manure (1.2:35.2)	Thermo actinomyces+ fungi	45 days	initial: 27 maturity: 16.5 control: 21.7	(Zhou et al., 2015)
RS+cow manure+ rapeseed cake (100:60:3)	-	22 days	initial: 31.2 maturity: 17.8	(Wang et al., 2016)
RS+cattle dung+0.1% urea solution	-	90 days	initial: 41.7 maturity: 17	(Goyal and Sindhu, 2011)

RS+goat manure+green waste (5:3:2)	EM consortium *A.niger+T.Viride*	90 days	initial: 32.4 maturity: 10.3	(Jusoh et al., 2013)
RS+goat manure+green waste (5:3:2)	-	90 days	initial: 34 maturity: 16.1	(Jusoh et al., 2013)
RS+green waste (4:1)	EM 3% (w/w) microbial inoculation	24 days	maturity: below 20	(Chen et al., 2019)
RS+green waste(4:1)	-	24 days	maturity: below 20	(Chen et al., 2019)
RS+donkey manure (10:1)	-	62 days	initial: 52.00 maturity:11.32 control:23.75	(Karanja et al., 2019)
RS+sewage sludge	-	45 days	initial: 20 maturity:12.18	(Zhao et al., 2016)

RS=rice straw, EM:=effective microorganisms, C:N=carbon to nitrogen ratio.

8.7. Effects of Rice Straw Compost on Soil and Plant

Organic fertilizers are used to enrich the soil organic matter, increase soil fertility and also improve and preserve the physical, chemical, biologycal properties of the soil (Assefa and Taddese, 2019; Bellitürk et al., 2019). They release nutrients slowly into the soil and feed both soil and plants as acting both fertilizer and soil conditioner, so keep the nutrient balance and supress the need of repeated synthetic fertilizer application (Shaji et al., 2021; Assefa and Taddese, 2019).

Studies show the improvement of soil quality and fertility after the replacement 50% of the inorganic fertilizers with rice straw compost (Sharma and Dhaliwal, 2019) and after the application of rice straw compost either alone or combined with inorganic fertilizers (Sodhi et al., 2009). Soil physical and chemical properties are enhanced by the application of rice straw/animal waste compost (Mahmoud et al., 2018) and by the repeated rice straw compost applications (Watanabe et al., 2009).

Organic fertilizers are safer, more beneficial and environment friendly than inorganic fertilizers so that they are used either instead of or in combination with inorganic fertilizers (Shaji et al., 2021; Assefa and Taddese, 2019; Bellitürk et al., 2019). The yield of rice is increased after the substitution 40-50% of inorganic fertilizer with rice straw compost (Sharma and Dhaliwal, 2019; Watanabe et al., 2009). The grain yield of the rice fertilized by rice straw compost is also found higher in comparison to fertilization by rice straw only and in comparison to the control with any amendment (Takakai et al., 2020). Similarly, yield of rice is found to be increased 13-26% higher by rice straw compost than that of control without compost application (Barus, 2012).

Plant growth and management of rice blast disease is improved by the application of rice straw compost prepared with cow manure and EM consortium (Ng et al., 2016). The yield and dry biomass of tomato is also significantly increased with the addition of rice straw compost at a rate of 30 % (v/v) (Ali et al., 2006). In an another study, rice straw compost application also increased dry weight of canola plants while increasing the organic matter of the soil three times more than the control (Mahmoud et al., 2009). Fertilization at a rate of 40% (w/w) with the compost prepared with rice straw, green wastes and EM lead to increase in cabbage seeding and cucumber growth performed by (Chen et al., 2019).

Composts are generally rich in micronutrients like Zn and Fe despite their relative poor macronutrient contents and additionally, the ones made of biosolids such as rice straw, have less heavy metal contents (Georg, 1993). A study of Mahmoud et al. (2018) confirmed that the rice straw compost produced from rice straw and animal waste and combined with rice straw bichar decreased the heavy metal uptake of canola while having the highest canola growth. There are various researches confirm the effect of composting the rice straw on soil health eg. fertility, aeration and plant health eg. availability of nutrients and yield.

8.8. Conclusion and Suggestions

Rice, as a major feed of human diet is being produced and consumed in a very high scale and this will continue accompanying an increase due to increasing population. Despite the increasing demand, the arable lands and agricultural labour tends to decrease and also hunger is still a great problem in the world especially in Asia where the rice is produced most and will be getting more demanded all around the world. Besides, losts and wastes from the field to and after the consumer affect negatively not only the economic losts and direct access to the food but also the environment in terms of pollution and the soil poisoning with excess chemical fertilizers instead of organic ones. In the frame of sustainability, agricultural, environmental and waste management systems should spin the wheel in a harmony.

Considerable amount of rice straw forms after harvest and that can easily been composted in or near the field so that environmental pollution coming from both transportation of the straw and burning in the field can be prevented. Compost can be prepared either with manures or effective microorganisms or other wastes or in different ratios of them. By using this compost in the field, chemical fertilizer addiction can be lowered and soil health can be healed in the following years after use as well as recyle and reuse the other wastes. These amendments can be performed by well organized farm systems and the role of rice farming systems in achieving the zero hunger and responsible consumption and production goals has to be precisely taken into consideration.

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CHAPTER 9

CONSTRAINTS TO IRRIGATED RICE FARMING TECHNOLOGY ADOPTION IN INDONESIA

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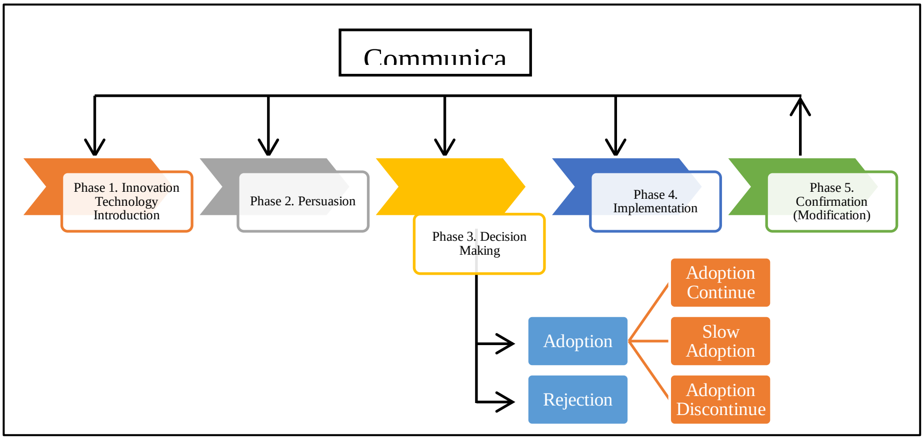
9.1. Introduction

The availability of rice, the staple food of Indonesians, for domestic consumption throughout the year is crucial. Indonesia has the third-largest area planted with rice and the third-highest total production in the world, but domestic rice production is still insufficient to meet domestic demand (FAO, 2020). In recent decades, the Ministry of Agriculture (MoA) has attempted to introduce many new technologies to rice farming to increase domestic production. In 2007, the government initiated the P2BN/ *Proyek Peningkatan Beras Nasional* (translated to National Rice Improvement Project). It was followed by a project of quality improvement intensification (*Perbaikan Mutu Intensifikasi*/PMI) technology, which was applied in all rice production centers included in the *Supra Insus* program. However, most of the projects have not fully succeeded. Diffusion rates for technology adoption have not reached the expected level. According to the Directorate General of Food Crops (Ministry of Agriculture of Republic of Indonesia, 2010), the adoption level of rice farming technology in the southern part of Sumatra Island was only 48%, more than 30% lower than the target level. Moreover, the Ministry of Agriculture of the Republic of Indonesia (2011) reported that only 10% of farmers in the eastern part of Indonesia used modern farming technologies in 2010, despite several innovations being introduced in 2007, such as the System of Rice Intensification and hybrid seeds.

The technology package with the PMI approach was still generally accepted. In addition, the government introduced the location-specific technology package with the PTT/*Pengelolaan Tanaman Terpadu* (Integrated Crop Management) approach. The components of PTT technology or a combination thereof differ between rice production centers with different biophysical and socio-economic conditions of farmers. The PTT technology was part of the intensification of rice crops on irrigated rice fields. As a technology package, it consists of various components, including hybrid seeds, pest control, nutrient and water management, and harvesting techniques.

Rogers (1983) illustrated the technology adoption process into five phases, from the introduction to confirmation or modification by the users. The adoption problem of agricultural innovation technology in Indonesia does not only lie in the phase of decision making (whether to adopt or reject the technology) but also includes the implementation and confirmation phase (Figure 1). According to Fagi (2008), PTT technology's top-down, instructive, and vertical recommendation can accelerate its adoption and dissemination, yet it is vulnerable to changes in the strategic environment. Adopting PTT technology may not be sustainable when some changes occur in the strategic environment, which is not conducive to farmers.

Figure 1. Process of innovation technology adoption (Rogers, 1983)



It is essential to clarify the factors that constrain farmers from adopting (and continue adopting) each technology to increase the diffusion rates of new technologies and boost rice production. Therefore, this chapter discusses the driving and inhibiting factors for technology adoption in Indonesia. It analyzes the factors that determine farmers' behavior towards each technology component and discusses the relationship between characteristics of the technology components and farmers' socio-economic and other conditions. By knowing the barriers to technology adoption, policymakers can determine the right policy direction, supporting infrastructure, and concrete strategy that must be taken.

9.2. Method

The primary data in this chapter are based on a case study, a survey conducted in 2007 and 2010 in an irrigated rice farming area in South Sumatra Province, where an innovative technology project for rice farming was introduced in 2006. Other primary data were collected from desk studies, including a literature review of similar studies regarding PTT and official documents, reports, or publications from related institutions. Various papers (on PTT, organic farming, SRI, and several rice innovation technologies and their adoption, results of PTT on socio-economic studies, and balanced fertilization) were employed as a basis for evaluation and analytical tools.

Moreover, interviews were performed to evaluate the performance of PTT in 2007, to study the perceptions of relevant local officials about PTT, and the changes that occurred after the implementation of regional autonomy. The interviews also provided technological input for PTT development locations, as an integral part of the growth center for rice and secondary crops, as well as the development of agribusiness principles through increasing productivity and the efficiency of production inputs. The key respondents interviewed were senior staff of the Provincial Agriculture Service, the Head of District Agriculture Sub-Department, extension workers, and farmers. Key questions were prepared before the Survey Team's departure to the field. New questions were asked during the interview to obtain more detailed information. The triangulation technique was used to clarify information.

The surveys were conducted in three out of eight of the 2006 PTT project's demonstration districts. From these three districts, one village in each district was selected. They were Bandar Jaya village in the Buay Madang district, Sido Makmur village in Belitang I district, and Kerujon village in the Semendawai Suku III district. Ten percent of the total rice farmer households in each village were randomly selected as the sample farmers, comprising 65 sample farmers. The demographic information collected for each household, using questionnaires, interviews, and focus groups, included the following: how much land the household owns, the form of land tenure, the number of family members, and their age, education level, and length of farming experience, the distance from the homestead to input-output markets and the local extension service, the household's holding capital and funds available for farming, whether a household received credit, whether farmers hold side jobs, and the amount of rice produced by adopting the new technology. In addition, information on producer prices, communication services, pests, and diseases were also obtained from the community survey and through interviews with the staff of the related institutions and organizations. The data gathered from these questionnaires and interviews were the essential inputs for analysis.

9.3. Results and Discussion

The Survey

Because rice farming has been mainly concentrated on Java Island, the government has been trying to expand rice production to the other islands, such as Sumatra and Sulawesi. Over the last two decades, Sumatra Island has become the government's main target because a permanent irrigation system exists in some parts of the island, particularly in the southern areas. The Ogan Komering Ulu Timur (OKUT) Regency is the core rice production area in the southern part of Sumatra Island. It comprises 15 districts and 257 villages, with a total population of 570,541 people in 2009. More than 80% of the population currently earns their primary income from the agricultural sector (BPS Kabupaten OKUT, 2012).

On average, the sample farmers owned 1.3 hectares of rice field, with a minimum of 0.5 hectares and a maximum of 5 hectares. Fields were mainly used as rice for two seasons a year, but after the second harvest, some farmers planted their fields with non-rice crops, such as soybeans, chilies, and shallots. The average household consisted of four members. The majority of the sample farmers did not go to high school or did not finish high school, with an average schooling duration of 7.6 years. However, the average farming experience was 31.3 years. In addition to being rice farmers, 16.9% of the participants had other jobs, such as a trader or merchant, animal breeder, or local community worker. During the rubber-harvesting season in the area, 35.3% of the farmers worked part-time at the rubber plantations.

Outline of the PTT Project

A project to diffuse a new rice farming technology was held in the study area during the dry cropping season (April to July) of 2006. Demonstration farming was conducted over 40 hectares in eight districts. The project offered technical advice and input materials (seeds, fertilizers, and bio-pesticides) to the farmers whose lands were used for the demonstration. As a result of this project, the government expected neighboring farmers to adopt the new technologies after observing the demonstration. The project was called the "*Pengelolaan Tanaman Terpadu* (PTT)," organized by the central Indonesian government in collaboration with the local government, several companies in Indonesia, and experts from Indonesian universities. Besides the OKUT Regency of South Sumatra Province, Bengkulu Province, as the neighboring province, was also the target of this project. PTT was introduced by the local government in Seluma Regency, especially in South Seluma Subdistrict and Rimbo Kedui Village (Sulastri et al., 2022).

PTT or Integrated Crop Management is an approach to applying agricultural technology performed directly on farmers' land in a participatory and site-specific manner, depending on the local ecosystem and socio-economic conditions. In this case, there may be differences in technological needs from one area to another. The implementation of PTT is based on four main principles. First, PTT enables plant, land, and water resources to be managed as well as possible. The second principle, PTT, utilizes the best agricultural technology produced by considering the elements of synergistic linkages between technology components. Third, PTT pays attention to technology's suitability for farmers' physical and socio-economic environment. Finally, PTT is participatory, meaning that farmers play an active role in testing and selecting technologies appropriate to local conditions and can go through the learning process (Arafah et al., 2007; Zaini, 2008).

PTT components are divided into essential components and optional components. The basic components include the use of new inbred or hybrid varieties, the use of quality and labeled seeds, spacing arrangements (known as the *legowo* system), balanced fertilization based on plant needs and soil nutrient status, the use of organic fertilizers, control of plant pest with a control approach, and Integrated Pest Management (IPM). Meanwhile, the optional components include tillage (based on season and cropping pattern), the use of young seedlings (younger than 21 days), planting one to three stems of seedlings, adequate irrigation, proper weeding, timely harvesting, and good post-harvest management (Jamal & Mardiharini, 2008; Wihardjaka & Nursyamsi, 2012).

