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Humic Acid for Soil Quality Improvement with Application of Scan Automation on Seedless Watermelon Cultivation

Ni'mawati Sakinah[1], Khoirul Bariyyah[1*], Ahmad Hadi[1], Kanthi Pangestuning Prapti[1], Annastia Loh Jayanti[1], Putri Istianingrum[1], Shinta Hiflina Yuniari[1], Moh. Fahrurrozi[2]

[1]Faculty of Agriculture and Fisheries, University 17 Agustus 1945 Banyuwangi, East Java

[2]Faculty of Economy, University 17 Agustus 1945 Banyuwangi, East Java

Orcid ID: Ni'mawati Sakinah (0000-0002-9834-9723); Khoirul Bariyyah (0000-0003-2073-3984); Ahmad Hadi (0000-0002-2573-9181); Kanthi Pangestuning Prapti (0000-0002-7638-7999); Annastia Loh Jayanti (0000-0002-7087-5617); Putri Istianingrum (0000-0001-6756-6015); Shinta Hiflina Yuniari (0000-0003-1112-1548); Moh. Fahrurrozi (0000-0002-4045-3122)

ABSTRACT

Purpose: Sustainable agricultural intensification needs to be well developed. Therefore, food and agricultural production activities can be continuously produced without damaging the ecosystems and environment. One that can be used is a plant biostimulant based on humus. This research was conducted to examine the effect of humic acid as a soil biostimulant and the impact of its use on the yield of seedless watermelon cultivated on marginal land. This study involve IoT technology through monitoring soil quality which is carried out based on the concept of precision agriculture using the farm management system (FMS) Agrooscan tool.

Methods: The study used humic acid factor for five treatments (0, 2, 4, 6, and 8 g/L). Observations included soil conditions monitored with Agrooscan instruments such as soil pH, nutrients (N, P, K), as well as measuring plant height, fruit weight, fruit volume and total sugar content (Brix).

Results: The results showed that application of humic acid increased the nutrient content in the soil and significantly affected soil pH and seedless watermelon yields. The 8 g/L treatment gave the highest soil N and K values, and was significantly different from no treatment (control).

Conclusions: Thus, exogenous use of humic acid as a soil nutrient supplement can be used to help increase marginal land use, including in the development of seedless watermelon cultivation. The use of Agrooscan as a tool to scan soil conditions plays a very important role in maintaining the quality of nutrients so that the growth of watermelon cultivation can run better.

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KEYWORDS: Agrooscan instrument, biostimulant, humic acid, scan automation, seedless watermelon, soil quality

Corresponding Author:
Khoirul Bariyyah

INTRODUCTION

Industrial revolution 4.0 had an impact on the agricultural sector to always able to adapt, change and develop. Changes in the agricultural system are not only related to the mechanization of tools and machines, but also lead to automation and digitalization of tools, that known as smart farming. The implementation of smart farming is expected to help increase the effectiveness of agriculture. The long-term goal is to produce self-sufficiency in food and sustainable agriculture with good quality. This food needs concept also related to the adequacy of nutrition for human survival. It is necessary to strengthen local agricultural production through efficient management while maintaining the environment as well.

In this study, observations were made on watermelon plants, which are horticultural plants that widely cultivated in Indonesia. The water content in watermelon (up to 92%) (Tadmor et al. 2005) makes watermelon one of the most popular favorite fruits, especially during hot weather or just to fulfill the nutritional needs from the fruit.

Nevertheless, Aziz et al. (2018) stated that the lack of knowledge about proper cultivation techniques and the selection of growth regulators used make the yields could not meet market demand optimally. Data states that watermelon productivity in Indonesia has

decreased, that in 2021 could reach 228.9 kw/ha, and then dropping to 190.2 kw/ha in 2022 (BPS 2023). One of the reasons for this decrease is the lack of optimal management of land resources, especially for land dominated by regosol soil types with loamy sand textures, such as in the watermelon-producing center area, namely in Muncar District, Banyuwangi. The problem that often occurs in regosol soil types is the soil's ability to absorb and store water is very low, so that nutrient leaching becomes quite high and causes less efficient fertilization (Nikiyuluw et al. 2018). Optimizing the management of land resources needs to be done so that soil fertility can be maintained, one of which is by treating with humic acid.

