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Prediction Fuzzy Implementation in Monitoring System Based On Humidity, Soil Quality, And Environmental Conditions

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Abstract

This research aims to understand, analyze and predict soybean plant growth by considering three main factors: moisture content, light intensity and soil pH. This research uses the number of soybean seeds as an indicator of overall plant health. The Mamdani method was used as an approach to optimize the processing of collected data to support plant growth. The experiment measured the impact of various moisture content (350ml, 700ml, 1050ml, 1400ml), light intensity (27lux, 54lux, 76lux), and soil pH levels (4pH, 5.5pH, 7pH). The objective was to identify the optimal conditions for soybean growth. The results showed a direct correlation between the number of input variables and soybean pod production. An increase in moisture content and light intensity led to an increase in the number of plants producing seeds. In addition, soil pH 7 emerged as the optimal growing medium. By utilizing MATLAB application, accurate data analysis and visualization of results can be done efficiently. This research provides valuable insight into the complex interactions between these factors and their effects on soybean growth. It can be concluded that this fuzzy method research has significant implications in effectively monitoring and measuring the quality of plant growth for sustainable agricultural development and can empower farmers to increase soybean yields.

Keywords: environmental conditions, fuzzy logic, matlab, soil fertility,

INTRODUCTION

Soybeans, as a unique food commodity, play a strategic role due to their popularity among society (Supadi, 2009). Soybeans have long been an affordable source of protein for the Indonesian population. As one of the plant protein sources, soybeans are often used as a basic ingredient in the food industry in Indonesia. The high protein content in soybeans significantly contributes to meeting the nutritional needs of the Indonesian population (Budiarti & Hadi, 2006).

Soybeans have become a legume commodity as an alternative source of protein and processed plant-based foods such as corn, cassava, and rice, making it the third main strategic food. Due to its high, balanced, and complete amino acid protein quality, soybeans are dubbed as "Gold from the Soil" or "World's Miracle" for its significant role in providing nutritious food for humans (Aldillah, 2015). Soybeans (Glycine max) are one of the food crops that play an important role in supporting the sustainability of the global agricultural system. This plant not only serves as a major plant protein source, but also contributes significantly to providing essential nutrients and bioactive compounds. The high protein content in soybeans makes it a strategic commodity for food security and human nutrition. Soybeans become a food commodity to meet the needs of the population, especially in terms of nutrition, as they contain plant protein at affordable prices for almost all segments of society (Rohmah & Saputro, 2016).

The importance of soybeans is not only limited to human consumption but also in the context of agro-industry and sustainable agriculture. Soybeans have the ability to improve soil nutrient balance, especially through nitrogen absorption and nitrogen fixation performed by Rhizobium bacteria that live symbiotically with soybean roots. In addition, soybean plants also play a role in crop rotation, which can increase overall agricultural land productivity.

However, the inability to produce in sufficient quantities can be a vulnerability that potentially affects various aspects, including social conditions (Budhi & Aminah, 2010). To date, Indonesia continues to experience increasing dependence on imports. For example, in the period 1999-2004, the import dependence ratio (RKI), which is part of the import from the total soybean supply in Indonesia, increased from 48.49 to 62.29 (Syaafat et al., 2005). Therefore, steps towards food self-sufficiency need to be taken because increasing dependence on imports can be a disaster, especially when world prices increase significantly due to declining stocks (Baharsjah, 2004).

The demand for soybeans (Glycine max (L.) Merr.) continues to increase every year. Soybeans play an important role in farmer economics, food consumption, and national food trade. Soybean production in Indonesia has fluctuated in recent years. Soybean production declined in 2006 and 2007 to 747,611 tons to 592,534 tons. However, production began to increase again to 775,710 tons in 2008 and 974,512 tons in 2009. Furthermore, from 2013 to 2015, soybean production continued to increase to 779,992 tons, 954,997 tons, and 963,183 tons (BPS, 2018).

The growth of soybean plants is heavily influenced by their surrounding environmental conditions, including water content, light intensity, and soil pH. Moisture also plays a crucial role in supporting soybean plant growth and significantly impacts plant size (Siskandar et al., 2020). Water scarcity is one of the key factors contributing to low soybean production in Indonesia. Decreased water availability can lead to plants reaching a critical point, which can subsequently affect the overall plant yield. Irrigation is closely related to the soil's water availability, which directly affects plant growth (Rahardian, 2013). The commonly used irrigation technique in soybean farming is continuous irrigation, maintaining the water surface level at approximately ± 5 cm below the soil, ensuring the lower root layer remains saturated. This method is one way to increase soybean production and optimize land use after rice harvest. The application of saturated cultivation techniques has been proven to enhance soybean plant growth, such as increasing ACC (1-aminocyclopropane-1-carboxylate), ethylene, and glucose production in roots, optimal nutrient absorption by plants, and increasing plant mass and volume (Ghulamahdi, 2007). An alternative approach that can be implemented is aquaponics, where plants are integrated with the water media in fish ponds. This method offers a promising solution as it can conserve water (Siskandar & Kusumah, 2019). Water used in fish ponds is not directly discarded, but is distributed to the plant growing media to meet the water needs of plants using an adequate water source.