The Role of PTT in Rice Production Increase

As mentioned previously, there are six technology components in PTT which are compulsory. Apart from being a feature of PTT, compulsory technology plays an essential role in increasing farmers' yields and income. The utilization of site-specific new high-yielding varieties in PTT provides high yields in various environmental conditions rather than the utilization of "any" high-yielding varieties. Moreover, using quality seeds with high purity and vigor and other cultivation technology breakthroughs provides a synergistic effect on increasing lowland rice yields. Seeds of superior varieties not only serve as an introduction to the technology but also determine the potential yield to be achieved, the quality of the grain to be produced, and production efficiency.

During the transplantation step, planting young seedlings in PTT provides an advantage in their tolerance to stress due to seed removal in the nursery, transportation, and replanting, compared to older seedlings. Furthermore, the increase in plant population can be done by direct seeding system in rows, *legowo* 4:1 system, or row system 20 cm x 20 cm. In conditions of low solar radiation, especially in the rainy season, increasing plant population is crucial to increase grain yields and efficient use of N fertilizers because fewer tillers are formed (Balasubramanian, 2002).

The PTT approach model is considered to be able to solve the problem of increasing rice yields. The results of the PTT model in the 2001 dry season in eight provinces (North Sumatra, West Sumatra, West Java, Central Java, East Java, Bali, West Nusa Tenggara, and South Sulawesi) showed an increase in rice productivity. The increase ranged from 7.1% to 38.4% compared to farmers' conventional technology (Fagi, 2008). In more detail, Zaini (2008) revealed the increase in grain yields and farmer profits from the application of each component of PTT in Table 1 below.

Table 1. Increase in yield and farmer's income by applying each PTT component

No	PTT Components	Yield Increase		Income Increase	
		Kg/ha	%	IDR'000/ha	%
1.	Site-specific high yield variety	275±20	8.9	228±18	5.2
2.	High-growth certified seedling	192±10	6.2	324±26	7.4
3.	Embankment height increase	96±10	3.1	70±5	1.6
4.	Nursery uniformity	232±20	7.5	337 ±27	7.7
5.	Optimum plant population/*legowo*	578±40	18.7	337±27	7.7
6.	Site-specific fertilization	765±60	24.7	1,117±88	25.5
7.	Water management	451±30	14.6	668±54	15.7
8.	Integrated pest management	346±30	11.2	587±46	13.4
9.	Early grain threshing	158±240	5.1	171±13	3.9
	Total	3,096±240	100	4,383±346	100

Source: Zaini (2008)

PTT Adoption

After the demonstration period in 2006, the PTT technology rapidly disseminated among farmers in the regency. The project succeeded in that all the farmers adopted at least one component of the new technology package. Unfortunately, the project failed to encourage farmers to adopt the whole technology package. In 2006, only 9 sample farmers adopted the whole package, while another 56 farmers adopted only one or some of the components of the technology package. The farmers who continued using the whole technology package had decreased to two in 2009. However, on average, the number of technology components used by the farmers increased from 3 in 2006 to 4 in 2009. It was discovered that a farmer might adopt one or several components during a particular cropping season and neglect them in the next season; moreover, the same farmer might adopt another separate component during the next cropping season. Likewise, farmers would adopt a component(s) for the first time during a particular cropping season and continue to use that component for the following season or re-adopted a component neglected during the previous season. Such conditions emphasized that the adoption of the new technology wildly fluctuated even during the three years after the demonstration period.

The level of adoption of new superior varieties was relatively low. Most farmers used high-yielding varieties that have been planted many times to decrease their production capacity. In addition, the mechanism of resistance to pests and diseases also decreased. In this case, the inhibiting factor for its production is not only due to the influence of the genetic ability of plants to produce but also the effect of the vitality of N fertilization to cure plants that are attacked by borers (Sipi & Subiadi, 2015). The interviews with farmers found that farmers' knowledge of PTT was limited. It was related to the lack of introduction of PTT technologies and the scarce availability of certified superior varieties in the field. Sjamsiar et al. (2015) stated that farmers managed their farming based on knowledge and using seeds that have been planted for generations.

The PTT can be considered more intensive than conventional or standard rice farming. Some components of the PTT require more money, skill or knowledge, and labor to perform than conventional methods. For example, the fertilizing component requires more money, while transplantation, according to PTT, requires more skilled labor than the conventional method. The interview with extension workers discussed that the PTT technology package's components could be categorized based on the decision type available for each component. Seed selection, fertilizing, and IPM adoption were considered the "independent individual" decision type, in which the adoption of these components was based on each farmer's decision.

Meanwhile, transplantation and proper harvest handling were considered "collective" type decisions because, in practice, both components required cooperation and agreement among farmers regarding timing and the division of hired skilled laborers owing to labor shortages in the area. It was also common for each farmer's household to help others conduct these two farming activities; thus, the adoption and implementation of these components depend on collective work. Water management was considered an "authority-imposed" decision because the adoption of this component depended on the availability and sufficiency of irrigation water, which the local government regulated based on a presidential decree.

Based on the survey, farmers adopted the technology component(s) that were easy to apply or gave them a direct benefit without requiring many inputs, such as proper harvest handling. Only the component of proper harvest handling was adopted and used by all the sample farmers continuously from 2006 to 2009. Notably, each farmer made unique decisions on which components to adopt, and changes in adoption and continuation occurred during those years. Some farmers adopted some components of the technology package from 2007 to 2009. However, adopters significantly increased in 2009, mainly for fertilizing and water management components.

From an interview with the Department of Agriculture and Food Crops of OKUT Regency, agricultural input price subsidies, extension service improvements, and the provision of irrigation canals took place throughout the entire study region from 2007 to the fiscal year 2009. These changes aimed to improve rice and other food crop production and farmers' welfare. The number of adopters of water management and fertilizing components changed from 2006 to 2009. However, determining whether these changes resulted from improvements in irrigation systems and fertilizer subsidies will require further analysis. Furthermore, there were no significant changes in the number of adopters of other technology components. One of the probable reasons for this lack of change is that poor weather during 2007–2008 resulted in poor yields (Department of Information and Communication OKUT Regency, 2010).

Determining and Inhibiting Factors of PTT Adoption

The data on farmers' socio-economic and the survey data on farmers' PTT adoption were compared. It was discovered that a highly educated farmer was more likely to adopt the fertilizing and IPM components. A farmer's active participation in group meetings was more likely to increase their likelihood of adopting all PTT components. Furthermore, a farmer's active contact with the extension agents was more likely to increase their likelihood of adopting seed selection, fertilizing, and IPM. A Farmer whose larger land area was more likely to adopt the transplanting component. Contrarily, a farmer whose land or house was further from input-output markets was less likely to adopt the IPM component. Last, farmers who live near the highway or have access to public facilities were more likely to adopt the fertilizing and IPM components.

Based on these findings, the factors influencing farm households' decisions to adopt PTT technologies were estimated using the logistic regression or logit model. The use of the logit model for this analysis is consistent with theories on adopting technologies (Alston et al., 1995; Lionberger, 1960; Rogers, 1983), which described the adoption process as having a logistic nature. This study uses the threshold decision-making theory proposed by Pindyck & Rubinfeld (1998). The theory points out that when farmers are faced with a decision to adopt or not to adopt a technology, there is a reaction threshold dependent on a specific set of factors. Greene (2008) stated that the logit model is commonly used for empirical analysis in discrete choice situations because of its mathematical convenience and simplicity.

This study's explanatory variables are classified into three main categories: the household's sociodemographic characteristics and economic and social factors. Beside, sociodemographic characteristics included farmers' age, education level, farming experience, and the distance from their homesteads to input-output markets. In addition, economic factors included the availability of farming funds, farm size, and whether farmers had side jobs. Also, social factors included access to extension services and farmers' group meetings. The data were from sample farmers in 2010 based on their experiences in 2006 and 2009. Up to the present (2021), these sample farmers no longer adopted the PTT technology, except for one component of post-harvest handling. It is assumed that the data in 2006 captured factors for technology adoption, while the data estimation in 2009 specified factors for sustainable technology adoption. These data were calculated using statistic software for Windows, SPSS, version 22.0 produced by IBM.

The factors influencing farmers' adoption of each component of the PTT technology package were analyzed rather than the whole package at once. Consequently, specific constraints on farmers' adoption of the new technology can be considered. However, a limitation of this study was a lack of verifiable data because the sample farmers (like many Indonesian farmers) did not have records of their farming. All the available data was based on participants' recall of past events correctly. For this reason, these findings cannot be generalized to the broader community based on this study alone.

Furthermore, it was also acknowledged that not all variables' parameters were significant in determining technology adoption. As the adoption situation of the new technology wildly fluctuated from 2006 to 2009, it was suspected that some factors other than the relatively stable socio-economic characteristics of farmers affected the adoption and potentially increased the explanation power of the regressions. Such factors may include each farmer's budget of inputs, sales price, preference for a specific technology, an unexpected event for the farmer, and other factors.

Many studies focus on the relationships between the cost to adopt and apply new technologies and the expected revenue from the technology to study and analyze farmers' behavior towards new technologies. However, this study found that money was not a constraint on adoption. Based on the survey, there was only a 20% difference in the costs spent by adopters who applied all the components and those who applied only some components of the new technology in OKUT Regency. However, adopting the entire package resulted in a greater than 50%

increase in production volume and revenue. It was observed that the variables affecting farmers' adoption varied for each component of the technology package.

Farmers' participation in group meetings and contact with extension agents were the most critical factors for adopting technology components. Participation in group meetings affected the adoption of all technology components in both years. In contrast, contact with extension agents affected the adoption of seed selection, fertilizing, and IPM components for both observed years. Amala et al. (2013) and Fachrista & Hendayana (2013) affirmed that households' sociodemographic characteristics and economic factors such as age, farming experience, education level, land size, and farming funds were the main factors that influenced agricultural technology adoption in Indonesia. However, none of these studies mentioned the effect of farmers' group meetings on agricultural innovation adoption, although each farming area in Indonesia has at least one farmers' group and association. Farmers' group meetings in the study area were usually held once a week; thus, there were 15 to 16 meetings in one cropping season. The evidence from this study suggested that farmers' group meetings enabled their knowledge and information network. Not only limited to collective-decision-related technology components, but the network effect was also crucial for individual-decision components (including seed selection and fertilizing). This finding is also supported by Conley & Udry (2000) and Foster & Rosenzweig (1995), who stated that farmers share information and learn from each other through such networks in agricultural innovations. Moreover, Effendy & Pratiwi (2020) also confirmed that sources of information, extension activities, and the nature of innovation significantly affected the adoption of PTT technology.

According to the interviews, before 2009, each extension worker had to work with at least 20 villages; hence, dissemination of information regarding new technologies was slow and sometimes overlapped with other kinds of technologies introduced in other areas in the study region. Under the new president and parliaments elected in 2009, the MoA employed nearly 10,000 new extension agents; furthermore, the number of extension agents has grown continuously since then. Currently, most rural districts in Indonesia are being served by public extension services due to these new reformations. Group meeting participation and contact with extension agents were essential variables in promoting technology adoption; thus, encouraging farmers' participation in group meetings and improving extension services will be indispensable to improving technology adoption.

Because the farmers' households in the study area usually use either a bicycle or a cart for transportation, farmers who live far away from the meeting locations find it difficult to attend meetings. The finding suggested that the local government facilitate farmers' group meetings in each village by allowing groups to use village halls or other government buildings to hold meetings instead of using the house of the village chief or school buildings. Holding meetings in various locations within the village may solve transportation problems.

The results suggest that farmers' education levels affected fertilizing and IPM component adoption. Because there are multiple steps involved in fertilizing various types and quantities of fertilizer, it was suspected that the less-educated farmers found applying the recommended fertilizing method difficult. Most of the farmers applied fertilizer based on the availability of the fertilizer at the time and decided the time of application and quantity based on their preferences. Likewise, there were also some difficulties related to IPM adoption. Even though the extension agents suggested when and what kind of plants should be planted for IPM, most farmers neglected this advice. They planted their fields with income-generating crops (such as soybeans and vegetables). When preventive methods were no longer effective, and the extension agents suggested using certain bio-pesticides, farmers were unwilling to buy the bio-pesticides. Fachrista & Hendayana (2013) and Hidayatulloh et al. (2012) mentioned that less-educated farmers tend to perform farming based on prior habits. When an innovation is introduced and suggested to less-educated farmers, more time is required for such farmers to change their habits and realize the importance of the adopted innovations.

Moreover, farmers' living distant from input-output markets affected seed selection and IPM adoption. According to the survey, the availability of ZA fertilizer and bio-pesticide required for seed selection was limited to certain area input stores. Meanwhile, in the case of the IPM component, based on the fact in the area, early prevention and pest and disease control depended on the season. High rainfall in the dry season during 2009 resulted in specific pests and diseases occurring in rice fields in the area. Considering this abnormal weather pattern, the recommended methods to prevent pests and diseases and the recommended bio-pesticides from controlling damage differed from those recommended in previous years.

Moreover, these methods were somewhat more complex than the conventional method. Furthermore, the bio-pesticide recommended during that time was only sold in specific markets nearby to urban areas, making it difficult for some farmers to adopt the IPM component. These findings suggest that the government must improve farmers' accessibility to the recommended inputs to increase adoption. It can be initiated simply by providing input markets near rural production areas instead of only near urban areas.

The regional factor also plays a role in the adoption of the technology. It was found that farmers who lived in the areas closed by or traversed by the major road were more likely to utilize the technology of fertilizing and IPM. It could be attributed to the fact that the areas traversed by the major road usually had better access to public facilities such as governmental office institutions, banks, credit institutions, irrigation canals, and others. Burhansyah (2014) affirmed that distance from settlement to location of the farm, distance from settlement to the source of technology, accessibility to the road, and accessibility to the source of technology also influence the adoption of innovation.

The interviews and focus group discussion revealed that farmers were afraid of the risk of failure following periods of poor weather. Furthermore, they were not willing to adopt particular technology components without seeing the success of other farmers who had adopted the components. This finding provides insight to the government that it is necessary to implement policies to minimize risk and uncertainty due to poor weather. As FAO (2013) presented, response farming can form the basis of strategies to adapt agricultural systems under variable weather conditions. Providing credit facilities and supporting institutions such as village cooperatives can also be solutions for farmers to obtain credit and fair loan interest rates and further minimize risk and uncertainty.

Sasongko & Witjaksono (2014) admitted that farmers' attitudes positively affect technology adoption. Meanwhile, communication behavior and motivation positively affect farmers' attitudes. Wongkar et al. (2016) added that the level of cosmopolitanism is highly related to the level of adoption of innovations in rice cultivation technology. Concerning the implementation of communication of various innovation technology packages among rural communities, there are still gaps and misunderstandings affected by several factors. Among these factors are farmers' socio-economic factors, including income, formal and non-formal education, and age of farmers.

Innovation characteristics become greatly important in influencing farmers' perceptions and attitudes. One of the arguments is that this perception is often the basis for farmers' decisions to accept or reject an innovation. If the technology has the characteristics that farmers want, the innovation will be readily accepted. According to Rogers (1983), these characteristics include components of complexity, comparative advantage, observability, compatibility, and trialability. Meanwhile, Sulastri et al. (2022) grouped it into variables of perceived ease of use and perceived usefulness.