Humic acid is a water-soluble organic component that can have a positive effect on plant growth. Humic acid is widely used in agriculture because it is an organic-based substance that is safe for the environment and has the ability to add nutrient supplements for plants that are quickly and easily absorbed (He et al. 2022). Even so, the use of the right dosage is important to note so that cultivation is more efficient. In this case, it is definitely need the concept of precision agriculture by utilizing the Internet of Things (IoT) to improve the quality and quantity of production in the agricultural industry.

Precision agriculture is the key in implementing agricultural systems that use information or data for every decision making in a measurable and clear observation. The concept of precision farming is based on the accuracy of production input data, so that crop yields can be more optimal (Pitono 2020). Precision agriculture is an approach that can be adopted to increase agricultural productivity by optimizing land resources using appropriate technology (Mufti and Hamidah 2022). Conventional farming patterns by rarely monitoring the conditions of land and fertilization treatments which are often carried out only based on estimates and farmers' habits, need to be developed towards precision farming.

This is because information on the condition of land resources such as soil acidity (pH), nitrogen (N), phosphorus (P), and potassium (K), soil moisture and soil temperature are very important as a basis for decision making in plant cultivation. One technology that can be used to monitor land conditions is the Agrooscan Farm Management System (FMS). Agrooscan is a complex system that combines several technologies including Internet of Things (IoT) Technology, Artificial Intelligence Technology (AI) and Big data as well as Information Systems and Data Management. This tool is designed to monitor the condition of cultivated land (soil pH, soil N, P, K element status, humidity and soil temperature).

This study aims to look at the response to the effect of humic acid on the quality of watermelon cultivation land conditions. Monitoring the nutrient condition of the cultivated land was carried out using the FMS Agrooscan tool. Data from this study will then be used as a reference in determining fertilization treatments. Furthermore, precision agriculture technology using Agrooscan is expected to be applied in all agricultural sectors in Indonesia.

MATERIALS AND METHODS

This research was conducted at the Experimental Garden located in Kumendung Village, Muncar District, Banyuwangi Regency, East Java Province, Indonesia from August to December 2022. The tools used in this study were the FMS Agrooscan instrument (PT. Agroobot Bangun Negeri, Rep. Indonesia), brix refractometer, hoe, tape measure and digital scale. The materials used in this study were humic acid 90 (potassium humate) and water as a solvent, mulch and watermelon seeds.

The study was carried out using a randomized block design (RBD) consisting of 5 treatments and 5 replications, namely no humic acid treatment (P0), humic acid concentration of 2 grams/liter (P1), humic acid concentration of 4 grams/liter (P2), concentration of humic acid humate 6 grams/liter (P3), and humic acid concentration 8 grams/liter (P4). The treatment of humic acid was carried out when the plants were 7-21 days after planting (dap), with fertilization intervals once every 7 days during the plant maintenance period. Each plant was given a treatment of 250 ml/plant. Parameters observed included soil pH, soil N, P, K, plant height, fruit weight, fruit sugar content. The data obtained were then analyzed using analysis of variance (Anova) at a level of 5%. Data showing a significant effect were further tested using Duncan's Multiple Rang Test (DMRT) at 5% level.

RESULTS AND DISCUSSION

FMS Agrooscan is an automated tool for monitoring the condition of agricultural land (soil pH, soil N, P, K element content, humidity and soil temperature). The working principle of FMS Agrooscan is that the microcontroller module will instruct the soil sensor to obtain the required soil parameters along with the location position (latitude and longitude) by utilizing the GPS module, then sending the parameter data to the server with the help of a 4G modem installed on the FMS Agrooscan device. An overview of block diagram of the FMS Agrooscan application is shown in **Fig. 1** as follows:

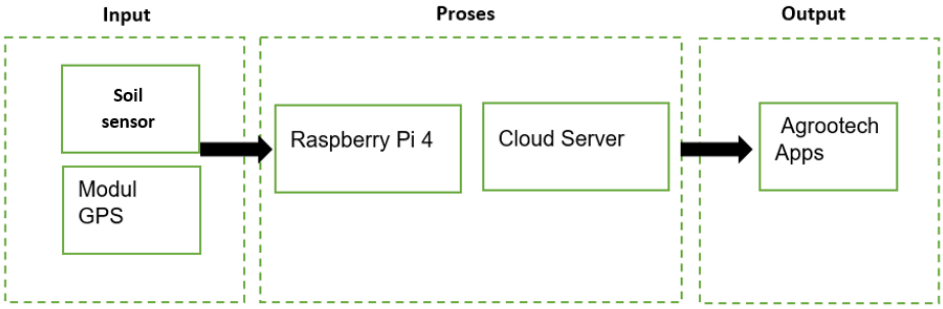

Fig 1. Block diagram of the FMS Agrooscan application.