In addition, soybeans require sufficient nitrogen (N) levels to process protein. Therefore, soybeans need symbiosis with other microorganisms such as Rhizobium, which can fix nitrogen from the air based on soil acidity. Rhizobium can only survive in soil conditions with a pH of 4.4 and above. This nitrogen fixation process is very sensitive to soil acidity levels (Hanafiah, 2009). Microorganisms play a crucial role in increasing soil fertility for plants. Through the decomposition process of organic matter, soil microbes convert organic residues into nutrients such as nitrogen, phosphorus, and potassium that can be easily absorbed by plants. Additionally, some microbes also play a role in binding nitrogen from the air and releasing it into the soil, increasing the availability of essential nutrients for plant growth (Manurung et al., 2017). Rhizobium can increase nitrogen levels fully, which can enhance soybean plant growth by accelerating plant metabolism to process carbohydrates into protein and then convert it into protoplasm (Meitasari & Wicaksono, 2017). Plant growth occurs through cell division processes in plant parts, especially roots, stems, and leaves, by binding carbohydrates through photosynthesis, while the photosynthesis process is influenced by the sufficiency of the required nutrients and environmental factors (Suhastyo & Raditya, 2019). Nitrogen (N) and phosphorus (P) are important requirements in the soil to accelerate the growth and development of new leaves (Augustien & Suhardjono, 2016).

Furthermore, soybeans are fast-growing plants and require strong sunlight intensity. If soybeans do not receive sufficient sunlight intensity during the growing season, it will affect soybean growth and yields (melda & Aziz, 2020). According to research conducted by Salsabila and colleagues (2019), shading has a significant impact on several growth and yield parameters of soybean plants, including plant height, leaf number, leaf area, plant dry weight, chlorophyll content, nitrogen content, and other yield components. According to research conducted by Sundari and Susanto (2016), increasing shading intensity tends to increase plant height and specific leaf area in soybean plants. However, at the same time, the number and area of leaves, light absorption rate, photosynthesis rate, leaf chlorophyll index, pod number, and seed weight per soybean plant tend to decrease with increasing shading intensity. According to research conducted by Rosawanti and colleagues (2015), drought stress in plants occurs due to an imbalance between soil water availability and the water needs of plants. Therefore, it is important to adjust the land so that crop yields can be optimized in using land with specific conditions (Naibaho et al., 2019).

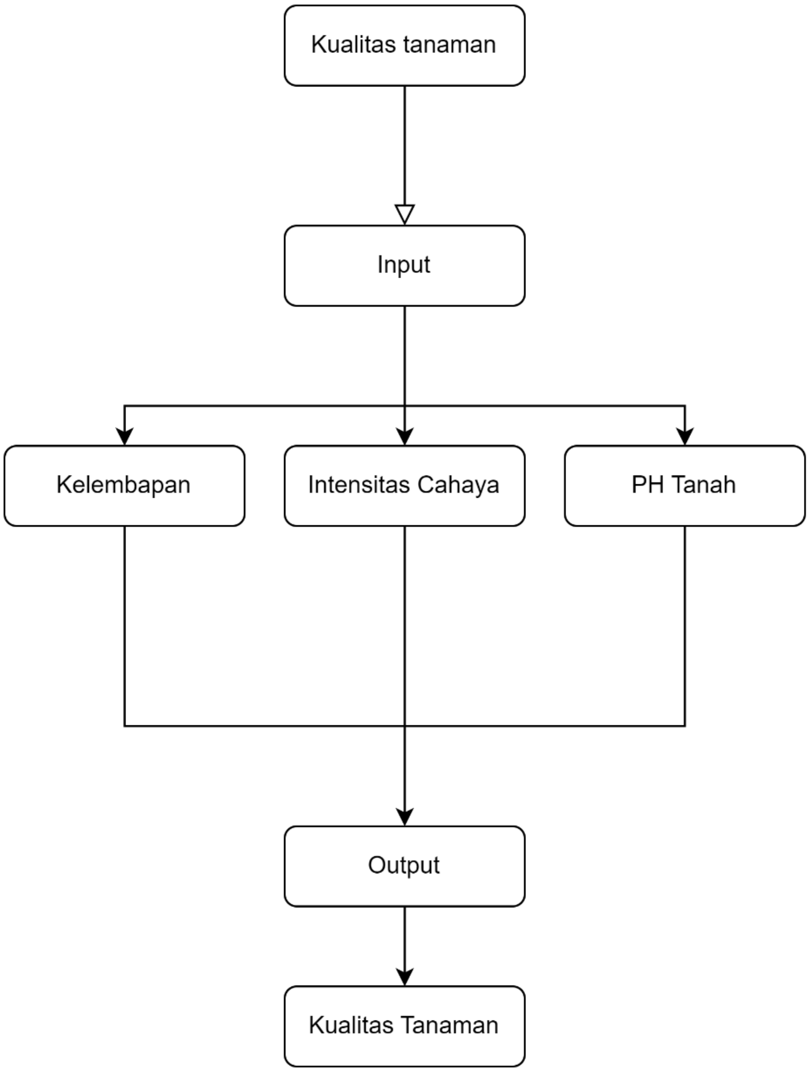
This study uses the Mamdani method and fuzzy logic approach to analyze input data on water content, light intensity, and soil pH. Fuzzy logic has advanced in computational concepts in various fields. With fuzzy logic focusing on high levels of truth, this makes it the best choice for regulating, controlling, and operating control systems aimed at facilitating humans in handling specific problems (Putra et al., 2018). This method is expected to provide a deeper understanding of how environmental conditions can be optimized to support maximum soybean plant growth. With a better understanding of the factors affecting soybean plant growth, this research is expected to make an important contribution to the development of sustainable and optimal agricultural practices.