9.3.1. Innovation Adoption Acceleration Strategy

Based on the results of PTT development in many locations in Indonesia, several lessons were learned for further scrutiny. The preparation of technology components, conducted with farmers in a participatory manner by considering the condition of the lowland rice farming system in each location, was intended not to repeat the same mistakes from the uniform approach to technology packages to increase rice production. Unfortunately, the PTT philosophy was poorly understood by agricultural officials. The interviews with extension officers revealed that extension communication techniques were generally one-way, causing the spread and adoption of technology far from the expected impact. The transfer of the extension function from the central government to the local government resulted in less than optimal national PTT socialization. From the farmer's perspective, there was no self-awareness of the economic benefits derived from adopting the PTT approach and the impact on land resources, environmental quality, and improvements in farmers' household incomes. The Indonesian government needs to learn from neighboring countries regarding the PTT approach. Integrated Crop Management in Thailand, the Philippines, and Vietnam has become popular. In Vietnam, this activity has been widely introduced since 2002 through campaigns in radio and national television broadcasts (Zaini, 2008). As a clean, competent, credible, and accountable development agent, agricultural development can be accomplished with good governance (Kustiari, 2016). In synergy with farmers, the government can support the successful application of sustainable rice cultivation technology.

Simultaneously, according to Pello et al. (2019), the role and motivation of the extension workers influence innovation adoption. Three aspects indicate the role of agricultural extension workers: the role of extension workers as educators and assistants, aspects of roles as analyzers and planners, and aspects as experts in evaluating activities and results of extension services. Furthermore, the motivational factor of agricultural instructors is also indicated by three aspects, the instructor's motivation for basic needs, status or social needs, and work performance need. Saridewi & Siregar (2010) agreed that the role of extension workers and technology adoption synergizes to increase rice production.

The strategy for accelerating the application of PTT technology can be achieved through group meetings and field meetings that invite farmers from different villages. It impacts the spread of PTT Technology, specific components, such as seed components, produced in demonstration activities. Sjamsiar et al. (2015) proposed that a technology demonstration should involve farmers with continuous group assistance so that farmers can learn and see firsthand the results.

In addition, the demonstration can be a place for practice and inspiration for non-adopter farmers. The increased income that can be achieved with the recommended technology determines the enthusiasm for implementing a program. The technology that was first recommended should be able to increase farmers' income by 50 to 150%. Permatasari et al. (2018) stated that the greater the benefits provided by new technology than the value generated by conventional technology, the more accelerate the adoption.

Pagiola & Holden (2001) stated that agricultural intensification with the adoption of innovations would be accepted sustainability if it meets several requirements. First, the higher the efficiency of the recommended technological innovation, the higher the price of the harvest after the implementation of the technological innovation. Second, the lower the opportunity cost due to the application of technological innovation compared to other activities, the lower the level of time preference (high discount factor). Third, the lower the current marginal utility compared to future consumption, the handling and its responsibilities must differ. And also the more extension, the more farmer participation to reach the higher production (Padjari, et al., 2021) and the extensor plays the importan rule (Ariana et al., 2021 and Sundari et al., 2021)

Referring to farmers' decision-making to adopt innovation, PTT has taken anticipatory steps into account. A clear example of an anticipatory step from the first requirement of "efficiency" is the use of balanced fertilization based on the soil series to reduce P and K fertilization and N fertilizer efficiency using the Leaf Color Chart (Zaini, 2008). The recommendation of planting quality seeds aims to reduce the use of seeds. After applying technological innovation, the varieties planted must follow market preferences to deal with the high price of grain. In addition, it is necessary to improve grain quality by applying appropriate pre-and post-harvest techniques. It is also crucial to disparate rice prices based on quality (taste and appearance). Another step that can be taken, though still not fully implemented from the government's perspective, is preventing imported rice adulteration. Rice imports should only be done for high-quality products. The government must put pressure and legal action on rice smugglers somewhat.

The lower opportunity cost of labor for other activities with PTT technology allows agricultural mechanization for pre-and post-harvest. This technology is intended to not depend too much on manual labor. The high marginal utility in the future can be anticipated by suppressing consumer preferences for imported rice by improving the quality of domestic rice. Another vital policy is encouraging vertical diversification of rice and its waste. The existence of the Rural Agribusiness Program in 2008 was beneficial for overcoming the problem of agricultural financing. Burhansyah (2014) disclosed that this program increased the number of innovation adopters.

Learning from the era of the green revolution, the development of agricultural programs must take a closer look at the conditions in which productivity improvement programs must have a balanced benefit for farmers. These conditions include profitable cultivation technology packages at various scales of land ownership and balanced land distribution with guaranteed ownership or rental rights. Obtaining inputs, farming credit, and marketing of products mean that policymakers pay more attention to small-scale farmers and farm laborers. Although this condition is not easy to achieve, concerted efforts must ensure that smallholders and farm laborers have equitable access to land, technological innovations, and more modern inputs. Therefore, farmers with different land tenure scales have equal access to advanced technology and get a fair price for their products.

9.4. Conclusion

The food security of a nation is not solely determined by the abundance of natural resources such as land and water. However, it is primarily determined by the quality and capacity of its human capital. Quality human capital will be able to make scientific and technological inventions and innovations, including irrigated rice cultivation technology. Appropriate application of rice science and technology will be able to provide innovative breakthroughs to break up deadlocks to increase rice productivity. The two pillars of a sustainable green revolution are applying rice science and technology based on ecology and economy. An absolute requirement to achieve food security through increased production is a serious effort with total dedication and responsibility, based on harmonious cooperation between development actors and efforts to conserve natural resources in a peaceful living situation.

As for the majority of agricultural technology introduced to farming areas in Indonesia, in some irrigated rice-farming areas of South Sumatra, agricultural technology was promoted as a package that included various components. This study revealed that, instead of adopting the technology as a package, farmers tended to adopt some technology components while neglecting other components. Whereas previous studies presented economic and sociodemographic characteristics of farmers as the significant constraints to adopting new technologies, the study highlighted the importance of farmers' group meetings in exchanging technical information among group members to promote component adoption. The findings suggested that a lack of knowledge and information networks may challenge technology adoption constraints. In addition, the findings recommend improving several conditions, including the availability of local government facilities for farmers' group meeting places and the construction of credit facilities and nearby markets for inputs. Such changes could promote the sustained success and stability of new technology adoption in rice farming in Indonesia.

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CHAPTER 10

MOLECULAR MARKER STUDIES IN SUSTAINABLE AQUACULTURE

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10.1. Introduction

Aquaculture production has become the fastest growing and most demanding food production sector in the world. While the aquaculture production was 87500927 tons, fisheries production was 1119435 tons, according to the FAO 2020 statistics (FAO, 2022). It is estimated that the aquaculture sector will grow by 31% in the next ten years (Gratacap et al., 2019). The aquaculture sector is affected by constantly increasing food demand, climate change, fisheries pressure on natural stocks, and environmental pollution. Under these conditions, the continuation of aquaculture production depends on sustainable approaches.

As in other production sectors, sustainability can be achieved with economically efficient and environmentally friendly approaches. Improving the yield of the stocks under production is essential to making aquaculture sustainable. Selection studies are essential in improving economic traits such as improving growth rate, feed conversion coefficient (FCR), increasing disease resistance, and increasing cold or heat tolerance. It has become more critical to improving the adaptation of aquaculture stocks to changing environmental conditions with climate change. Even in both aquaculture and hydroponic mixture system that called aquaponics to produce more fishes and vegetable at once (Sundari, et al., 2021) Protecting the genetic resources of aquatic stocks is crucial for the sustainability of fisheries and farming. Not only fish but other invertebrate aquatic organisms such as mussels and sea cucumbers are threatened by overfishing (Günay et al., 2021). It is reported that if necessary precautions are not taken until 2050, severe losses may occur in natural fish stocks due to fisheries (Béné et al., 2015).

The advances in molecular genetics have provided significant benefits and rapidity to the genetic improvement of aquaculture stocks in the last 30 years. Species identification, population genetic studies, marker-assisted selection (MAS) studies, gene-assisted selection (GAS), parent determination, quantitative trait locus (QTL) determination, linkage mapping, and genome-wide association studies (GWAS) can be carried out via molecular markers (Özcan Gökçek, 2020a).

10.2. Molecular Markers

Genetic markers are essential molecular tools in taxonomic studies, identifying unknown species even at the larval stage, and population genetic studies. The main fields of molecular marker studies:

- Determining the genetic diversity of natural and aquaculture populations is essential to the sustainability of the aquatic ecosystem,
- Gene-assisted selection (GAS) and marker-assisted (MAS) selection studies,
- Genetic identification of invasive species, determination of the effect on genetic diversity of natural populations, hybridization, and monitoring of interactions,
- Detection of species obtained through illegal fishing,
- Species detection of bacteria, viruses, and parasites in aquaculture species.

The presence of a gene or locus in more than one form in a population is called polymorphism. At least two alleles must be present in a gene to identify as a polymorphism. Monomorphism is the presence of a single type of allele in the locus or gene region. Molecular markers provide direct (DNA-based) or indirect (phenotype-based) information about a genotype in a particular locus or gene (Işık et al., 2022). The detection of polymorphisms and possible relationships with yield characteristics (harvest weight, growth rate, meat quality, etcetera.) are revealed with the help of molecular markers (Özcan Gökçek and Işık, 2020b; Işık and Özdil, 2020). The prediction accuracy increases with the genotypic information of selection studies in aquaculture populations. Havestein et al. (2003) reported that the yield of farm animals could improve by 600% with the application of genetic technologies in the selection.

In addition to breeding studies, molecular markers can be used in many areas, such as controlling and monitoring genetic diversity in natural and cultural stocks, detecting the spread of invasive species, and species determination in aquatic food products. It is possible to classify molecular markers into three categories: I. Generation hybridization (RFLP), II. Generation PCR-based (PCR-RFLP, RAPD, SSRs, etcetera.) and III. Generation sequencing (Sanger) and DNAchip (Illumina etcetera) based SNP (Single Nucleotide Polymorphisms) markers. Also, markers can classify as PCR-based and non-PCR-based markers. New technologies are being developed to reveal the genome more quickly, precisely, and comprehensively.

10.3. Non-PCR based markers

The development of molecular technology in the 1970s made it the first non-PCR-based marker to analyze polymorphisms (variation) in the genome sequence at the DNA level. Genomic DNA is cut with a restriction enzyme that recognizes a specific nucleotide sequence, or different cutting sites are detected in the DNA to which the probe DNA hybridizes. Thus, differentiation can be detected by sequence differences between individuals. Since the RFLP technique has a codominant feature and is more disadvantageous than PCR-based studies, its use has decreased today (Yorgancılar et al., 2015).

10.4. PCR-based markers

The discovery of the Polymerase Chain Reaction (PCR) by Kary Mullis in 1983 gave great impetus to molecular marker studies.

PCR-RFLP (Restricted Fragment Length Polymorphism)

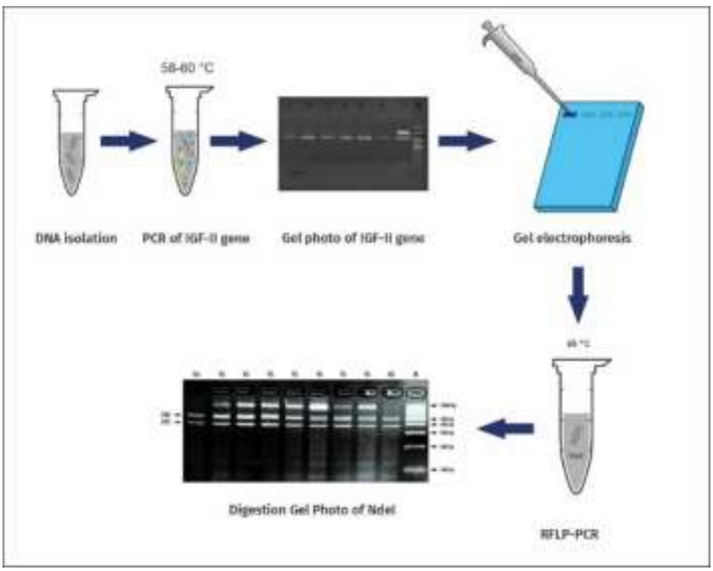

Figure 1. RFLP analysis (Özcan Gökçek et al., 2020c)

PCR amplifies a locus on the genome, and the PCR product is cut from the polymorphic sites with various restriction enzymes. The PCR products are cut and separated by agarose gel electrophoresis, and differences between individuals are determined according to their band size (Figure 1). PCR-RFLP determines polymorphisms in gene regions, and possible relationships with economic traits are investigated in many studies. Sánchez-Ramos et al. (2012) amplified the 13000 bp region of five candidate genes related to growth in *Sparus aurata* by the PCR-RFLP method. As a result of the study, they determined a significant relationship between the *MSTN*-1 gene and the growth traits of *Sparus aurata*. Özcan Gökçek et al. (2020c) found statistically significant associations between the genotypes of *IGF-II-Nde*I locus and body weight and total length of European seabass (*Dicentrarchus labrax*) with the PCR-RFLP method.

PCR-RFLP technique was also used to identify fish and aquatic invertebrates (Galal-Khallaf et al., 2017; Wilwet et al., 2018; Pappalardo et al., 2018). Ferrito et al. (2019) defined shark and swordfish slices via COIBar-RFLP analysis. They reported that the mislabeled swordfish products were identified with the *Mbo*I restriction enzyme. Researchers have found that COIBar-RFLP could be a suitable molecular tool for food identification in seafood. Madeira et al. (2018) used *Sau3A*l ve 16S rRNA restriction nucleases to identify two sea cucumber species. They suggested that the PCR-RFLP was a valuable method for genetic and taxonomic studies of holothurians.

RAPD (Random Amplified Polymorphic DNA)

The RAPD method reveals genetic differences in plant and animal samples. It is an easy and cheap method. This method does not need prior knowledge of a specific target DNA region or gene. A large number of individuals and many loci can be examined simultaneously and quickly with the help of primers of 8-15 nucleotides (Liua ve Cordesb, 2004). Because it does not require prior knowledge about the DNA sample provides a tremendous advantage for organisms whose genome has not been identified yet. In addition, the RAPD technique is an excellent tool where urgent identification is required, such as bivalve species and invasive species (Özcan-Gökçek et al., 2017). Neekhra et al. (2014) reported that 6 of 10 random decanucleotide primers were a fast, cheap, and suitable method for detecting genetic differentiation and band evaluation in 3 species belonging to the *Cyprinidae* family. In another RAPD study, species-specific identification was performed with unique band patterns via random primers in 3 different gray mullet species (*M. cephalus*, *L. Murata*, and *L. ramada*) (Abou-Gabal et al., 2018).

Özcan Gökçek et al. (2017) used RAPD markers to genetically identify invasive and native oyster species collected from the Aegean Sea (Figure 2). Sixteen diagnostic RAPD bands were found in the study; eleven were specific to the *Crassostrea* genus, and five were specific to the *Ostrea* genus. RAPD markers; have low reproducibility and limited use compared to other markers due to difficulties in evaluating PCR band homologies (Ali et al., 2004).