On the server the data will be displayed in the FMS application to make it easier for users to view soil N, P, K and pH data. The data obtained is used to determine recommendations for the addition of N, P, K according to the cultivated commodity. Data obtained from monitoring results using the FMS Agrooscan can be used as a basis for monitoring soil conditions precisely according to plant needs. Based on scanning that carried out on soil conditions at 10 different points of planting area, here is the following data that has been compiled by FMS Agrooscan:

Table 1 Results of monitoring land conditions in kumendung village using FMS Agrooscan.

Sample	N (ppm)	K (ppm)	P (ppm)	pH	Humidity (%)	Soil Temperature (°C)
Point 1	2	6.8	2.7	8.8	29.9	28.3
Point 2	3.1	10.7	4.3	9	51.1	28.8
Point 3	1.8	6.1	2.4	8.9	37	28.4
Point 4	1.6	5.4	2.1	8.8	27.8	30.7
Point 5	1.2	4.3	1.7	9	47.1	31.7
Point 6	1.2	4.2	1.7	8.8	28	31.4
Point 7	1.4	4.9	1.9	8.8	20.2	28.3
Point 8	1.2	4.2	1.7	8.7	21.6	28.1
Point 9	2	6.8	2.7	9	36.7	32.2
Point 10	1.2	4.2	1.7	8.6	20.2	28.1
Average	1.67	5.76	2.29	8.86	32.5	29.6

Table 1. shows the results of data monitoring soil conditions of planting area in Kumendung Village, Muncar, Banyuwangi District using the FMS Agrooscan. The monitoring results show that soil acidity tends to have a neutral to alkaline pH, relatively high soil temperature of 28.3 – 32°C and low soil moisture. Soil temperature is an important growth factor because it can directly affect plant growth, humidity, aeration, structure, microbial activity, and enzymatic decomposition of litter, as well as the availability of nutrients for plants (Hanafiah 2013). Data from Agrooscan also shows that N, P, K nutrients in soil are relatively low. The use of humic acid is expected to act as a soil ameliorant. This is because humic acid has the ability to improve soil structure physically and chemically so that a looser, crumbly and lighter soil is formed. Humic acid is an organic substance that has a complex molecular structure with a high molecular weight, as a macromolecules and polymers that containing active groups. Humic materials have distinctive hydrophobic and hydrophilic properties that can bind minerals to the soil surface.

- Effect of Humic Acid on Soil Conditions

The results of observations on soil conditions are shown in **Fig. 2**, shows the different responses to pH in humic acid treated soils. Soils that were not treated with humic acid showed different soil pH. Humic acid as an agricultural soil biostimulant can act as a chelating agent for cations in the soil, because it has negatively charged carboxyl and phenolic groups. This property makes humic acid able to keep ions available and function as a soil buffer (Rahmandhias and Rachmawati 2020).

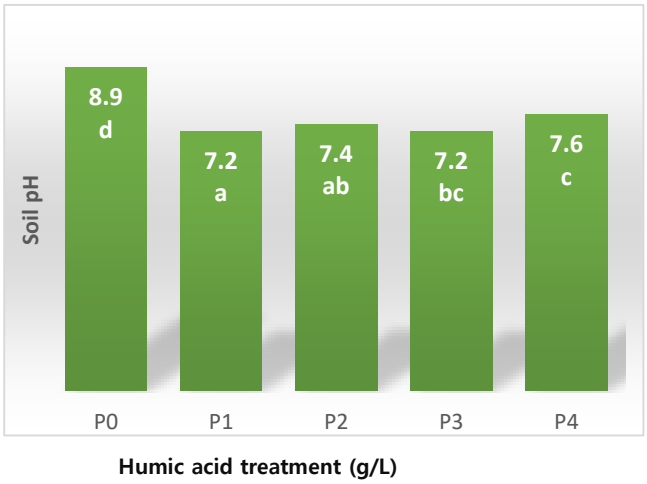

Fig 2. Effect of humic acid concentration on soil pH.