METHODS

This research was conducted in the vocational school environment of IPB University. The data collection method used was literature study by searching data from journal articles, references, and information from experts related to soybean production, markets, processing, and development in Indonesia.

1. **Research Methods**

   The following flowchart will explain the stages in data processing. First, determining the objective of the research, which is to gather data regarding the various qualities of soybeans and the factors influencing their growth. Next, defining the parameters to be set as input variables, performing calculation operations on each variable using the rules for each condition to ensure that the output corresponds to the variable factors using the Matlab application, and determining the output of the calculation results, which is the quality of soybean plant growth.



Gambar 1. Flowchart

Quantitative research involves the use of numerical data and statistical analysis (deductive), while qualitative research uses verbal data analyzed inductively in the form of narratives, schemes, and illustrations. Action research is a type of research that cannot be fully categorized into quantitative or qualitative research because its observation stage can involve numerical data (such as scores) or verbal data (conditions) (Rukminingsih et al., 2020). This research utilizes numeric variables as parameters for calculations and verbal variables (conditions) which will become a rule where if the condition is met, calculations will be based on the corresponding rule. If the condition is not met, another appropriate rule will be used.

2. Data Collection

Data collection is a critical stage in the research process that requires a good understanding of its concepts and methods. This article comprehensively discusses data collection, ranging from basic concepts to techniques used in the process. Important concepts such as validity, reliability, and generalizability are also discussed in detail. The method used for this research is literature study or library research. This research falls into the category of library research, which is a series of studies that use data collection methods from various library sources such as books, encyclopedias, scientific journals, newspapers, magazines, and documents (Arikunto, 2014). The first set of data concerns the influence of water intensity on the growth of soybean plants.

Table 1. Data Intensitas Air Penyiraman Tanaman Kedelai

No	Intensitas (ml)	Biji Polong
1.	350	26
2.	700	32
3.	1050	34
4.	1400	39

Sumber : Hendra Mahardika, Y., & Simanjuntak, B. H. (2022). Pemberian berbagai level air dan pengaruhnya pada pertumbuhan dan hasil tanaman kedelai (Glycine max (L) Merr) varietas Grobogan. Vegetalika, 11(4), 266-279. https://doi.org/10.22146/veg.76102

For the second data, which is about the influence of light intensity on soybean plant growth.

Table 1. Data Intensitas Cahaya Terhadap Tanaman Kedelai

No	Intensitas (lux)	Biji Polong
1.	27	39
2.	54	56
3.	76	76

Sumber : Handriawan, A., Respatie, D. W., & Tohari. (2016). Pengaruh Intensitas Naungan terhadap Pertumbuhan dan Hasil Tiga Kultivar Kedelai (Glycine max (L.) Merrill) di Lahan Pasir Pantai Bugel, Kulon Progo. Vegetalika, 5(3), 1-14.

And lastly, the data regarding the effect of soil pH on soybean plant growth.

Table 1. Data Pengaruh pH Tanah Terhadap Tanaman Kedelai

No	pH	Biji Polong
1.	4	7
2.	5.5	10
3.	7	16

Sumber : Hartati, R. D., Suryaman, M., & Saepudin, A. (2023). Pengaruh pemberian bakteri pelarut fosfat pada berbagai pH tanah terhadap pertumbuhan dan hasil kedelai (Glycine max (L.) Merr). JA-CROPS Journal of Agrotechnology and Crop Science, 1(1), 26-34.