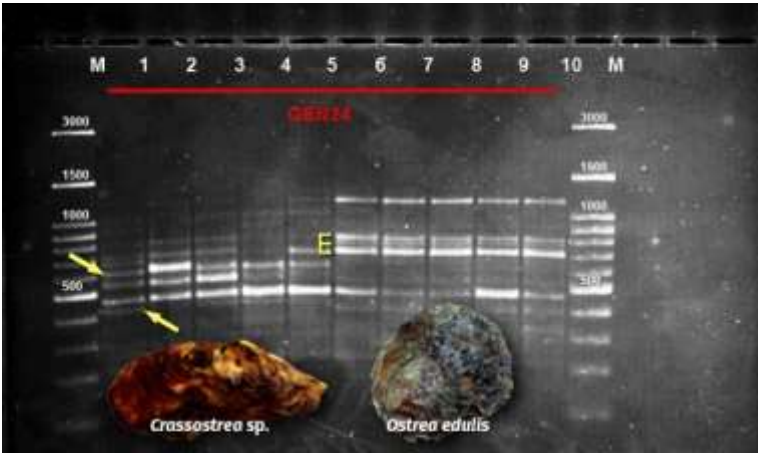

Figure 2. Different oyster species and a gel photo of RAPD bands (Gökçek et al., 2017)

Microsatellites/ SSRs

The SSRs (Single Strand Repeats) or microsatellites marker consists of sequentially repeated groups scattered throughout the prokaryotic and eukaryotic genome. They are species-specific, highly polymorphic, codominant markers, easily studied by PCR. Microsatellite markers are widely used to detect genetic diversity, inbreeding, parental determination, species identification, and commercial tracking (Olununmi 2019). Besides, they are very effective markers for QTL (Quantitative Trait Locus) determination, MAS, and genetic linkage mapping. Sigang et al. (2021) have determined 220709 SSRs in the spotted seabass (*Lateolabrax maculatus*) population. Dinucleotide replication was found at an 85% rate and was primarily seen in AG replications in the *L.maculatus* genoe. The use of genome-wide SSRs found in this study was recommended for marker-assisted selection studies of spotted sea ba s. The progress of SSR markers has been successfully carried out in many aquatic species such as common carp (*Cyprinus carpio*) (Ji et al., 2012), (Huang et al., 2019), Pacific oyster (*Crassostrea Gigas*) (Jiang et al., 2014), and shrimp (Zhang et al., 2019; Yuan et al., 201). Sawayama et al. (2017) reported that the MHC immune gene, which is associated with a major QTL, is a candidate gene for Red sea bream iridoviral disease in red sea bream. They reported that this gene could be used in the MAS study of red sea bream.

Microsatellites are widely used to determine the genetic diversity of natural and farm populations. The microsatellite markers were used for monitoring the genetic diversity of 9 clams (*M. petechial*) populations (Xu et al., 202). They stated that these results would be a handy reference for detecting genetic diversity, monitoring, and protecting clam populations in the future. Genetic diversity of European seabass (Quere et al., 2012; Karahan et al., 2014), Atlantic salmon (*Salmo salar*) (Gilbey et al., 2018), carpet shell (*Polititapes rhomboids*) (Chac'on et al., 2021), silver carp (*Hypophthalmichthys molitrix*) (Luo et al., 2022), lumpfish (*Cyclopterus lumpus*) (Maduna et al., 2020), Nile tilapia (*Oreochromis niloticus*) (Makeche et al., 2022) were studied with SSRs.

SNPs (Single Nucleotide Polymorphisms)

SNPs are caused by polymorphism of a single nucleotide in the genome, and some SNPs seen in exon regions may change the amino acid sequence g. SNPs can be found in the DNA sequence as transition, transversion, insertion, and deletion (Işık et al., 202). Some SNPs located in a gene's intron regions or UTR regions can indirectly affect gene expression by changing regulator sequences. SNP markers are widespread, suitable for digital genotyping, located in coding and non-coding regions of DNA, and more stable than microsatellites. SNPs are widely used to identify candidate genes that affect quantitative traits. SNPs are determined by sequencing many gene regions associated with growth, development, and yield characteristics in farm animals and aquaculture species (Işık et al., 2021) (Figure). Jaser et al. (2017) identified ten SNPs in the *GH* gene of Nile tilapia; nine of them in the promoter region and one within the 5'UTR region. They have found that five SNPs were significantly correlated with growth traits. Özcan Gökçek and Işık (2020) found AT indel and two SNPs in exon 1 and 5' UTR regions of *IGF*-I gene of European seabass.

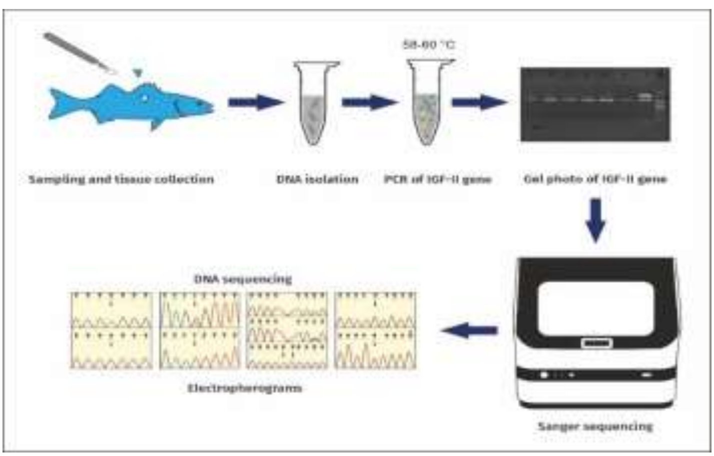

Figure 3. Steps of the SNP analysis (Özcan Gökçek et al., 2020b)

They determined statistically significant associations between the genotypes of IGF-I g.46749C > T, g.46672A > G and growth trai s. Tran et al. (2021) identified that two SNPs (*IGF*1:13680 A>T and *IGF*1R:13357 T>C) were significantly associated with the growth trait *IGFIR* and *IGFI* genes of striped catfish (*Pangasianodon hypophthalmus*). The new methods in sequencing technologies (NGS, WGS) and high-density linkage maps are created by identifying large numbers of SNPs in the genome (Abdelrahman et al., 2017; Sigang et al., 2021; Penaloza et al., 2021) (Figure1). Genetic variances and genetic structures of populations of Gilthead sea bream and European sea bass were investigated with a MedFishSNP array (~60K) (Villanueva et al., 202).

Table 1. Summarization of SNP studies in the aquaculture species

Species	Method of Identification	SNP array density	Numbers of SNPs	References
Dicentrachus labrax	Read-Seq		234,148 SNPs	Tine et al., 2014
Dicentrachus labrax	Pool-Seq	~30K	~20 million SNPs	Penaloza et al., 2021
Salmo salar	RNA-seq		~96,000 SNPs	Tsai et al., 2016
Ostrea edulis	Rad-Seq	~11K	588,266 SNPs	Gutierrez et al., 2017
Crassostrea gigas	Rad-Seq	~27K	12.4 million SNPs	Gutierrez et al., 2017
Cyprinus carpio	2b-Rad Seq		~413,059 SNPs	Su et al., 2020
Oreochromis niloticus	Pool-Seq	~65K	~20 million SNPs	Penaloza et al., 2020
Sparus aurata	Pool-Seq	~30K	~20 million SNPs	Penaloza et al., 2021

The study results detected slight differentiation between eastern and western Mediterranean seabass populations and between Mediterranean and Atlantic seabream populations. It has been reported that the adequate population size is generally more than 1000 in natural populations and less than 100 in farm populations. They suggested that breeding and selection programs should increase genetic variation in farm populations, and escaping from fish farms to nature should be prevented. Some studies of SNPs summarization in the aquaculture species are shown in Table 1.

Aslam et al. (2020) analyzed with Affymetrix SNP-chip (57,184 SNPs) for parasitic diseases (AGD: Amoebic gill disease) of salmon (Salmo sala). They identified three candidate genes, c4, tnxb, and slc44a4, in the QTL2 region of salmon with GWAS (Genome-Wide Analysis Study) analysis. The GWAS method has been reported to increase the prediction accuracy rate by 9-17% compared to breeding studies based on pedigree knowledge. GWAS analysis was performed with a 190 K high-density SNP array in Pacific oysters (*Crassostrea gigas*) (Liu et al., 202?).

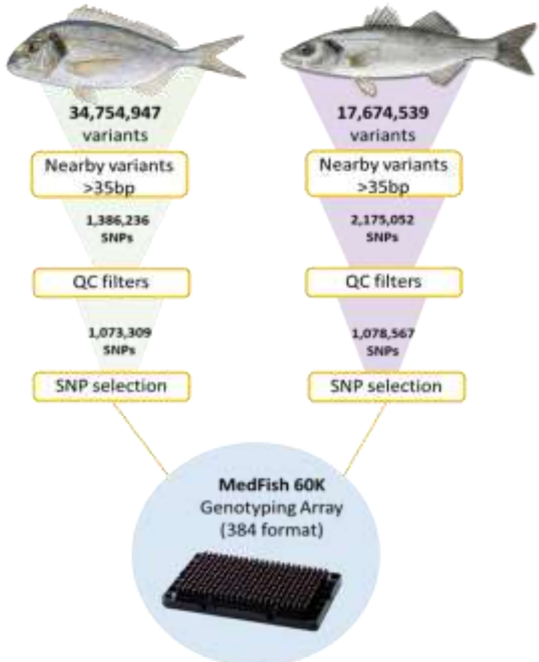

Figure 4. Process of SNP array analysis (medaid-h2020.eu 2020)

This study found the associations of eleven SNPs with growth, yield characteristics, and shell shape of Pacific oysters significant. An SNP is within the exon region of the dipetalogastin gene, which may affect the growth of oysters. This study identified new candidate genes and SNPs related to oyster growth, which is helpful for marker-assisted selection. The studies of whole-genome analysis have stimulated the gene transfer and genome editing studies in aquaculture species (Dunham 2014; Simora et al., 2020; Tao et al., 2020; Özcan Gökçek, 2022).

DNA Barcoding

DNA barcoding technique is based on sequencing of amplified a specific region of genomic DNA, chloroplast DNA or mitochondrial D A. Hebert et al. (2003) have developed universal primers specific to the mitochondrial cytochrome-c oxidase subunit 1 (*COI*) gene, so the *COI* gene has been accepted as the official barcode marker in animals (Hebert 2003a,). The universal primers of the *COI* gene are pretty stable, and the nucleotide substitution rate is high enough to distinguish closely related species and different populations of the same species (Yatkın and Nurper, 201). DNA barcoding was a quick, reliable, and effective method for identifying aquatic animals and processed products (Zhang and

Hanner, 2011; Crocetta, 2015; Shen et al., 2016; Koban Baştanlar, 201). The spread of invasive species is increasing due to climate change and human activities within the aquatic ecosystem. DNA barcodes and integrated databases (BOLD: HTTP: //www.boldsystems.org) play an essential role in tracking the biodiversity of natural populations, identifying alien species, and identifying species acquired from illegal fishing (Williams et al., 2013; Imtiaz et al., 2017) (Figure 5).

In Rahman et al. (2018) study, they investigated 149 freshwater fish species by sequencing the *COI* gene region in Bangladesh. They revealed that the mt *COI* regions of 53 fish had not been reported before in this country. In addition, identified 30 fish species have never been previously described. Invasive Crustacean species are widespread throughout the world. Primers are widely used in detecting these mt COI species and other barcodes (*16S* rDNA, *ITS*1, *ITS*2, etcetera.). Özcan Gökçek et al. (2020d) have identified an invasive oyster species: Pacific oyster with mt *COI* barcode in the Marmara sea of Turk y. In aquaculture, mainly broodstocks are obtained from natural stocks. Therefore, DNA barcoding plays a vital role in monitoring the spread of invasive species and their effects on native aquatic populations.

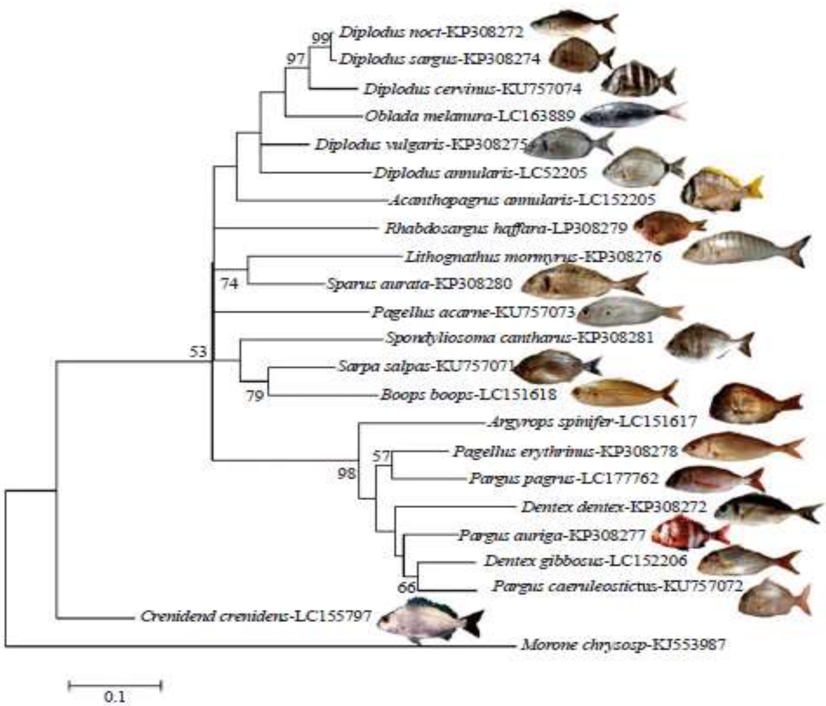

Figure 5. The ML tree of Sparidae fish species is based on the fragment of the mtCOI gene (Abbas et al., 2017)

10.5. Conclusıon

Efforts to increase production productivity and cultural stocks' welfare are essential for sustainable aquaculture. In this context, molecular markers are powerful tools that increase the accuracy of selection studies to improve economic traits. The precision in species identification of molecular markers enables them to find applications in various areas, from natural and hunting stocks to invasive species, endangered species, and species identification in processed fishery products.

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CHAPTER 11

THE ROLE OF LOCAL FOOD IN MANAGING STUNTING IN EAST NUSA TENGGARA PROVINCE

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11.1. Introduction

Stunting is one of the nutritional problems faced in the world, especially in developing countries, which causes stunted growth and mental development. The problem of stunting is driven by individual factors, including food intake, birth weight, infectious diseases, and environmental factors (UNICEF, 2013). Presidential Regulation Number 72 of 2021 concerning the acceleration of stunting reduction, which aims to reduce the prevalence of stunting, reduce the quality of preparation for family life, ensure the fulfil of nutritional intake, improve parenting patterns, service quality, and health, access to drinking water and sanitation. Even can increase nutrient status of community throughout local food (Sundari, et al., 2021, 2021) such banana pseudostem, tubers, bulbis etcetera.