One of the determining factors for the level of soil fertility is acidity, which can be measured from the soil pH value (Santoso et al. 2020). Soil conditions affect the optimization of nutrient absorption. Based on the research results of Lubis et al. (2015) the ideal pH value for plants is a neutral pH condition (7). This is because at a neutral pH, many nutrients are available to plants, especially the essential macro nutrients (N, P, and K). Neutral pH conditions will provide more nutrients available to plants (Novia and Fajriani 2021). To get a soil pH that is close to precision in the neutral pH range, several chemical addition treatments need to be carried out. To increase the pH value, you can add lime solution, while to decrease the pH value, you can use sulfur as input.

Based on the results, it is known that the application of humic acid affects changes in soil pH. The graph above shows that humic acid treatment helps control soil pH to be more neutral. Humic acid is an organic compound that has undergone a process of decomposition to form humus, known as humification and dissolves in alkali. Humic acids have good benefits for soil and plants. The benefits of humic acid for the soil are helping loosen the soil, transfer nutrients from soil to plants, increase pore space and soil capacity to hold water, and stimulate microbial growth in the soil (Suwahyono 2011).

In nature, humic acid is formed through physical, chemical and biological processes from materials derived from plants and animals through a humification process. Due to its structure consisting of a mixture of aliphatic and aromatic organic compounds, which are indicated by the presence of active groups of carboxylic acids and quinoids, humic acid has the ability to stimulate and activate biological and physiological processes in living organisms in the soil (Mindari et al. 2022). Another positive role of the application of humic acid is as an organic substance that increases the availability of nutrients from the soil by reducing soil pH (Khan et al. 2013). Humic acid has amphiphilic properties that can help reduce soil acidity, especially soils that contain a lot of aluminum because humic acid binds aluminum as a complex compound that is difficult to dissolve in water so it cannot be hydrolyzed (Noroozisharaf and Kaviani 2018).

- Effect of Humic Acid on Soil Nutrients (N, P, K)

Nitrogen is the main nutrient for plant growth which is needed for the growth of vegetative parts of plants such as leaves, stems and roots. Nitrogen is also the main constituent of protein macromolecules which play an important role in cell growth, so that a deficiency in element N can cause stunted plants. Phosphorus is an element that becomes part of the protoplasm and cell nucleus. The function of phosphorus for plants is to accelerate and strengthen vegetative to generative growth, accelerate flowering and fruit ripening, and increase plant productivity. Meanwhile, element K affects the formation of proteins and carbohydrates, increases plant resistance to disease attacks, and improves seed quality (Sutedjo 2010). The following (**Fig. 3**) is data collected from scanning the response of soil nutrient availability to a given humic acid treatment.