3. Data Analysis

Data analysis is a systematic process conducted to search for and organize the results of observations, interviews, and other data with the aim of enhancing the researcher's understanding of the case being studied. The findings of data analysis are then presented in the form of findings that can be utilized by others (Muhadjir, 2000). Data analysis is a systematic process of searching, organizing, measuring, and arranging data obtained from observations, interviews, or other sources. The purpose of data analysis is to enhance the researcher's understanding of the case being studied and present it in a form that can be utilized by others. In practice, data analysis is carried out from the beginning of data collection in the field, and this process involves measuring the sequence of data, organizing data into patterns, categories, and basic descriptions. This is done intensively to ensure that the collected data cover all aspects relevant to the research.

Fuzzy logic is a process in information processing that has membership degrees in the range of 0 to 1, which have two values namely 1 or 0. In the context of fuzzy logic, quantities are expressed using linguistic (language) (Budihartono & Suhartoni, 2014). Fuzzification is the process of converting initial crisp input values into fuzzy values consisting of linguistic variables and membership levels.

These membership levels are calculated based on the membership functions used (Siregar et al., 2023).

The Mamdani fuzzy method is part of the Fuzzy Inference System used to make conclusions or make the best decisions in uncertain situations. In its process, the Mamdani fuzzy method uses linguistic language and has fuzzy algorithms that can be mathematically elaborated, making it easier to understand (Surbakti et al., 2020). The Mamdani method is one of the most commonly used approaches in fuzzy logic, which can help in dealing with uncertainty in decision-making. The first step of this method is fuzzification, where crisp input variables are converted into fuzzy variables using membership functions. Then fuzzy rules are created to link fuzzy inputs with fuzzy outputs, using terms such as "If... then". After that, fuzzy inference is used to determine how strongly the rules apply and their implications on fuzzy output variables, often using fuzzy logic operators AND, OR, and NOT.

Fuzzy inference is the process used in fuzzy logic systems to transform fuzzy inputs into fuzzy outputs. This is done by following the rules established in the fuzzy knowledge base. In fuzzy inference, the application of implication functions is used to determine the degree of correspondence between input and existing rules, while composition among rules is used to determine the contribution level of each rule to the final result. Thus, fuzzy inference allows a fuzzy logic system to generate new fuzzy sets based on established rules.

Defuzzification is the stage in the fuzzy inference system where fuzzy output is converted into crisp values. One commonly used defuzzification method is the centroid method, where the center point value of an output set is sought (Hidayah et al., 2020).

RESULTS AND DISCUSSION

In the results and discussion section, we will discuss the outcomes of the research on the implementation of fuzzy logic in a plant monitoring system based on humidity, soil quality, and environmental conditions, using input parameters of humidity, light intensity, and soil pH as data, which are then processed to generate plant growth quality monitoring.

Membership Function dalam menentukan kualitas tanaman kedelai

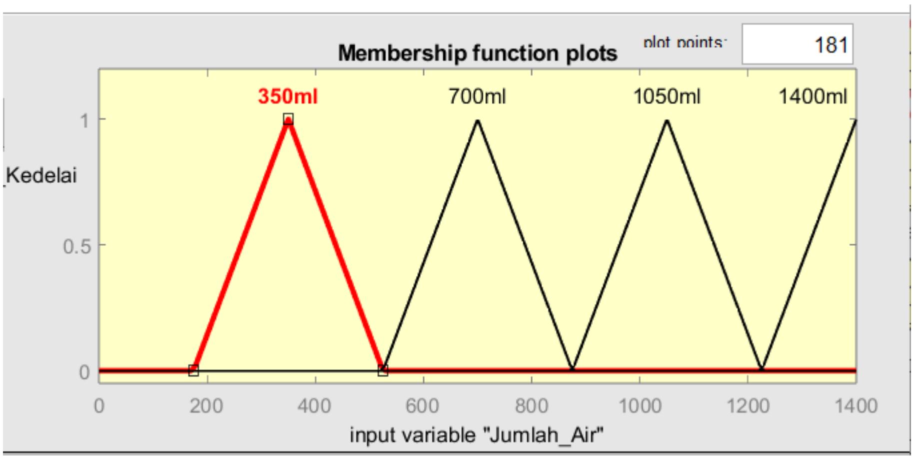
This section explains the calculation process starting from factors, formulas, conditions, rules, influences, and the results of the calculation. First is the fuzzification of input data, namely the variables of water index, light, and soil pH. Then, the data is processed using the Matlab application by calculating and classifying variables. Determining the output from the variables is done using the centroid method.