The Indonesian Nutritional Status Study (2021) explains that the national stunting rate in Indonesia has decreased by 1.6% per year from 27.7% in 2019 to 24.4% in 2021. Most of the 34 provinces showed a decline. However, it differs from East Nusa Tenggara Province, the only province in Indonesia that still recorded the highest stunting rate with 37.8%. Furthermore (NTT Provincial Government, 2015) made it clear that this percentage indicates that public health problems are at an appalling level or below the average described according to the WHO classification.

Nursalam (2010) explained that there were various shocks in the occurrence of malnutrition (stunting), and one of the triggers was the problems in the province of NTT. Food scarcity caused by the NTT area, which has a rocky soil structure and little rainfall, has resulted in stunting in NTT. Furthermore (NTT Provincial Government, 2015) also explained the limitations of the NTT community in obtaining nutritious food caused by limited access to food and local food shortages.

The Indonesian Nutritional Status Study (2021) found that South Central Timor Regency had the highest stunting prevalence rate in NTT, reaching 48.3%, followed by North Central Timor District at 46.7% in 20, where this figure was the second-highest in Indonesia. NTT Province. The factors that cause stunting in NTT Province are a lack of nutritional intake, such as a lack of consuming healthy, nutritious, vitamin, protein, and mineral foods.

It can do it by empowering the community by introducing food ingredients. One of the foodstuffs that contain much nutritional intake is local food which is a source of zinc and protein because malnutrition or stunting has a lot to do with micronutrient deficiencies. Micronutrients are contained in local food ingredients for height and weight gain. Local food is an agricultural raw material that is rarely sought after, even though its nutritional content plays a role in reducing the prevalence of stunting.

Several types of local food in NTT Province contain the nutritional value of protein and zinc, which play a role in improving stunting growth, such as local corn, sweet potatoes, and beans. Corn contains complex carbohydrates, vitamins (B, C, D), and omega-3 (is an essential nutrient ordered by the brain); sweet potatoes contain iron, vitamins (C, D, B6) are rich in fiber; while the nuts contain protein, vitamins (C, B6) iron and magnesium, and others.

Local food is a raw material that will later be processed into value-added products. Several community organizations campaign for local food consumption to be promoted by the local community. These organizations educate people to process food ingredients such as corn, beans, sweet potatoes, and Fruits into value-added foods. The organization called *Lakota Kujawas* has a mission to cultivate residents and solve some of the social problems faced in the village, such as poverty, low literacy culture, human trafficking, and others. This organization aims to develop the tradition (Culture) of the Mollo people with various creations and innovations as well as community empowerment and cultural wealth in the Land of Timor through literacy, entrepreneurship, and the arts. This study aimed to determine local food's role in stunting prevention in East Nusa Tenggara Province using a descriptive method.

11.2. Food

Food is biological and air resources, either processed or unprocessed, so that human life can consume, including food and other raw materials that can use in the process of preparing, manufacturing, and processing food and beverages (Law of the Republic of Indonesia No.18 of 2012 concerning Food).

Local Food

Nugraheni (2017) explains that the local community consumes local food according to the potential and local wisdom. Local food is a food product that has long been produced, developed, and consumed in an area or a specific local community group. Generally, local food products are processed from local raw materials, local technology, and local knowledge as well. In addition, local food products are usually developed according to local consumer preferences, so these local food products are closely related to the local culture. Furthermore (Feliase, 2021) explained that local food sources in Eastern Indonesia are abundant in abundance, not East Nusa Tenggara (NTT). Local food is well managed to meet the needs of the community. Several types of local food are often found in NTT, such as sorghum, beans, corn, moringa leaves, sweet potatoes, and many other types of local food in the NTT area. Local food has been known to the people of NTT for a long time. Besides that, local food has various types and forms to be consumed to meet needs. Local food contains sources of carbohydrates, proteins, minerals, vitamins, and other functions that can be flavored.

Types of local food in NTT Province

a. Tubers

Tubers are one type of plant that changes in size and shape (swelling) due to changes. These changes also result in anatomical changes. The organs that make up the tuber are mainly stems, roots, or their modifications. Only a few plants form tubers using their leaves (Heny, 2012). Root crops are one plant often used as food by the community, especially in rural areas, as a substitute for rice. The existence of root crops commonly known to the public is currently limited to root crops such as cassava, sweet potato, and taro.

Figure 1. Local sweet potato. (Source: @ig lakoat.kujawas)

Maybe it is less popular with other types of tubers, and the community has tended to fulfill their carbohydrate needs from rice (Budie, 2013). Root crops such as sweet potato can be processed into:

1. Sweet potato jam uses ingredients such as sugar, citric acid, sweet potatoes, and salt to taste.
2. Dodol uses ingredients such as coconut, glutinous rice flour, sugar, sweet potato, and salt.

3. Sweet potato candy with ingredients, namely sugar, sweet potato, citric acid, and water
4. Sweet potato flour uses sweet potato ingredients that have been dried and then ground.

b. Corn

The Research and Development Center for Food Crops (2015) explains that corn is a carbohydrate-producing food crop. Besides being a carbohydrate source, corn is also an essential source of protein on the Indonesian menu. Corn is rich in functional foods, including dietary fiber that the body needs, essential fatty acids, isoflavones, minerals (Ca, Mg, K, Na, P, Ca, and Fe), anthocyanins, beta carotene, (provitamin A), amino acid composition, essential, and so on. Corn is a resource that is rich in calories and is often used as a staple food. The corn calories are 342 calories/100 grams, one high cereal type.

Cahyani (2010) explained that corn could be distinguished based on the planting period, variety, and shape of the seeds. There are three types of maize based on the planting period, namely: maize with a planting period of 75-90 days which is called short-lived maize, maize with a planting period of 90-120 days which is called early maturity maize, and maize with a planting period of more than 120 days which is called long-lived maize. Furthermore (Jatmiko, 2009) explained that corn could be divided into local, hybrid, and transgenic corn based on the type or variety.

Figure 2. Local varieties of maize. (Source: @ig. lakoat.kujawas)

c. Beans

Susilowati *et al.* (2021) explained that beans, also called legumes, belong to the leguminous family. Nuts contain large amounts of dietary fiber if they can help lower cholesterol levels. Nuts are low in calories, low fat, and low in sodium salt. Nuts also contain protein, complex carbohydrates, folate, and iron. Various types of beans have been widely known, such as soybeans (*Glycine max.*), green beans (*Phaseolus radiatus*), kidney beans (*Phaseolus Vulgaris*), and various other types. Various types of beans can be distinguished based on the variety or type of name, color, shape, and physical character.

Figure 3. Local beans (Source: @ig. lakoat.kujawas)

Nuts are the primary source of vegetable protein and have many benefits. Nuts have many nutritional advantages, including a cheap source of protein, rich in the amino acid lysine, low in fat and no cholesterol, and a good source of B vitamins, calcium, iron, zinc, copper, and magnesium. , low in sodium and sodium content.

11.3. Stunting

Stunting is a chronic malnutrition problem caused by a lack of nutritional intake for a long time. Malnutrition causes problems in the future, such as difficulties in achieving optimal physical and cognitive development. Stunting children have a lower *Intelligence Quotient* (IQ) than the average IQ of normal children (Kemenkes RI, 2018). Septisuari (2018) explains the impact and factors that cause stunting.

Stunting Impact

Stunting can have a harmful impact, both in the short and long term. In the short term, stunting can cause growth failure, cognitive and motor development barriers that affect brain development and educational success, and not optimal physical body size and metabolic disorders. Stunting is a manifestation of a growth disorder in the body. If this happens, then one of the organs of the body that is quickly at risk is the brain. In the brain, nerve cells are closely related to the child's response, including seeing, hearing, and thinking during the learning process.

The long-term impact of stunting is a decrease in intellectual capacity, structural and functional disorders of nerves and brain cells that are permanent and cause a decrease in the ability to absorb lessons at school age which will affect productivity as adults and increase the risk of diseases such as diabetes mellitus, hypertension, coronary heart disease, and stroke. Children experiencing stunting have the potential for imperfect growth and development, low motor skills and productivity, and a higher risk of suffering from non-communicable diseases. Stunting in toddlers impacts potential economic losses due to decreased work productivity and maintenance. All of this will reduce the quality of human resources, productivity, and competitiveness of the nation.

Factors Causing Stunting

Stunting is related to many factors, and these factors are related to one another. Furthermore (UNICEF, 1998) explained that factors related to nutritional status include stunting. First, the direct causes of stunting are nutritional intake and infectious diseases. Unbalanced nutritional intake does not meet the amount and composition of nutrients that meet the requirements of balanced nutrition, such as varied, appropriate, clean, and safe foods. For example, babies are not exclusively breastfed. Second, indirect causes, namely the availability of food at the household level, the behavior or care of mothers and children, and health and environmental services. All are related to the quality of parenting. Food availability at the household level, the behavior or care of mothers and children, and health and environmental services are influenced by the main problems in the form of low education, food availability, and job opportunities. All the causes of nutritional problems above are influenced by fundamental problems called political and economic crises.

Features of stunting

Persistent characteristics or symptoms are characterized by late puberty, age 8-10. Most children are quieter, do not make much *eye contact*, stunted growth, the face looks younger than their age, and delayed tooth growth. Some cases have poor performance on attention and learning memory tests, low body weight for their age, and spinal growth. We acknowledge that this is not the case for everyone who is stunted.

Figure 4. Characteristics of stunting children. (Source: www.viva.co.id)

11.4. Local Food Processing Into Value-Added Products

Food is the raw material of agricultural products such as vegetables, fruits, nuts, and tubers, which are then processed into new products with added value. This food product is then processed according to local culture and wisdom by the local area, which is then termed "local food."

One of the organizations in NTT called *Lakota Kujawas* is a children's social entrepreneurship community that converts local food ingredients into products that have added value. Some of the processed food products are:

1. Processing of candied dried fruit from orange peel and carom, star fruit

Figure 5. Candied dried fruit. (Source: @ig. lakoat.kujawas)

2. Processing forest yam, sweet potato, cassava, plantain banana, and taro are processed into flour for noodles and bread.

Figure 6. Flour from sweet potato, banana, and soybeans (Source: @ig. lakoat.kujawas)

Figure 7. Noodles made from sweet potatoes, bananas, and soybeans (Source: @ig. lakoat.kujawas)

3. Processing *luat* sauce using raw materials from fermented chili, salt, tamarind juice, lemon peel, basil leaves, sipa leaves, mint leaves, coriander leaves, and garlic. This *luat* sauce can last up to 1 year.

Figure 8. Luat Sauce

4. Tempeh is made using local beans (rope beans, green beans, red beans, Turi beans, and koto).

Figure 5. Tempeh made from local. (Source: @ig. lakoat.kujawas)

5. Processing sourdough bread made using mocaff flour variants of pumpkin and purple sweet potato (using *wild yeast* and natural bacteria, homemade lactic acid staying 24 days).

Figure 6. Sourdough bread

11.5. The Role of Local Food in Preventing Stunting

Utilization of local food that contains nutrients is a solution to encourage the prevalence of high growth rates or reduce failure to thrive due to chronic malnutrition (stunting). Proper processing and packaging allow local food to be consumed safely and healthily without containing chemicals. Pranita (2021) explains that some sources of nutrition are derived from local food:

1. Carbohydrates are the largest source of energy in the human body. Carbohydrate intake is needed for 50 to 60% of total daily calories. Types of carbohydrate sources in food intake are vegetables, fruits, and sweet potatoes.
2. Protein is a nutrient needed for the body because it has a very vital function. Protein is one of the nutrients that the body needs in large quantities. When protein is consumed, it is then converted by the digestive system into amino acids, which will then be used by the body to work as a source of energy.
3. Fat is a substance needed by the body as follows:
   a. My source of energy
   b. As a form of membrane and structure of body cells as well as introducing several substances and absorbers of fat-soluble vitamins

c. As a means of transportation of various substances in the body's metabolism
d. As a body temperature regulator (insulator)
e. Some essential fatty acids must be present in the food consumed because the body cannot produce them independently.
f. Children who grow up in conditions of lack of fat intake in their daily menu will not grow optimally.

4. Mineral
   a. Calcium has the most functions compared to other body minerals, including regulating the body's muscle contractions and heart rate, helping build bones and teeth, and ensuring blood pumps usually walk. Sources of calcium are found in dairy and processed products, tofu, fish, beans, and green vegetables such as broccoli and cabbage.
   b. Iron. Some sources of iron are red meat, liver, dried fruit, nuts, seeds, cereals, dark green leafy vegetables, and eggs.

Sources in local food have nutritional value that meets nutritional requirements, are easy to manage, like, and accept, have appropriate protein quality to stimulate physical growth, and are free from germs, preservatives, dyes, and toxins meet value. Social, economic, cultural, and religious.

11.6. The Role of Government and Community Institutions in Tackling Stunting in NTT

Local Food Processing Training

Activities regarding the processing of local food into the food of national standard organized by the local government by utilizing various types of local food such as corn, beans, sweet potatoes, potatoes and sorghum, and others that are converted into foods that have added value. In addition, there are also other training programs such as packaging, prospects for local food products in modern markets, business analysis, *public speaking* related to product marketing, and digitalization *of marketing to increase* SME business opportunities and partnerships**.**

Local Government Programs in Preventing Stunting

The grand strategy to prevent and overcome stunting in East Nusa Tenggara Province in 2019-2023, to implement convergence actions in handling and preventing stunting (short toddlers) in NTT Province, is considering that stunting prevention and handling cannot be carried out only by the health sector. Thus, there is a need for cross-program and related sector involvement. Interventions for preventing and controlling stunting are divided into two, namely Specific Nutrition Interventions and Sensitive Nutrition Interventions.