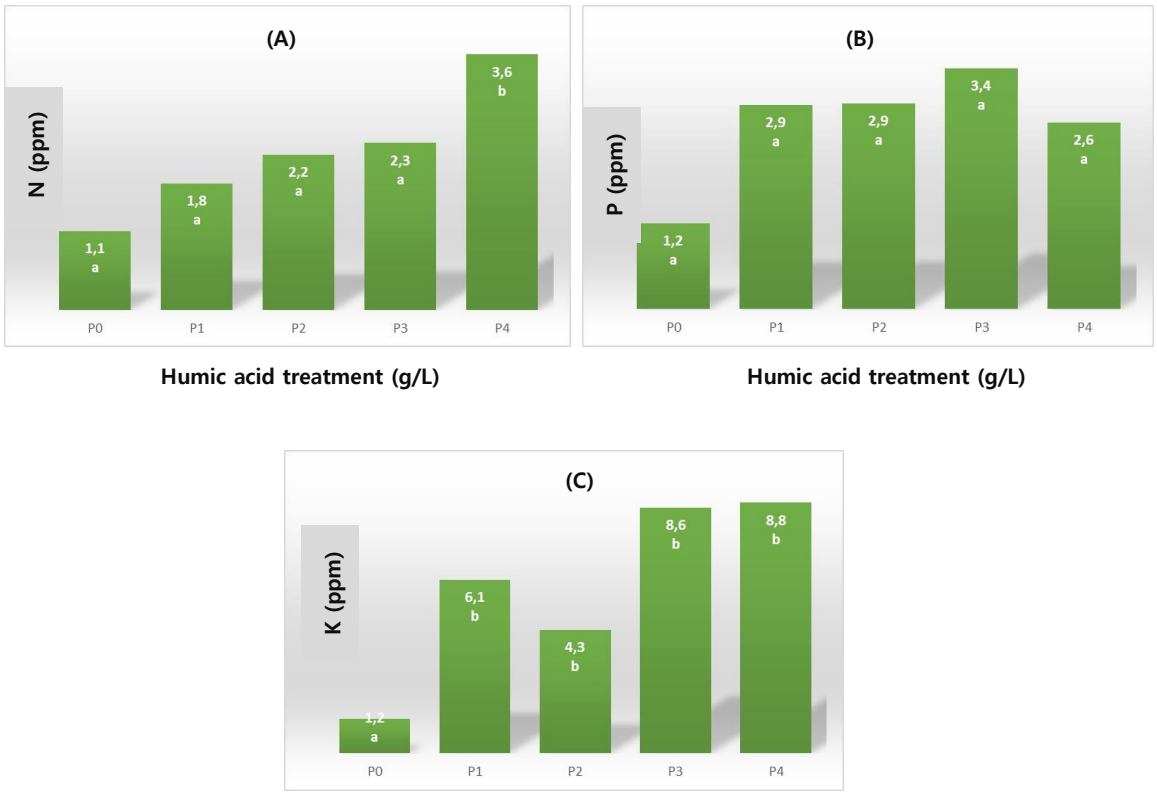

Fig 3. Effect of humic acid concentration on soil nutrients (A) N-Nitrogen; (B) P-Phosphorus; (C) K-Potassium.

Humic acid is able to increase the availability of nutrients in the root system, so that it will be more easily absorbed by plants. This is in line with the observations above which show that humic acid treatment increases the levels of N, P, and K in the soil (**Fig. 3**). The concentration of nitrogen in the soil increased significantly, especially when the humic acid concentration was 8 grams/liter. Phosphorus concentration also increased, although it cannot be said to be a significant difference statistically. Humic acid treatment also appears to significantly increase potassium availability. Humic acid causes the soil to have the ability to retain water as well as to keep NH4+ and NO3- ions available for plants. Rahmandhias and Rachmawati (2020) reported that the application of humic acid containing 12% N was able to provide the N element in the soil that plants needed and increased productivity in land kale plants. Humic acid that is applied to nutrient-poor soil is more efficient at helping plants absorb nitrogen nutrients than fertile soil (Rahmandhias and Rachmawati 2020). Humic acid gives a positive response to increasing the availability of potassium and phosphate elemental concentrations (Salman et al. 2005).

Here, the use of FMS Agrooscan is needed in regular monitoring of land conditions during the cultivation process. Agrooscan makes it easier to scan land conditions with more specificity and precision. This instrument will provide information if there is an oddity or lack of nutrients in the soil, so that control measures can be taken more quickly. Thus, cultivation will take place in a more directed manner and the use of nutrients can be focused according to the needs of the plants.

- Effect of Humic Acid on Fruit Yields

One of indicator for measuring growth is plant height. In this study, observations of plant height were carried out weekly, starting from the first week (7 dap) to the third week (21 dap). Plant height is an indicator of growth that is easily observed and shows the influence of the environment and the treatment given. The measurement results for plant height are shown in the graph below,

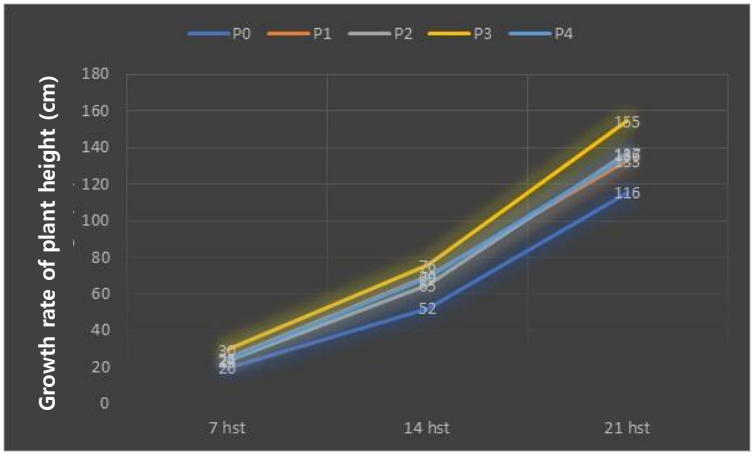

Fig 4. Growth rate (plant height) aged 7-21 days after planting (dap).