Trapezoid Formula :

$$F(X) = \left\{0,\ x \le a\ \frac{x-a}{b-a},\ a \le x \le b\ 1,\ b \le x \le c\ \frac{d-x}{d-c},\ c \le x \le d\ 0,\ d \le x\right\}$$

Triangle Formula :

$$F(X) = \left\{0,\ x \le a\ \frac{x-a}{b-a},\ a \le x \le b\ \frac{c-x}{c-b},\ b \le x \le c\ 0,\ d \le x\right\}$$



cahaya

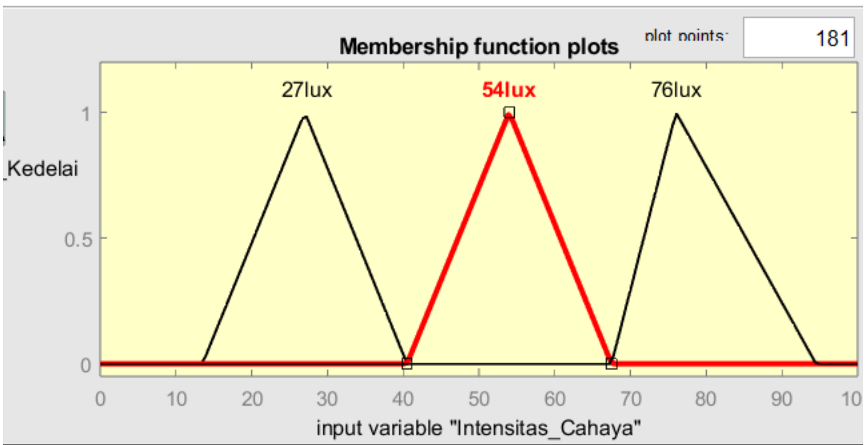
Gambar 1. Grafik membership function variable jumlah air

$$F(Air) = \{\mu350(x)\{0 \ if \ x\leq 175 \ \frac{x-175}{350-175} \ if \ 175\leq x\leq 350 \ \frac{1 \quad if{=}350 \ \frac{525-x}{525-350} \ if \ 350\leq x\leq 525}{0 \ if \ x\geq 525} \ \mu700(x)\{0 \ if \ x\leq 525 \ \frac{x-525}{700-525} \ if \ 525$$

The water membership function describes the input variable of water quantity, using a triangular shape with a range from 0 ml to 1400 ml. This range is divided into four segments with each peak point at certain values. The ranges of these values are:

1. For a value of 350 ml, the range is from 175 ml to 525 ml, with the peak point at 350 ml.
2. For a value of 700 ml, the range is from 525 ml to 875 ml, with the peak point at 700 ml.
3. For a value of 1050 ml, the range is from 875 ml to 1225 ml, with the peak point at 1050 ml.
4. For a value of 1400 ml, the range is from 1225 ml to 1575 ml, with the peak point at 1400 ml.

Thus, the membership function for the water quantity variable illustrates how the membership level of different input values is within a specific range. For example, if the water quantity value is 500 ml, then its membership level in the range of 350 ml will be higher than in the range of 700 ml or 1050 ml, and so on.



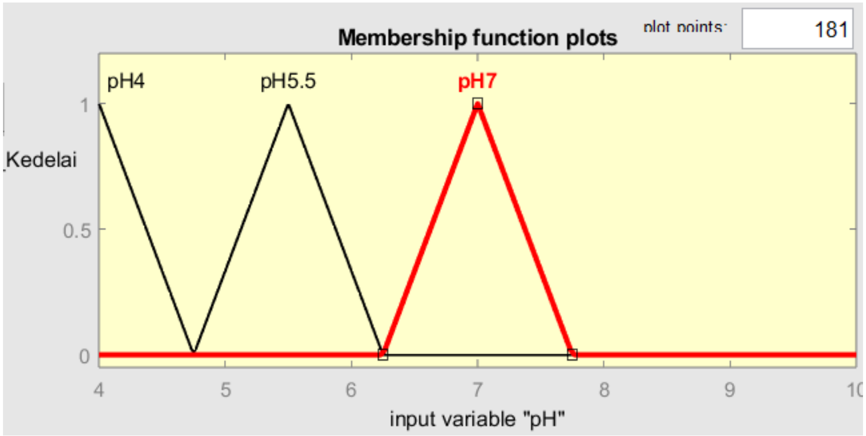
Gambar 2. grafik membership function variable input intensitas cahaya

$$F(Cahaya) = \{27lux(x)\{0 \ if \ x\leq 13.5 \ \frac{x-13.5}{27-13.5} \ if \ 13.5\leq x\leq 27 \ \frac{\frac{40.5-x}{40.5-27} \ if \ 27\leq x\leq 40.5}{0 \ if \ x\geq 40.5} \ 54lux(x)\{0 \ if \ x\leq 40.5 \ \frac{x-40.5}{54-40.5} \ if \ 40.5\leq$$

The membership function for the input variable of light intensity is triangular with a range from 0 lux to 100 lux. This range is divided into three segments with each peak point at certain values. The ranges of these values are:

1. For a value of 27 lux, the range is from 13.5 lux to 40.5 lux, with the peak point at 27 lux.
2. For a value of 54 lux, the range is from 40.5 lux to 67.5 lux, with the peak point at 54 lux.
3. For a value of 76 lux, the range is from 67.5 lux to 94.5 lux, with the peak point at 76 lux.