Specific nutrition interventions are aimed at children in the First 1,000 Days of Life and contribute to a 30% reduction in stunting. The framework of specific nutrition intervention activities is generally carried out in the health sector. This intervention is also short term where the results can be recorded in a relatively short time. Activities that are ideally carried out to carry out specific nutrition interventions can be divided into several primary interventions starting from pregnancy to delivery of toddlers:

a. Specific nutritional interventions targeting pregnant women include providing supplementary food to pregnant women to overcome chronic energy and protein deficiency, overcoming iron and folic acid deficiencies, overcoming iodine deficiency, tackling worms in pregnant women, and protecting pregnant women from malaria other diseases. Other co-morbidities in pregnant women,
b. Specific nutrition interventions targeting breastfeeding mothers and infants 0-6 months are carried out through several activities that encourage early breastfeeding initiation, primarily through the provision of first breast milk/colostrum and exclusive breastfeeding.
c. Specific nutrition interventions targeting breastfeeding mothers and children 7-24 months include activities encouraging continued breastfeeding until the child/baby is 24 months old. Then, after the baby is over six months old, it is accompanied by complementary feeding, giving vitamin A, providing deworming medicine, providing zinc supplementation, fortifying iron in food, providing protection against malaria, providing a complete basis, as well as preventing and treating diarrhea.
d. Specific nutrition interventions targeting adolescent girls and schoolchildren include activities to provide blood supplement tablets for young girls at school and campaigns and counseling on a four-star balanced nutrition menu (carbohydrates, animal protein, vegetable protein, vegetables) for the general public and school children so that parents give school children with healthy food to school.
e. Specific nutrition interventions with family targets include activities for fostering family eating patterns based on a balanced nutritional menu, standardizing toilets and bathrooms, and monitoring clean water quality.

f. Specific nutrition interventions through health promotion and community empowerment include the development of promotional media related to stunting prevention and control both through print media (newspapers, billboards, banners, posters, leaflets, etcetera.) and electronic media (television, radio) as well as the development of local specific media, increasing community capacity through orientation training for Community Leaders, Religious Leaders, Cadres, PKK, Professional Organizations, etcetera., and Improvement of Community-Based Health Efforts (UKBM) such as monitoring the growth of children under five at the Posyandu (Integrated Healthcare Center)

Sensitive nutrition interventions should ideally be carried out through various development activities outside the health sector and contribute to 70% of stunting interventions. The target of NTT, the growing NTT welfare through specific nutrition intervention, is for the public and not specifically for pregnant women and toddlers in the First 1,000 Days of Life. Activities are related to Sensitive Nutrition Interventions can be carried out through several generally macro activities across ministries and institutions. Eighteen activities can reduce stunting through sensitive nutrition interventions. They are as follows:

a. Coordinator of the Task Force for Handling Stunting at the provincial and district/city levels (Regional Development Planning, Research, and Development Agency).
b. Research on Moringa consumption for pregnant women (Regional Research and Development Agency).
c. Provide and ensure access to clean water up to the household level (Public Works and Public Housing Service).
d. Provide and ensure access to sanitation (Department of Public Works and Public Housing).
e. Perform food fortification, Moringa food processing industry (Department of Industry and Trade).
f. Provide access to health services and Family Planning, Youth and Toddler Family Development (BKKBN).
g. Provision of National Health Insurance (JKN) (BPJS Kesehatan).
h. Universal Maternity Guarantee (Jampersal) is available.
i. Provide parenting education for parents (Department of Women's Empowerment and Child Protection).

j. Provision of Universal Early Childhood Education (PAUD) to prevent stunting (Department of Education and Culture).
k. Provide education on reproductive health and nutrition for adolescents (BKKBN and the Office of Women's Empowerment and Child Protection).
l. Provision of social assistance and security for low-income families (Social Service).
m. Increasing food security and nutrition (Department of Agriculture and Food Security).
n. Dissemination of information to the public related to nutritional problems, especially stunting, through mass media (Department of Communication and Information).
o. Provision and Utilization of Village Funds in the context of intervention in nutritional problems for toddlers and under-fives and Members of the Village Community Business Entity (BUMDES).
p. Provision and marketing of marine and fishery products up to the Village Level (Department of Marine and Fisheries and Department of Industry and Trade).
q. Non-Cash Food Assistance and Joint Business Cooperatives (KUBE).
r. Extension of food access until it reaches the household level (Department of Agriculture and Food Security).
s. And the availability of Animal Food Proteins up to the household level (Department of Marine and Fisheries and Department of Animal Husbandry).

11.7. Related Local Government Programs to Promote Local Food Consumption

Related local government progam that carried out in site can promote communitie to consumpt local foor.

1. Technology utilization program: With the existence of technology, it is easier for the community to obtain food with the help of local food provider applications.
2. Urban agriculture program: helping local food farmers who cannot produce locally because of limited land can be overcome by urban farming (*urban farming*).
3. Program to increase the variety of processed: Rice which is a basic need, can be supported with other foods such as sweet potatoes, corn, and

sorghum. Compared to rice, sorghum is far superior in terms of nutrition, such as protein, calcium, iron, phosphorus, and vitamin B1.

11.8. Conclusion

The government's policy of increasing local food production is one of the efforts to overcome the problem of stunting in the Province of East Nusa Tenggara (NTT). South Central Timor Regency is the most significant stunting case with 48.3%, followed by North Central Timor Regency with a stunting rate of 46.7%. The policy taken by the local government to help reduce the stunting rate in NTT is by managing local food so that the nutritional value is relatively high. The use of local food can also be improved by processing it into several types of value-added food pioneered by a youth entrepreneurial organization called "*Lakota Kujawas*" such as processing candied dried fruit from orange peel and carom, star fruit; local food processing, and there are still many processed local food products. The local community still needs policies to manage local food sources because there are inadequate skills in managing local food.

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CHAPTER 12

COMPARISON OF BEAN CULTIVARS A GROWN IN SUFFICIENT IRON-CONTAINING ENVIRONMENT IN TERMS OF SOME NUTRITIONAL PROPERTIES

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12.1. Introduction

Bean is a dicotyledonous plant, and in terms of iron uptake mechanism, it is included in the plant group specified as Strategy-I. The plants in this group take the ferric (Fe^{+3}) iron in the soil after converting it into ferrous (Fe^{+2}) iron (Figure 1).

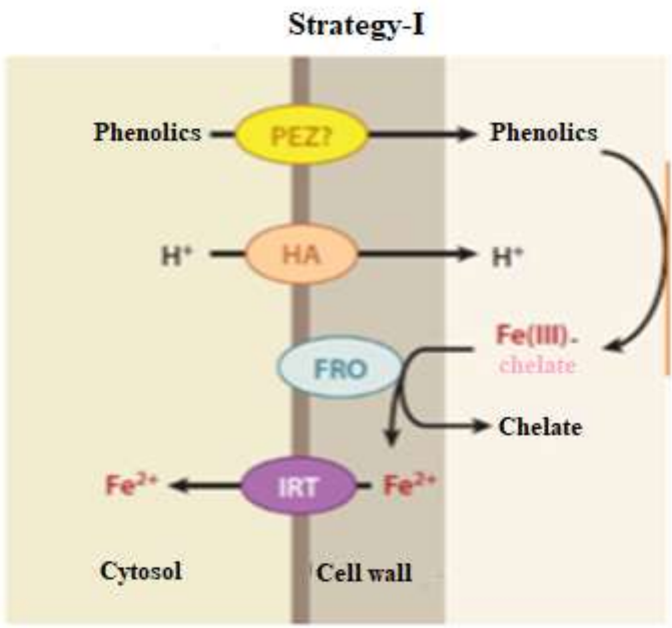

Figure 1. Iron uptake mechanism in Strategy-I plants (including beans)

In Strategy-I, plants' iron uptake was improved by obtaining plants with the following characteristics: i) by obtaining plants that provide protons, increase the acidity of soil and the solubility of iron in the soil, ii) by obtaining plants that reduce Fe^{+3} to Fe through increasing the activity of Fe^{+3} chelate reductase enzyme, iii) by obtaining plants that transport Fe^{+2} from *plasmalemma* by providing Fe^{+2} career activity.

Strategy-I plants are usually dicotyledon plants, and by transferring genes related to iron uptake and transfer from *Arabidopsis thaliana* to these plants, it has been tried to obtain varieties effective in iron uptake. Studies have shown that in tomato plants exposed to iron deficiency, Fe^{+3} chelate reductase enzyme activity increased in the root where chlorophyll is decreased (Zamboni et al., 2012). In selecting bean cultivars that are effective in iron uptake, chlorophyll content of leaves in varieties grown in iron deficient or iron sufficient mediums, chlorosis index values, active iron in leaves, root ferric reductase enzyme activity, acidity in root medium are taken into account as index values. In recent studies, iron content in nodules of the roots of different bean cultivars has also been used as an index due to the importance of iron in bean rhizobium symbiont (Krouma et al., 2006).

According to Loué (1986), the physiological roles of iron in plants are listed as follows:

1) Iron is effective in respiration in plants,
2) It is influential in chlorophyll formation
3) It is effective in photosynthesis
4) It is essential in protein metabolism. In iron deficiency, the protein content in the leaf is reduced by half compared to healthy leaves.
5) It is effective in nucleic acid metabolism, half reducing RNA in iron deficiency. It is effective in nitrogen fixation in leguminous plants. The large protein part of nitrogenase has a 9:1 ratio of Fe:Mo. In the small protein part of the enzyme, there is an iron atom in each protein molecule. Iron-containing ferredoxin provides the electrons required to reduce molecular nitrogen in legumes.
6) It is required in the reduction of nitrates. In addition to iron, flavin adenine dinucleotide, cytochrome b, molybdenum, and manganese are also required to reduce nitrates.

Başar (2002) stated that foliar ferrous sulfate application provided successful results in the removal of iron chlorosis in soybean and reported that foliar application of Fe-EDDHA increased the active and total iron content of leaves and prevented chlorosis. In their study in Tunisian vineyards, Ksouri et al. (2001) found that chlorosis in leaves occurred due to the decrease in chlorophyll-a and chlorophyll-b content, while total iron did not change in leaves with and without chlorosis. Researchers have stated a high correlation between active iron (Fe^{+2}) content and chlorophyll content in plant leaves. Researchers have also reported that the photosynthesis activities of plants depend on the active iron content of leaves. Korkmaz et al. (2006) stated that the correlation coefficients of the relationships between chlorophyll-a, chlorophyll-b, and total chlorophyll content of peach leaves and active iron content of leaves were positive and statistically significant and reported that the correlation coefficients of these relationships were $r=0.972^{**}$, $r=0,963^{**}$ and $r=0,975^{**}$, respectively. In the study, chlorophyll-a, chlorophyll-b, and total chlorophyll content of leaves increased as their active iron content increased. The researchers who concluded that active iron could be a good criterion for determining plants' iron nutritional status reported no correlations between active iron and the total iron content of peach leaves.

Barak and Chen (1983) reported that potassium fertilizers in peanuts reduced the chlorosis of limestone due to their effect on cation-anion balance. Researchers reported that while the chlorophyll content of plants grown in soils containing 63% lime increased by 90% with the effect of Fe-EDDHA chelate, it increased by 73% and improved with the effect of potassium chloride and potassium nitrate fertilizer. Loué (1986) stated that the interaction between phosphorus and iron was meaningful and that the enrichment of soils with phosphorus is among the factors that increase chlorosis in calcareous soils, while they reported that there was no general correlation between the available phosphorus content of the soil and iron chlorosis. Olsen (1972) reported that phosphorus-bound iron was less mobile than citrate-bound iron and stated that the reducing effect of phosphor on iron uptake was more critical when the pH of the growth medium was high. Ayed (1970) stated that since the phosphor content of the medium was high, iron content was slightly affected in plants showing iron chlorosis, while the phosphor iron ratio was very high. This study also reported that high phosphor content in plants could decrease iron mobility. The phosphor and iron content in tomato roots was higher than the part above ground, related to the formation of iron phosphate in or on the roots.

Watanabe et al. (1965) also reported that excessive amounts of phosphor applied to the growth medium of various plants increased iron chlorosis and caused decreases in the product. Within the framework of these studies, in the comparison of bean cultivars grown in sufficient iron medium in terms of iron nutritional properties, dry matter amount, chlorophyll concentration, the active and total iron content of plants, ferric reductase enzyme activity on leaves, total nitrogen in the plant, phosphor and potassium content of plants were taken into account. This study aimed to compare bean cultivars grown in a medium including sufficient iron in terms of some iron nutritional properties and to determine the best iron nutritional characteristic of the cultivars.

12.2. Material and Method

The 15 bean varieties examined in the study were obtained from the T.R. Ministry of Agriculture Black Sea Agricultural Research Institute Directorate. The names of the 15 different bean cultivars examined in the study are as follows: 1) Önceler (pole bean), 2) Göynük (dwarf), 3) Eskfbud-2 (pole bean), 4) Ktakfbv.2(FÇ.113) (dwarf), 5) Pure line (Eskfbvd-6) (dwarf), 6) Yunus90 (dwarf),

7) Eskfbud-11 (pole bean), 8) Eskfbvd-14 (pure line) (pole bean), 9) Zülbiye (dwarf), 10) Eskfbud-7(dwarf), 11) Karalcaşehir 90 (dwarf), 12) Ada - 13-6-(dwarf), 13) Ktakfbvd1(pure line) (dwarf), 14) Ktakfbvd-3 (Fç.304) (dwarf), 15) Eskfbvd-8-(pure lne) (dwarf). In the trial, the following nutrient solution reported by Hewitt [15], which was adjusted to pH 6.0, was applied: 1,0 mM NH_4NO_3; 1,60 mM KH_2PO_2; 3,50 mM $CaSO_4$; 1,50 mM $MgSO_4$; 1,50 mM K_2SO_4; 4,0 µM H_3BO_3; 4,0 µM $ZnSO_4$; 4,0 µM $MnSO_4$; 0,12 µM $(NH_4)_6Mo_7O_{24}$. Chelated Iron (Fe-EDDHA) containing 100 µM Fe was added to this nutrient solution. This nutrient solution was applied to 15 bean cultivars in pots filled with 445 g quartz sand.

In the trial carried out by growing a bean plant in each pot, 30 mL of the nutrient solution prepared at the above concentrations was applied daily. Bean cultivars were grown for 50 days. Leaf samples were taken from the plants for analyses on fresh leaves. Above-ground parts of the plants were dried in ovens set at 65 ^{o} C, and dry matter weights were determined (Kacar and Inal, 2008). Ferric reductase activity in fresh leaves was carried out according to the method reported by Ojeda et al. (2004). Active iron was determined in fresh leaf samples. For this, fresh leaf samples were extracted with 1,0 N hydrochloric acid, and the atomic absorption of active iron in the filter was determined with a spectrophotometer (Takkar and Kaur, 1984). Chlorophyll-a, chlorophyll-b, and total chlorophyll determination were made in fresh leaf samples as reported by Arnon (1949) and Witham et al. (1971). Kacar and Inal (2008) reported that total nitrogen, phosphorus, potassium, and iron were found in dried and ground plant samples. CLA clustest or similarity test was applied to determine and group the similarity and dissimilarity of bean cultivars grown in a good iron environment. Clustering analysis was performed according to the Ward method in JMP.5.0 statistical package program. In addition, Biplot analysis was performed to determine the best iron nutritional properties of cultivars grown in a sufficient iron environment and to group these bean cultivars.

12.3. Results and Discussion

Iron nutritional properties are determined in some bean cultivars grown in a sufficient iron environment.

Table 1 shows the mean values of 10 characteristics determined in bean cultivars grown in sufficient iron nutrition environment. When the table is examined, the highest dry matter amount was found in variety number 4, while the lowest dry matter amount was found in variety number 9 in sufficient iron nutrition environment. The highest ferric reductase activity in the leaf was found in variety 6, while the lowest ferric reductase activity in the leaf was found in variety 7. The highest chlorophyll-a content was found in variety 11 leaf, while the lowest was found in variety 4. the highest chlorophyll-b content was found in variety 7. In contrast, the lowest chlorophyll-b content was found in variety 9. The highest total chlorophyll content was found in variety 11, while the lowest total chlorophyll content was found in variety 4. The highest active iron and total iron content were found in variety 9, while the lowest active iron and total iron content were found in variety 11. The highest nitrogen content was found in variety 7, while the lowest nitrogen content was found in variety 14; the highest phosphorus content was found in variety 3, while the lowest phosphorus content was found in variety 15; the highest potassium content was found in variety 3, while the lowest potassium content was found in variety 14.