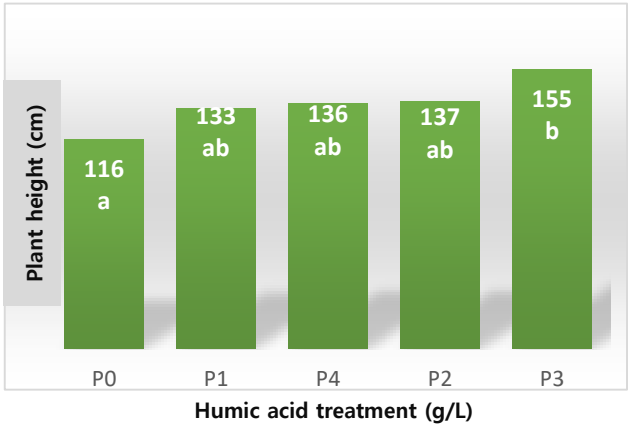

Fig 5. Effect of humic acid concentration on seedless watermelon plant height

The application of humic acid can increase the ability to absorb nitrogen (N) and phosphorus (P) from the soil, which are needed in the process of preparing plant components, such as protein and others (Sarno and Eliza 2012; Verlinden et al. 2009). Humic acids also play a role in increasing metabolic processes in plants, one of which is increasing the rate of photosynthesis (Heil 2005). Photosynthesis is one of the important physiological reactions in plant growth and development. Photosynthesis is related to providing an energy source for cells to carry out their functions, including the function of cell differentiation or elongation (Indra et al. 2019). With an increase in the rate of photosynthesis, the process of cell elongation and growth also increases. One of the cells that experience elongation is the stem cell, which is expressed as an increase in plant height.

The results of the treatment of humic acid application on watermelon cultivation soil showed that there was a fairly high increase in fruit weight. This shows that humic acid also has an indirect impact on fruit yields. Response of humic acid treatment on fruit weight and volume shows in **Fig 6**.

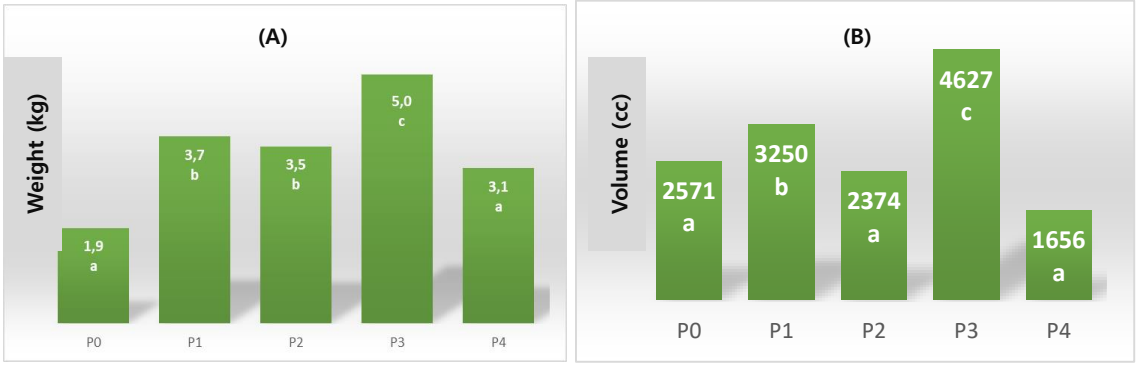

Fig 6. Effect of humic acid concentration on seedless watermelon yield (A) weight (kg); (B) volume (cc).

Photosynthesis is an important part of plant growth and development. The rate of photosynthesis can run optimally if the gas supply and other elements needed run normally. One part of the plant that plays a role in the entry pathway for gas exchange is the mouth of the leaf or stomata. Humic acid helps decompose the nutrient potassium in the soil which plays a role in the process of opening and closing stomata, so that the need for photosynthesis can be fulfilled properly. As stated by Nugroho (2011) in his research, the availability of potassium in the soil can increase fruit weight in tomato plants. Humic acid can improve the physical, chemical and biological properties of soil.

Humic acids can improve soil conditions that have been degraded and minimize the possibility of loss of nutrients from organic fertilizers due to washing or evaporation. Commercial humic acid products that are widely used in the agricultural sector contain various components that have the ability to provide complete nutrients that play an important role in the process of plant growth and yields (El-Boray et al. 2015).