Thus, the membership function for the light intensity variable illustrates how the membership level of different input values is within a specific range. For example, if the light intensity is 50 lux, then its membership level in the range of 54 lux will be higher than in the range of 27 lux or 76 lux, and so on.



Gambar 3. grafik membership function variable input pH

$$F(pH) = \{\mu pH \pm 4(x)\{0 \ \ if \ x \leq 4 \ \frac{\frac{4.75-x}{4.75-4} \ if \ 4\leq x\leq 4.75}{0 \ if \ x\geq 4.75} \ \ \mu pH \pm 5.5(x)\{0 \ \ if \ x\leq 4.75 \ \frac{x-4.75}{5.5-4.75} \ if \ 4.75\leq x\leq 5.5 \ \frac{\frac{6.25-x}{6.25-5.5} \ if}{0 \ if \ x}$$

The membership function for the input variable of pH is triangular with a range from 4 to 10. This range is divided into three segments with each peak point at certain values. The ranges of these values are:

1. For a pH value of 4, the range is from 4 to 4.75, with the peak point at pH 4.
2. For a pH value of 5.5, the range is from 4.75 to 6.25, with the peak point at pH 5.5.
3. For a pH value of 7, the range is from 6.25 to 7.75, with the peak point at pH 7.

Thus, the membership function for the pH variable illustrates how the membership level of different input values is within a specific range. For example, if the pH is 6, then its membership level in the range of 5.5 will be higher than in the range of 4 or 7, and so on.

Next is to conduct a sample calculation by evaluating a case study of soybean planting using 3 variables: the water amount is 750, the light intensity is 50 lux, and the soil pH is 6.6.

For the water amount of 750 ml, it falls within the range of 700 with a range of 625 to 875 ml.

$$\mu \ air \ (750) = \frac{875-750}{875-700} = \frac{125}{175} = 0.7$$

For the light intensity of 50 lux, it falls within the range of 54 with a range of 40.5 to 67.5 lux.

$$\mu\, cahaya\ (50) = \frac{54 - 50}{54 - 40.5} = \frac{4}{13.5} = 0.3$$

For the pH level of 6.6, it falls within the range of 7 with a range of 6.25 to 7 pH.

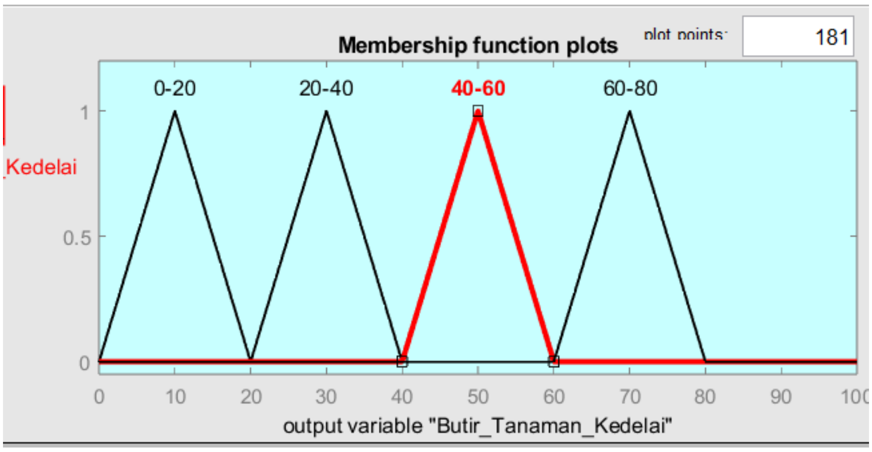
$$\mu\, pH\ (6.6) = \frac{7 - 6.6}{7 - 6.25} = \frac{0.4}{0.75} = 0.5$$

The rules defined in the fuzzy method variable calculation algorithm:

1. If (Jumlah_Air is 350ml) and (Intensitas_Cahaya is 27lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 0-20) (1)
2. If (Jumlah_Air is 700ml) and (Intensitas_Cahaya is 27lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 0-20) (1)
3. If (Jumlah_Air is 1050ml) and (Intensitas_Cahaya is 27lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 0-20) (1)
4. If (Jumlah_Air is 1400ml) and (Intensitas_Cahaya is 27lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 0-20) (1)
5. If (Jumlah_Air is 350ml) and (Intensitas_Cahaya is 54lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 0-20) (1)
6. If (Jumlah_Air is 700ml) and (Intensitas_Cahaya is 54lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 0-20) (1)
7. If (Jumlah_Air is 1050ml) and (Intensitas_Cahaya is 54lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 0-20) (1)
8. If (Jumlah_Air is 1400ml) and (Intensitas_Cahaya is 54lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 20-40) (1)
9. If (Jumlah_Air is 350ml) and (Intensitas_Cahaya is 76lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 20-40) (1)
10. If (Jumlah_Air is 700ml) and (Intensitas_Cahaya is 76lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 20-40) (1)
11. If (Jumlah_Air is 1050ml) and (Intensitas_Cahaya is 76lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 20-40) (1)
12. If (Jumlah_Air is 1400ml) and (Intensitas_Cahaya is 76lux) and (pH is pH4) then (Butir_Tanaman_Kedelai is 20-40) (1)
13. If (Jumlah_Air is 350ml) and (Intensitas_Cahaya is 27lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 0-20) (1)
14. If (Jumlah_Air is 700ml) and (Intensitas_Cahaya is 27lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 0-20) (1)
15. If (Jumlah_Air is 1050ml) and (Intensitas_Cahaya is 27lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 0-20) (1)
16. If (Jumlah_Air is 1400ml) and (Intensitas_Cahaya is 27lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 20-40) (1)
17. If (Jumlah_Air is 350ml) and (Intensitas_Cahaya is 54lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 20-40) (1)
18. If (Jumlah_Air is 700ml) and (Intensitas_Cahaya is 54lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 20-40) (1)
19. If (Jumlah_Air is 1050ml) and (Intensitas_Cahaya is 54lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 20-40) (1)
20. If (Jumlah_Air is 1400ml) and (Intensitas_Cahaya is 54lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 20-40) (1)
21. If (Jumlah_Air is 350ml) and (Intensitas_Cahaya is 76lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 20-40) (1)

22. If (Jumlah_Air is 700ml) and (Intensitas_Cahaya is 76lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 20-40) (1)
23. If (Jumlah_Air is 1050ml) and (Intensitas_Cahaya is 76lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 40-60) (1)
24. If (Jumlah_Air is 1400ml) and (Intensitas_Cahaya is 76lux) and (pH is pH5.5) then (Butir_Tanaman_Kedelai is 40-60) (1)
25. If (Jumlah_Air is 350ml) and (Intensitas_Cahaya is 27lux) and (pH is pH7) then (Butir_Tanaman_Kedelai is 20-40) (1)
26. If (Jumlah_Air is 700ml) and (Intensitas_Cahaya is 27lux) and (pH is pH7) then (Butir_Tanaman_Kedelai is 20-40) (1)
27. If (Jumlah_Air is 1050ml) and (Intensitas_Cahaya is 27lux) and (pH is pH7) then (Butir_Tanaman_Kedelai is 20-40) (1)
28. If (Jumlah_Air is 1400ml) and (Intensitas_Cahaya is 27lux) and (pH is pH7) then (Butir_Tanaman_Kedelai is 20-40) (1)
29. If (Jumlah_Air is 350ml) and (Intensitas_Cahaya is 54lux) and (pH is pH7) then (Butir_Tanaman_Kedelai is 20-40) (1)
30. If (Jumlah_Air is 700ml) and (Intensitas_Cahaya is 54lux) and (pH is pH7) then (Butir_Tanaman_Kedelai is 40-60) (1)
31. If (Jumlah_Air is 1050ml) and (Intensitas_Cahaya is 54lux) and (pH is pH7) then (Butir_Tanaman_Kedelai is 40-60) (1)
32. If (Jumlah_Air is 1400ml) and (Intensitas_Cahaya is 54lux) and (pH is pH7) then (Butir_Tanaman_Kedelai is 40-60) (1)

Following the rules set in the variable calculation program, the result obtained is consistent with the established criteria, which is in the range of 40-60 seeds.



Gambar 4. grafik membership function untuk variable output

$$Luas\ Daerah\ (LD) = \frac{1}{2}(c - a)\ x\ t$$

$$Luas\ Daerah\ (LD) = \frac{1}{2}(60 - 40)\ x\ 1$$

$$Luas\ Daerah\ (LD) = \frac{1}{2}(20) = 10$$

Calculating Moment

$$M1 = \int_{40}^{50} \frac{x-40}{10} x\, dx = \mathbf{233.33}$$

$$M2 = \int_{50}^{60} \frac{60-x}{10} x\, dx = \mathbf{266.67}$$

Defuzzyfikasi

After the calculation process, the next step is to determine the Crisp/Centroid value using the centroid method. The calculation is done by adding moment1 and moment2, then dividing it by the shaded area's area.