Table 1. Mean values of 10 characteristics were determined in bean cultivars grown in sufficient iron nutrition environment (plants fed with 100 µM iron solution)

Cultivar number	DM g plant^{-1}	Chlo. a, mg g^{-1}TM	Chlo. b, mg g^{-1} M	Total chlo. , mg g^{-1} TM	Active Fe, ppm	FRA, µmol hour^{-1} g^{-1} TM	Total Fe content, ppm	N content, %	P content, %	K content, %
1	7,34*	0,73	0,39	1,12	29,40	66,68	212	2,89	0,65	2,31
2	6,82	0,80	0,44	1,25	24,43	23,27	208	2,61	0,65	2,21
3	5,76	0,96	0,51	1,47	24,00	26,95	202	2,68	**0,92**	**2,97**
4	**10,00**	**0,66**	0,42	**1,08**	26,50	103,58	183	2,13	0,72	2,52
5	8,19	0,69	0,41	1,10	34,96	42,85	196	2,55	0,59	1,86
6	7,87	0,74	0,43	1,17	30,86	**341,30**	255	2,19	0,49	2,01
7	5,54	0,99	**0,56**	1,55	47,45	**20,78**	257	**3,21**	0,64	2,57
8	6,03	0,81	0,40	1,21	29,63	42,93	190	2,50	0,54	2,34
9	**4,47**	0,74	**0,38**	1,12	**61,25**	42,59	**446**	2,61	0,73	2,90
10	5,19	0,75	0,39	1,15	47,50	32,57	282	2,33	0,45	1,91
11	4,57	**1,06**	0,50	**1,56**	**23,33**	56,73	**180**	2,49	0,51	2,02
12	4,68	0,81	0,41	1,22	24,76	159,6	189	2,49	0,63	1,92
13	5,55	0,81	0,45	1,26	29,00	146,55	196	2,44	0,66	1,88
14	5,25	0,76	0,41	1,22	26,33	137,47	202	**2,11**	0,59	**1,80**
15	5,45	0,94	0,50	1,44	30,43	110,71	227	2,57	**0,41**	2,30

*Each number is the mean of three replicatios

Grouping of some bean cultivars grown in a sufficient iron environment in terms of predetermined iron nutritional properties, similarity and dissimilarity values

Figure 2 shows some bean cultivars grown in a sufficient iron environment regarding predetermined iron nutritional properties. When Figure 2 is examined, it can be seen that bean cultivars grown in a sufficient iron environment are grouped in 2 in terms of iron nutritional properties. 11 varieties (1, 5, 2, 8, 10, 4, 6, 12, 13, 14, 9) are clustered in the first leading group, while four varieties (3, 7, 11 and 15) are clustered in the second leading group.

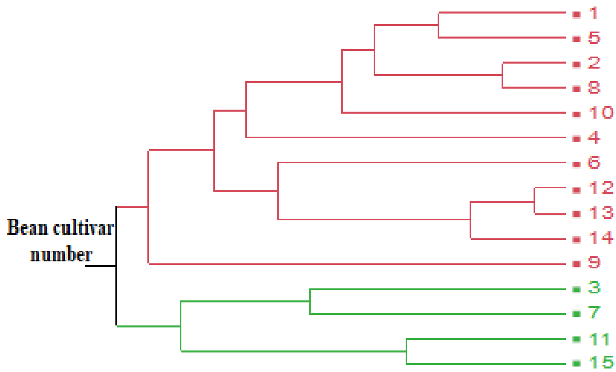

Figure 2. Grouping of some bean cultivars grown in a sufficient iron environment in terms of predetermined iron nutritional properties

Table 2 shows the intragroup similarity values of the cultivars in terms of the properties examined in a good iron nutrition environment. When Table 2 is examined, it can be seen that varieties 12 and 13 were the most similar, while varieties 1 and 3 were the most dissimilar in terms of iron nutritional properties in a good iron nutrition environment.

Table 2. Similarity and dissimilarity values of the cultivars in a sufficient iron nutrition environment in terms of iron nutritional properties

Grouping of some bean cultivars grown in a sufficient iron

Number of groups	Intragroup similarity value	Group members	
14	0,783	12	13
13	1,059	2	8
12	1,221	12	14
11	1,426	1	5
10	1,500	11	15
9	1,724	1	2
8	2,687	1	10
7	2,824	3	7
6	2,901	6	12
5	3,090	1	4
4	3,591	1	6
3	3,617	3	11
2	5,200	1	9
1	6,583	1	3

environment in terms of the best iron nutritional properties

Figure 3 shows some bean cultivars grown in a sufficient iron environment regarding the best iron nutritional properties. Figure 3 shows the classification of the characteristics examined in a sufficient iron nutrition environment and the changes in cultivars in terms of characteristics. In the analysis made with the Biplot method, PC1 (1st main component) constituted 36.3% of the variation, PC2 (2nd main component) constituted 30.1% of the variation, and the sum of PC1 and PC2 constituted 66.4% of the variation.

As seen in Figure 3, characteristics according to cultivars and the distribution of cultivars differed in a sufficient iron nutrition environment. According to the results of the analysis made, it was found that cultivars 4, 6, 12, 13, and 14 were suitable in terms of ferric reductase activity in leaf and dry matter amounts in a sufficient iron nutrition environment and that these cultivars were in the same group. Similarly, it was found that cultivars 1, 2, 5, 8, 9, and 10 were suitable in terms of active Fe in leaf, total phosphorus, and iron content in a sufficient iron nutrition environment and that these cultivars were in the same group.

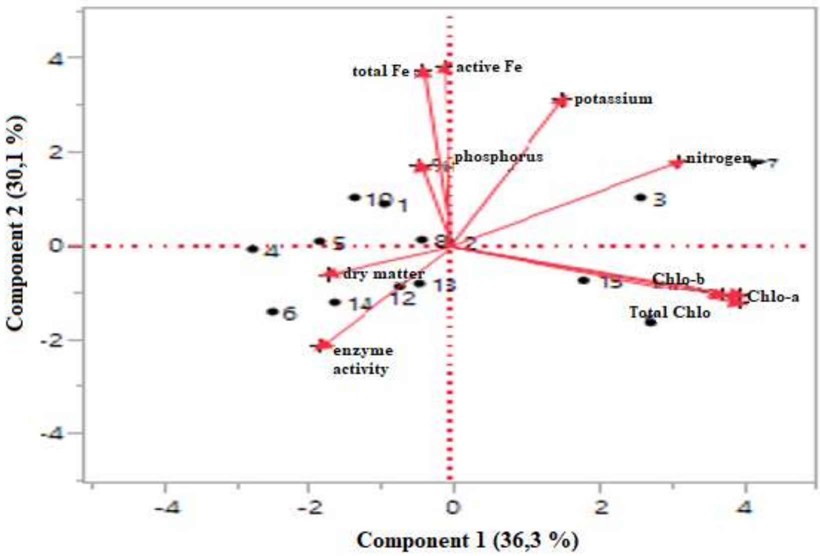

Figure 3. Grouping of some bean cultivars grown in a sufficient iron environment in terms of the best iron nutritional properties

It was also found that cultivars 3 and 7 were suitable in terms of total nitrogen and potassium content in a sufficient iron nutrition environment and that these cultivars were in the same group. Similarly, it was found that cultivars 11 and 15 were suitable in terms of chlorophyll-a, chlorophyll -b, and total chlorophyll in leaf in a sufficient iron nutrition environment and that these cultivars were in the same group.

The resistance of five different dry bean cultivars (Coco Blanc, Striker, ARA14, SVM29-21, and BAT477) to iron deficiency was examined in a study (Krouma et al., 2003). Chlorosis symptoms, plant development, acidity capacity in the root environment, and ferric reductase enzyme activity in roots were chosen as the index in this study. In this study, chlorosis symptoms in BAT477 and Coco Blanc cultivars were found to be more severe when compared with other cultivars. It was observed that the rhizosphere acidification capacity of Striker, SVM29-21, and especially ARA14 bean cultivars was high in nutrient solution but deficient in iron. In addition, it was also observed that plants grown in iron sufficient environment increased the pH of plants' nutrition solution. The rhizosphere acidification capacity of plants was measured in a nutrition solution environment containing 10 mM KCL+1mM $CaCl_2$. ARA14 was found to have the highest acidification capacity, followed by Coco Blanc and BAT477. It was found that root ferric reductase activity increased in all bean lines in iron deficiency conditions, and the highest root ferric reductase activity was found in the Striker bean cultivar. The deficiency condition means that the Striker cultivar is effective in iron uptake.

The same study on selecting bean cultivars adapted to iron deficiency was based on cultivars' rhizosphere acidification capacity and root ferric-chelate reductase activity (Krouma et al., 2003). When the indices specified in this study were considered, the bean cultivar resistant to iron deficiency was determined as ARA14. The solubility of ferric iron is facilitated as a result of rhizosphere acidification. An increasing correlation was found between proton outlet and ferric reductase activity in the cultivars examined. Researchers showed that ferric reductase activity is pH sensitive and inhibited in alkaline soil. It was stated that iron content in the nodule could also be used as an index in selecting cultivars resistant to iron deficiency in legume plants. In this study, researchers also showed that the chlorophyll content of Flamingo bean (resistant to iron deficiency) grown in sufficient and deficient iron environment was higher than the Coco Blanc (sensitive to iron deficiency).

12.4. Conclusion

Bean cultivars grown in a sufficient iron environment were grouped in 2 in terms of iron nutritional properties. 11 cultivars (1, 5, 2, 8, 10, 4, 6, 12, 13, 14, 9) were clustered in the first leading group, while four cultivars (3, 7, 11 and 15) were clustered in the second leading group. In other words, varieties 1, 5, 2, 8, 10, 4, 6, 12, 13, 14, and 9 grown in a sufficient iron environment were similar regarding iron nutritional properties. Similarly, cultivars 3, 7, 11, and 15 were similar regarding iron nutritional properties. It was found that cultivars 12 [Ada-13-6-(dwarf)] and 13 [Ktakfbvd1 (pure line) (dwarf)] were the most similar, while cultivars 1 [Önceler (pole bean)] and 3 [Eskfbud-2 (pole bean)] were the most dissimilar in terms of iron nutritional properties in sufficient iron nutrition environment. It was found that cultivars 12 and 13 were suitable in terms of ferric reductase activity in leaf and dry matter amounts. Cultivar 1 [Önceler (pole bean)] was excellent regarding active Fe in leaf, total phosphorus, and iron content. It was also found that cultivar 3 [Eskfbud-2 (pole bean)] was a suitable cultivar in terms of total nitrogen and potassium content.

Of the cultivars 1 [Önceler (pole bean)] and 3 [Eskfbud-2 (pole bean)], which were dissimilar, it was found that cultivar 1 [Önceler (pole bean)] had higher dry matter, active iron, total iron, and nitrogen content and ferric reductase activity values than cultivar 3 [Eskfbud-2 (pole bean)]. However, it was found that cultivar 3 [Eskfbud-2 (pole bean)] had higher chlorophyll-a, higher chlorophyll-b, total chlorophyll, total phosphorus, and potassium content than cultivar 1 [Önceler (pole bean)].

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CHAPTER 13

DETERMINATION OF THE RESISTANCE OF SOME SUNFLOWER LINES TO IRON DEFICIENCY

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13.1. Introduction

The sunflower plant is a plant species sensitive to iron deficiency, and in case it is grown in soils with iron deficiency, significant yield and quality losses occur. According to the analysis of many soil samples collected from different regions of Turkey, Fe deficiency is the most common micro element deficiency after zinc, with a rate of 27% (Eyüpoğlu and Korucu, 1997). The characteristics of reducing the rhizosphere pH and increasing the capacity of the roots to reduce +3-valent iron (Fe^{+3}) to +2-valent iron (Fe^{+2}) in order to adapt to iron deficiency conditions in plants such as sunflower were reported to differ considerably between genotypes (Alcantara and Guardia, 1991). Researchers also stated that iron uptake in sunflower was related to the capacity of roots to decrease rhizosphere pH or to reduce +3 valent iron to divalent iron (Fe^{+2}) in the rhizosphere. It was stated that the sunflower was one of the plant species sensitive to iron deficiency (Mengel et al., 1994; Ranieri et al., 2001).

Görmüş and Barutçular (2016) reported that the sunflower was a susceptible plant to iron deficiency, and they also stated that the cultivation area and production of sunflower in Turkey, especially in the Çukurova Region, increased significantly in recent years. Eyüpoğlu et al. (1997) stated that the available iron concentration of Turkish soils was low, which may cause significant losses in the yield and quality of sunflowers. Strategy-I plants are generally dicotyledonous plants, and by transferring genes related to iron uptake and transport from Arabidopsis thaliana to these plants, it has been tried to obtain varieties that are effective in iron uptake. The studies determined that chlorophyll decreased in tomato plants exposed to iron deficiency, and Fe+3 chelate reductase enzyme activity increased in the root. In Strategy-I plants, it was reported that plants with the following issues were capable of iron uptake. These features were: 1) the roots of varieties capable of iron uptake had the feature of increasing the acidity of the soil and the solubility of iron in the rhizosphere by removing protons. 2) Plants capable of iron uptake had the feature of reducing +3-valent iron (Fe^{+3}) to +2-valent iron (Fe^{+2}) by increasing the Fe^{+3} chelate reductase enzyme activity in their roots under iron deficiency conditions. 3) Varieties capable of iron uptake had the feature of enabling the transport of +2 valent iron (Fe^{+2}) from the plasmalemma by increasing the Fe+2 transporter activity (Zamboni et al., 2012). It was reported that the uptake and availability of iron significantly decreased due to unsuitable soil, climate, and plant factors. It was also stated that poorly ventilated, cold, calcareous or alkaline soils were soils where iron deficiency was common in plants (Marschner et al., 1986; Inskeep and Bloom, 1987). Plants grown in such soils developed adaptation mechanisms against iron deficiency conditions by increasing iron availability in the rhizosphere. As a result of these mechanisms, it was stated that they got enough iron with their roots. Root responses in adaptation to iron deficiency conditions varied among plant species. It was stated that reducing +3-valent iron to +2-valent iron (Fe^{+2}) on root surfaces was an essential process for iron uptake of Strategy-I plants (Chaney et al., 1972; Römheld and Marschner, 1986). Marschner et al. (1986) stated that another characteristic of Strategy-I plants in conditions of iron deficiency was to increase the acidity of the rhizosphere with an ATP_{az} proton pump, which contributed to the iron nutrition of the plant by increasing the solubility of iron in the rhizosphere.