The increase in fruit weight and dimensions after humic acid treatment is thought to be closely related to the mechanism of mineral absorption. Humic acid activity synergizes with the action of other growth hormones such as auxins, giberlins and cytokinins which play a role in elongating cell size and intercellular fluid (Chen et al. 2004). Humic acid treatment with concentrations of 4 and 8 grams/liter produced fruit shapes with volume that were not significantly different from watermelons produced from treatment without humic acid. However, the 2 and 6 gram/liter treatments were able to produce watermelons with larger dimensions than the control treatment.

Several previous studies have reported many things related to the role of humic acids in improving soil conditions. So far humic acid has been widely applied to many crops and confirmed to produce good effects on crop quality, as well as on soil structure and ecological environment. However, the direct effect of humic acid on fruit quality, especially fruit physical quality such as weight and volume, has not been widely reported. Research on the systematic evaluation of their specific impact on fruits is quite limited. He et al. (2022) reported that there was no significant difference in the shape and dimension indices of lemon fruit treated with humic acid. The use of humates can play a significant role in enhancing plant growth as well as being a biotechnology tool for sustainable agriculture systems (Canellas 2015).

The Brix indicator is the amount of dissolved apparent solids (in grams) in every 100 grams of solution. Brix is closely related to the refractive index of a sugar solution. If the brix of a sugar solution is 16, it means that out of 100 grams of sugar solution, 16 grams are dissolved solids and 84 grams are water. The amount of solids dissolved in solution (brix) can be determined using a measuring instrument such as a refractometer. Refractometer is a measurement tool based on the value of the refractive index.

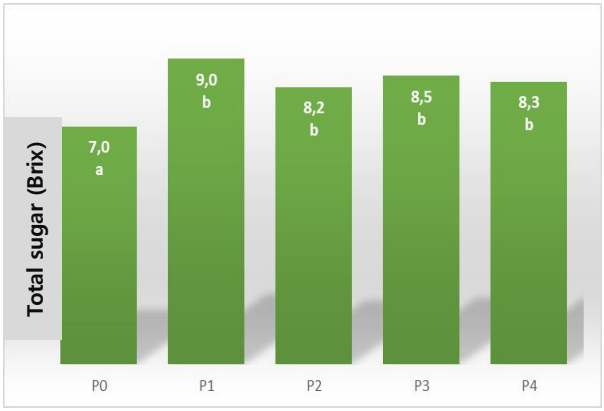

Fig 7. Effect of humic acid concentration on total sugar.

The brix value can be used as initial screening data to determine the level of sweetness of a product, including fruit. The higher the degree of Brix, the higher the sweetness value (Sjarif et al. 2021). That **Fig 7.** above shows result of humic acid on watermelon sugar content. The total Brix value is often chosen as the most important parameter in determining fruit quality. The taste attribute is the main consideration because consumers buy fruit to enjoy its sweet taste, so they will prefer sweet fruit when buying watermelon. Besides that, the sweet taste is also an indication of a good level of fruit maturity. The results showed that humic acid treatment significantly increased the Brix score of the watermelons produced. This indicates that humic acid as a soil conditioner is able to provide good nutrition for the sustainability of plant metabolism. A good soil conditions with guaranteed availability of nutrients make the process of cell development and maturation run normally so that the breakdown of carbohydrate components into sugars during the maturity phase goes well.

Changes in the metabolic system will have an impact on the characteristics of fruit yields (Canellas, 2015). The addition of humic acid will help stimulate increased absorption of the nutrients Phosphorus (P) and Potassium (K), which in this case are also associated

with increased transport rates and also the main results of the photosynthesis process such as starch, sugar and organic acids. There is the formation of the maximum amount of various forms of carbohydrates in leaf and fruit tissues then converted into specific sugars such as glucose and sucrose. Thus, an increase in sugar in response to humic acid can occur (El-Boray et al. 2015; Mikkelsen 2005).

CONCLUSIONS

Overall the results of the observations showed that the treatment of humic acid as a nutrient supplement for the soil had a good effect on improving soil conditions, helping plant growth and had a positive impact on watermelon crop yields. Humic acid is an environmentally friendly component, but excessive use can have an effect on changing the characteristics of soil conditions. In the context of implementing smart farming in the future, it is very important to pay attention to the use of nutrient supplements or fertilizers in the right amount. Dosing according to plant needs will help maintain soil conditions that remain natural and can be used for sustainable farming without experiencing excessive changes in conditions.

CONFLICT OF INTEREST

The authors have no conflicting financial or other interests.

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