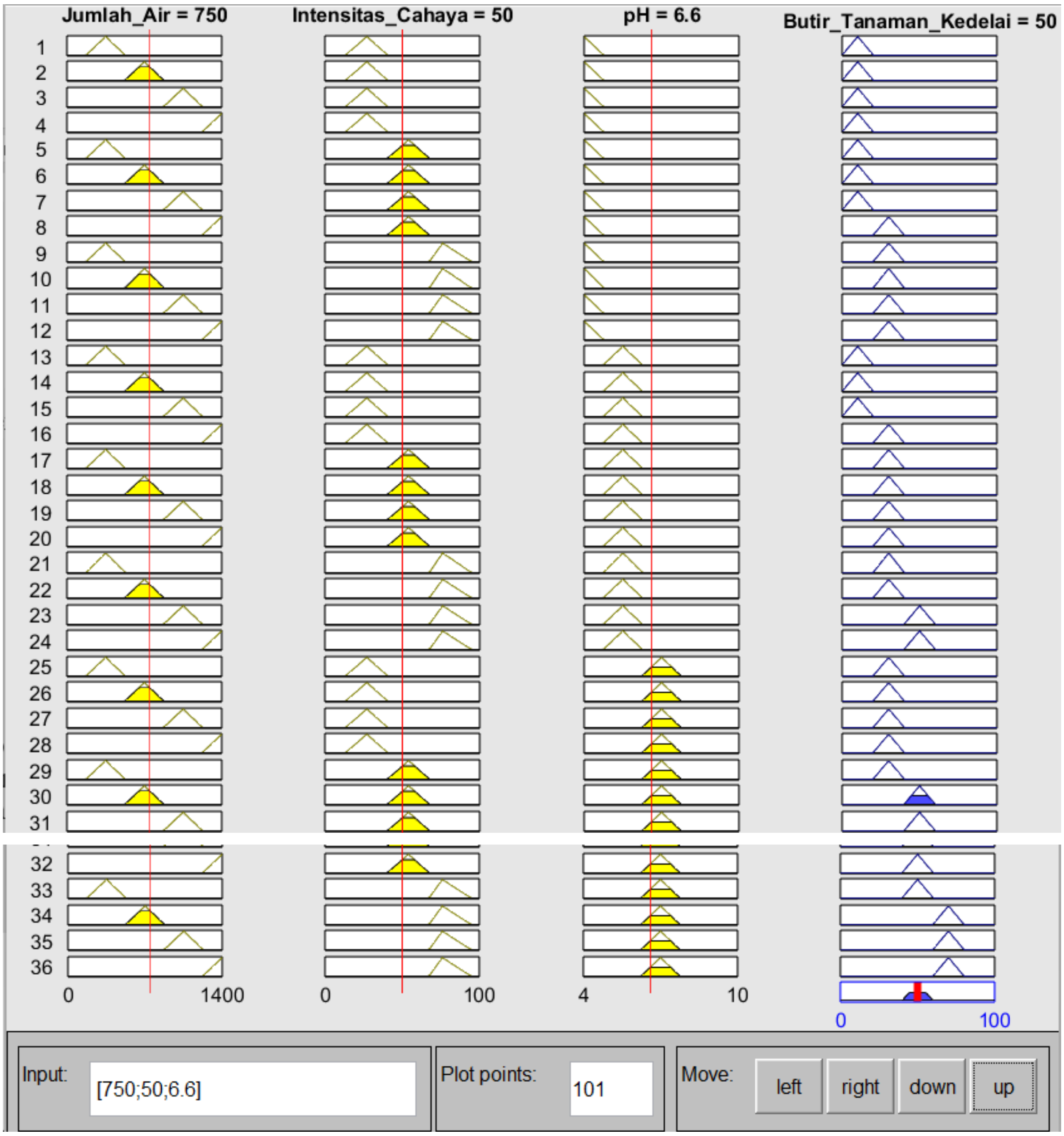
:

$$\mathbf{Z^*} = \frac{M1+M2}{LD}$$

$$\mathbf{Z^*} = \frac{233.33+266.67}{10}$$

$$\mathbf{Z^*} = \frac{500}{10}$$

$$\mathbf{Z^*} = \mathbf{50}$$



Gambar 5. grafik hasil dari defuzzyfikasi

In the Matlab calculation, the obtained result aligns with the calculation using the fuzzy method, which is 50 seeds (estimated). This proves that the fuzzy method can be utilized for accurate calculations in problems involving conditions (linguistic), classification (classification), and other general issues.

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CONCLUSION

This study employs the fuzzy method to monitor the quality of plant growth based on several input variables, such as humidity, light intensity, and soil pH. This method helps address issues involving linguistic conditions and complex data classification. The membership functions for each input variable, namely water quantity, light intensity, and soil pH, are used to depict the membership level of input values within specific ranges.

The calculation process is carried out by considering the rules established in the algorithm for calculating variables using the fuzzy method. An example calculation is performed for the case of soybean planting using predefined input variables, resulting in the quality of plant growth in a specific quantity of grains. The defuzzification stage is conducted to convert fuzzy output into crisp values that can be understood. The centroid method is utilized to calculate crisp values based on the moments generated from the membership functions and the area under the curve.

The final outcome of this research is a crisp value representing the quality of soybean plant growth based on the provided inputs. The quantity of soybean grains obtained through the calculation aligns with the fuzzy method applied. Therefore, it can be concluded that the fuzzy method significantly contributes to effectively monitoring and measuring the quality of plant growth, especially in the context of complex data grouping and assessment based on linguistic conditions.

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