It was reported that iron was an essential element in the many cellular functions of the plants on the biosynthesis of the chlorophyll, photosynthesis, respiration, DNA synthesis, electron transport chain in mitochondria and chloroplasts, protein synthesis, reduction of nitrates to ammonia. (Ishimaru et al., 2006; Kumar et al., 2013). Iron is also involved in the structure of enzymes such as catalase, peroxidase, aconitase, and superoxide dismutase. (Marschner, 1995). Fe^{+2} and Fe^{+3} redox couple play an essential role in plant development by increasing enzymatic redox reactions (Gill and Tuteja, 2010). In plant breeding, hybrid varieties are obtained by crossing between lines. The iron nutritional abilities of hybrid varieties come primarily from the lines used in crossing. Individuals formed as a result of inbreeding are called lines. Inbreeding is the process of crossing between close relatives. Knowing the iron nutrition capabilities of the lines obtained by inbreeding for many years is crucial because it reflects the iron nutrition ability of the hybrid variety to be obtained. This study aims to compare the resistance of some sunflower lines to iron deficiency and determine the best characteristics of the line that is resistant to iron deficiency.

13.2. Material and Method

Material

In the study, seven different sunflower lines were examined. It consisted sunflower line,laboratory number, the average number of seed per head, rate if grain filling, head diameter, head shape, sunflower seed shell or debulled seed. Some characteristics of sunflower lines are given in Table 1.

Table1. Some table characteristics of sunflower lines (Aytaç et al., 2016)

Sunflower line no	Laboratory number	The average number of seeds per head	Rate of grain filling	Head diameter	Head shape	Sunflower seed shell / dehulled seed
12	1	869	80.0	25.2	Smooth-smooth conic	52.2
18	2	972	77.0	27.1	Smooth conic	58.5
21	3	708	82.0	24.2	Smooth-smooth conic	53.66
25	4	928	73.0	25.1	Smooth	54.65
28	5	967	62.8	26.6	Smooth-smooth conic-invert conic	51.63
34	6	869	68.0	23.8	Smooth-invert conic	58.42
37	7	754	81.2	22.5	Smooth conic-invert conic	65.18

Method

Sunflower lines were grown in 300mL plastic pots with drain holes filled with 445g of washed quartz sand. Factorial trials were carried out in a randomized parcel plot design of 7×3 (line × iron dose) in a quartz sand environment. In the trials, each treatment was applied with three repetitions, the pH of the nutrient solution used was adjusted to 6.0, and the nutrient concentration was given below (Öztürk et al., 2008): 0.75 mM K_2SO_4; 2.0 mM $Ca(NO_3)_2 \cdot 4H_2O$; 1.0 mM $MgSO_4 \cdot 7H_2O$; 0.25 mM KH_2PO_4; 0.1 mM KCl; 1.0 µM $MnSO_4$; 1.0 µM $ZnSO_4 \cdot 7H_2O$; 10 µM H_3BO_3; 0.01 µM $(NH_4)_6Mo_7O_{24}$; 0.1 µM $CuSO_4.5H_2O$. Fe-EDDHA was added to the applied nutrient solution containing 0.45 and 100 µM Fe. Dilution was done after emergence, so there was one sunflower plant in each pot. After dilution, 50 ml of the nutrient solution was applied to each pot from the nutrient solution every day.

Sunflower lines were grown for 50 days by applying the nutrient solution. Leaf samples were taken for analysis to be made on fresh leaves. The aboveground parts of the plants were dried in an oven set at 65°C, and their dry matter (DM) weights were determined (Kacar and İnal, 2008). Ferric reductase enzyme activity was determined in fresh roots and leaves, according to Ojeda et al. (2004). Enzyme activity was expressed as µmol/hr/g of Fresh Matter (FM)

For the determination of active iron, fresh leaf samples were extracted with 1.0 N hydrochloric acid, and the iron in the filtrate was determined by atomic absorption spectrophotometer (Takkar and Kaur, 1984). Chlorophyll-a, chlorophyll-b, total chlorophyll, and carotenoid determinations were made according to Arnon (1949) and Witham et al. (1971). Tolerance index values of sunflower lines to iron deficiency were calculated as follows:

$$\textbf{Proportional values, \% = (A / B)} \times \textbf{100}$$

A: Chlorophyll-a, chlorophyll-b, total chlorophyll, active iron contents, and dry matter amounts determined in lines grown with iron-free nutrient solution

B: Chlorophyll-a, chlorophyll-b, total chlorophyll, active iron contents, and dry matter amounts determined in lines grown with 45 µM or 100 µM iron-containing nutrient solution

Statistical Analysis

A cluster test or similarity test was applied to determine the proximity and distance of sunflower lines from each other in terms of iron nutrition indices under iron deficiency conditions. According to Ward's Method, cluster analysis was performed in the JMP.5.0 statistical package program. In addition, Biplot analysis was carried out to classify the iron nutrition indices and other characteristics according to the lines, determine the change of the lines according to these indices and characteristics, and determine the best characteristics of the lines.

13.3. Results and Discussion

Classification of sunflower lines under iron deficiency conditions, their proximity distances, and their good characteristics

The values of 19 different parameters related to iron nutrition indices and other characteristics examined in sunflower lines under iron deficiency conditions are given in Table 2. Under iron deficiency conditions, line 25 had the highest values among sunflower lines regarding root ferric reductase enzyme activity (FRA), dry matter content, and leaf nitrogen content. In addition, it was determined that line 21 had the highest values in terms of ferric reductase activity and active iron content in the leaf, then line 34 had the highest values in terms of chlorophyll-a content in the leaf. Line 18 had the highest values in terms of chlorophyll-b content in the leaf; Line 12 had the highest values in terms of total chlorophyll content in the leaf and line 28 had the highest values in terms of root cation exchange capacity (Root CEC)

Table 2. Values of iron nutrition indices and some other characteristics of sunflower lines under iron deficiency conditions

Sunflower line no	FRA at root µmol/hr/g FM	FRA in leaf, µmol/hr/g FM	Chlorophyll-a, mg/g FM	Chlorophyll-b, mg/g FM	Total chlorophyll, mg/g FM	Active Fe, ppm	Yield, g DM/plant	N, %	Root KDK, me/100g DM
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
12	**252.42**	**337.24**	**1.5**	**0.62**	**2.13**	**7.56**	**10.35**	**0.98**	**3.51**
18	**258.95**	**332.12**	**1.05**	**0.7**	**1.89**	**7.32**	**12.8**	**1.04**	**3.2**
21	**245.48**	**355.31**	**1.42**	**0.54**	**1.96**	**14.64**	**9.48**	**0.94**	**3.55**
25	**273.11**	**341.75**	**1.43**	**0.58**	**2.02**	**9.12**	**13.32**	**1.1**	**4.58**
28	**234.9**	**333.93**	**1.46**	**0.59**	**2.06**	**8.02**	**8.6**	**1.03**	**5.89**
34	**249.53**	**333**	**1.58**	**0.53**	**2.11**	**7.85**	**10.46**	**1.06**	**3.89**
37	**253.9**	**327.9**	**1.46**	**0.5**	**1.97**	**7.03**	**12.81**	**0.96**	**4.54**

Seven different sunflower lines grown under iron deficiency conditions were divided into two groups regarding the determined characteristics. While the first group consisted of 18 numbered sunflower lines, the second group consisted of lines 12, 28, 34, 37, 25, and 21 (Figure 1).

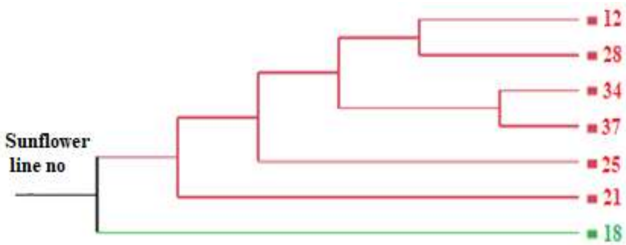

Figure 1. Classification of sunflower lines according to their iron nutritional abilities in iron deficiency conditions

Among the lines forming the second group, line 12 was found to be high in terms of chlorophyll-b and total chlorophyll contents. Korkmaz et al. (2021) compared the sunflower lines grown under iron deficiency conditions in sand supplemented with lime regarding their iron nutritional abilities. Researchers found that ferric reductase activity, chlorophyll-a, chlorophyll-b, and total chlorophyll contents in root and leaf in sunflower line 12 were higher than in sunflower line 21.

It was concluded that line 12 was better than line 21 regarding iron nutritional characteristics in iron deficiency conditions. Researchers compared the iron nutritional properties of sunflower lines grown under iron deficiency conditions in the calcareous and lime-free environment and determined that the results were similar. In addition, line 34 was found to be high in terms of chlorophyll-a and nitrogen contents in leaves; line 21 was found to be high in terms of active iron content in the leaf and ferric reductase enzyme activity in the leaf, and line 25 was found to be high in terms of dry matter content and ferric reductase enzyme activity in the root. In plants such as sunflowers, it was reported that the characteristics of reducing the rhizosphere pH and increasing the capacity of the roots to reduce Fe^{+3} to Fe^{+2} to adapt to the iron deficiency conditions were significantly different between genotypes (Alcantara and Guardia, 1991).

Researchers also stated that iron uptake in sunflower was related to the capacity of roots to decrease rhizosphere pH or to reduce Fe^{+3} to Fe^{+2} in the rhizosphere. The researchers stated that the root ferric reductase activity of ineffective lines in iron uptake was higher than the roots without added MES when five mM MES [2-(N-morpholino) ethane sulfonic acid] buffer solution was added to the nutrient solution in a non-iron root environment. The researchers also reported that the difference between the lines regarding root ferric reductase activity would depend on the experimental conditions. De la Guardia et al. (1989) found that the effective sunflower line in iron intake reduced pH in the environment of iron-free development and increased the ferric reductase activity until the fifth day and decreased rapidly. Researchers also reported that the reductase activity could be at a high level for a long time if the pH of the root growth environment were buffered with an MES buffer solution.

Intra-group proximity values of the lines are given in Table 3. When the table was examined, it was seen that lines 34 and 37 were closest to each other regarding the characteristics examined in iron deficiency conditions, and it was seen that lines 12 and 18 were the farthest lines from each other. Ferric reductase enzyme, chlorophyll-a, total chlorophyll, and active iron content values were higher in the leaf under the iron deficiency conditions in the sunflower line 12 compared to line 18. Torun et al. (2017) discussed the degree of symptom, SPAD value, chlorophyll concentration, green part dry matter yield, ferric reductase enzyme activity, green part iron concentration, and pH value of the growing environment in the selection of iron deficiency tolerant varieties of the sunflower plant. The researchers stated that the proton secretion characteristic and iron reductase enzyme activity were necessary, and they found that the iron-active genotype TR-3080 had a higher root ferric reductase enzyme activity in iron deficiency than the iron-deficiency-sensitive genotype TR-6149-SA. The researchers reported that the decrease in the iron concentration in the leaf was 23%

under iron deficiency conditions in the TR-3080 sunflower genotype, which was an iron-active variety, whereas it was 35.4% in the TR-6149-SA sunflower cultivar sensitive to iron deficiency.

Although lines 34 and 37 were close to each other, line 34 showed higher values in leaf than line 37 in terms of ferric reductase enzyme activity, chlorophyll-a, chlorophyll-b, total chlorophyll, and active iron contents.

Table 3. Intra-group proximity values of sunflower lines under conditions of iron deficiency in a lime-free environment

Group numbers	In-group proximity value	Group constituents	
6	3.027	3	37
5	3.362	12	28
4	3.988	12	34
3	4.304	12	25
2	5.371	12	21
1	5.501	12	18

` The characteristics classification examined in iron deficiency conditions and the change of the lines according to the characteristics is given in Figure 2. In the analysis made with the Biplot method, PC1 (1st main component) constituted 28.6%, PC2 (2nd main component) constituted 24.3% and 52.9% of the variation. As seen in Figure 2, it differed in terms of the characteristics and distribution of lines according to lines. According to the analysis results, it was seen that Line 37 in the second group was found to have the best characteristics of chlorophyll-a (III) and total chlorophyll contents (V) in the leaf in terms of iron nutrition under iron deficiency conditions. Lines 12, 25, and 28 in the second group had the best characteristics of proportional chlorophyll-a (XV), root cation exchange capacity (VIII), proportional total chlorophyll (XVII), proportional chlorophyll-b (XVI), and proportional dry matter (XIX) and nitrogen content (IX) in terms of iron nutrition in iron deficiency conditions. In other words, lines 12, 25, and 28 were found to be tolerant to iron deficiency in terms of chlorophyll-a, chlorophyll-b, total chlorophyll, and yield. The best characteristics of line 18 under iron deficiency conditions were yield (VII), ferric reductase activity in root and leaf (I and II, respectively), chlorophyll-b (IV), and proportional active iron (XIII) and proportional chlorophyll-b (XI).

In iron deficiency conditions, it can be said that line 18 was tolerant in terms of active iron and chlorophyll-b. The best characteristics of lines 21 and 34 under iron deficiency conditions were found as active iron (VI), proportional total chlorophyll (XII), and proportional chlorophyll-a (X). Lines 21 and 34 were tolerant in terms of total chlorophyll and chlorophyll-a under iron deficiency conditions (Figure 2). It was stated that dicotyledonous plants such as tomatoes showed reactions related to iron activity, removed protons, and ferric chelate reducing activity in iron deficiency. It was reported that these reactions were not observed in tomato plants fed with sufficient iron in the plasma membranes of stem cells (Bienfait, 1988).

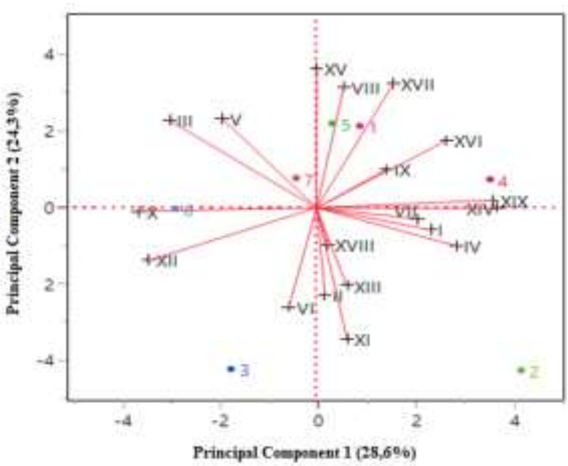

Figure 2. Determination of the best iron nutrition indices of sunflower lines under iron deficiency conditions and grouping the lines according to these indices

13.4. Conclusion

Sunflower lines formed two groups regarding iron nutritional status under iron deficiency conditions. While line 18 formed the first group, the second group consisted of lines 12, 28, 34, 37, 25, and 21. In terms of iron nutritional status in iron deficiency conditions, it was seen that lines 34 and 37 were closest to each other, and lines 12 and 18 were found to be the farthest from each other. It was observed that ferric reductase enzyme, chlorophyll-a, total chlorophyll, and active iron content values were higher in the leaf in sunflower line 12 than in line 18. The best characteristics of line 12 in terms of iron nutrition in iron deficiency conditions were proportional chlorophyll-a, root cation exchange capacity, proportional total chlorophyll, proportional chlorophyll-b, and proportional dry matter and nitrogen content.

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