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Optimizing the Growth and Production of Shallots (*Allium ascalonicum* L) by applying Liquid Organic Fertilizer from Kampar River Fish Waste on Ultisol Soil

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ABSTRACT

Red onion is a strategic commodity because it is one of the horticultural products required for household consumption, the culinary industry, and medicinal purposes. The Kampar Regency is known for producing river fish, which the residents of Kampar and Pekanbaru consume. If this refuse is not correctly managed, it can pollute the environment. This refuse can be converted into liquid organic fertilizer (POC) due to its ability to improve soil fertility and shallot plant growth. This study aimed to determine the effect of interaction and the primary optimization of the growth and yield of shallots on ultisol soil by administering POC derived from the fish refuse of the Kampar River. The investigation was conducted in the experimental garden of the Riau Islamic University, Pekanbaru, Faculty of Agriculture. The research employed a wholly random design with two factors. The first factor consisted of four levels of concentration of river fish waste (0, 22,5, 45, 67.5, and 90 ml-1) and the second factor consisted of four levels of frequency of river fish waste (1, 2, 3, 4 times). The data were analyzed and the BNJ Advanced Test was administered at a 5% confidence level. The results indicated that the interaction and main effects were significant for plant height, number of leaves, age of tuber formation, number of tubers, wet tuber weight and dried tuber weight, with the optimal treatment consisting of 67.5 – 90 ml-1 applied three to four times.

Keywords: *shallots, frequency, concentration, Kampar river fish waste*

1. INTRODUCTION

Riau has a considerable amount of marginal land, including Ultisol land. According to the Central Bureau of Statistics (2017), the Ultisol land area of Riau Province is 2,221,938.38 ha and is located between 0° 25' - 0° 45' north latitude and 101° 14' – 101° 34' east longitude. Due to intensive alkaline discharge, Ultisol soil has a low nutrient content, resulting in a rapid rate of decomposition of organic matter, pH 5.5 (low to very low). And the presence of a high clay fraction content makes it difficult for water to permeate the soil, for roots to grow, and for plants to obtain oxygen and nutrients. Ultisols are marginal lands with low levels of productivity, sluggish to moderate permeability, and low aggregate stability; consequently, the majority of these soils have a low water-holding capacity and are susceptible to erosion. ([i]Prasetyo (2006).

Kampar Regency is one of the regions in Riau Province with a total area of 10,983.46 km2 and tremendous fishery potential, as it is a region with a large fishery industry. The annual productivity of the fisheries sector in Kampar Regency is estimated at 23,949.61 tonnes, of which 799 tonnes, or 3.34 percent, are caught in public waters.

Riau Province residents consume more fish than the national average of 41 kilogrammes per capita per year. This number is predicted to continue to rise as the potential for fisheries, particularly in coastal regions, is very rapid. Fish waste is not utilized even though fish waste contains organic fertilizer constituents such as N (Nitrogen), P (Phosphorus), and K (Potassium). The high consumption of river fish increases the amount of fish waste (Hapsari et al., 2013)

Shallot (Allium ascalonicum L.) is a horticultural crop that the community requires as an ingredient for various types of food to meet their daily requirements. Considering population growth, shallot consumption is anticipated to increase by an average of 3.47 percent per year between 2020 and 2024, or by an estimated average of 1,021,300 tonnes per year. Meanwhile, per capita consumption has increased by an average of 2.51 percent per year, or 3.83 kilogrammes per person per year (Pusat Data & Informasi Pertanian, 2020)

According to data from the Central Bureau of Statistics in 2022, the harvested area, production, and productivity for 2019 to 2021 are recorded. In 2019, the harvested area was 92 ha with a yield of 507 tonnes and a productivity of 5.51 tons/ha; in 2020, the harvested area will decrease to 63 ha with a yield of 263 tonnes and a productivity of 4.17 tons/ha; and in 2021, the harvested area will increase to 67 ha with a yield of 329 tonnes and a productivity of 4.91 tons/ha. Due to low soil fertility and suboptimal cultivation methods, the results obtained, as demonstrated by the preceding data, remain subpar. For this reason, it is necessary to develop and expand intensive shallot cultivation, including the cultivation of shallots on Ultisol soil, by enhancing production technology, such as liming, fertilizing, employing adaptive varieties, and suppressing pests and plant diseases.

Organic fertilizers contain complete nutrients, but the amount of each type of nutrient is low. Using organic fertilizers is useful for increasing the efficiency of using chemical fertilizers. So that the dose of fertilizer and the impact of environmental pollution due to the use of chemical fertilizers can be significantly reduced (Dermiyati, 2015). Liquid organic fertilizer contains many macro, micro, hormones, and amino acids needed by plants. In addition, in liquid organic fertilizer some microorganisms will improve soil fertility so that it can support plant growth and development (Pangaribuan, D. H,, et al, 2017)

FAO standards for liquid organic fertilizer are 12% nitrogen, 8% phosphorus, and 6% potassium. According to Hapsari et al. (2013), the nutrient content of fish waste is 64.78 percent nitrogen, 43.39 percent phosphorus, and 31.16 percent potassium, which complies with FAO standards.

The fish waste consists of skin, bones, fins, tails, and internal organs. According to Zahroh, Kusrinah, and Setyawati (2018), fish offal contains 36-57% protein, 0.05-2.38% crude fibre, 24-63% moisture, 5-17% ash, Ca levels of 0.9-5%, and P levels of 1-1.1%.

2. MATERIAL AND METHODS

The time of this research was carried out for four months, starting from September – December 2022, at the Experimental Garden of the Faculty of Agriculture, Riau Islamic University, Pekanbaru City, Riau Province.

The materials used were shallot seeds of the Brebes Bima variety, fish waste such as silver catfish, cork, baung, catfish, and toman obtained from fish traders from the Kampar River (Teratak Buluh Village and Bulu China Village), NPK Mutiara 16:16:16, insecticide , EM-4, Dithane M-45, Furadan, bran, coconut water, granulated sugar, and water. While the tools to be used are 1.5 L bottles, plastic buckets, pH meters, scales, hoes, machetes, knives, raffia rope, gembor, tape measure, 25 ml measuring cups, 500 ml measuring cups, hand sprayers, zinc plates and stationery.

At the time the research was conducted, the ambient temperature was between 25.0 and 28.0 degrees Celsius, the relative humidity was between 55% and 98%, and the wind was blowing from west to north at a speed of 10 to 30 kilometres per hour.

This investigation utilized a completely randomized design (CRD) factorial with two factors. The first factor was the concentration of river fish waste, which had five levels: 0, 22,5, 45, 67.5, and 90 ml-1. The second factor was the frequency of river fish waste, which had four levels: 1, 2, 3, and 4 times. Each experimental unit contained 16 plants per plot and 8 plants were used as observation samples, with a plot size of 100 cm x 100 cm and a total of 60 plots.

The phases of the research conducted in the field included the production of POC from river fish refuse, which took place in the compost house of the Faculty of Agriculture for four weeks. Land preparation, making of plots, and application of dolomite at a dose of 400 g per plot (4 tonnes ha-1) 14 days before planting, followed by application of Bokashi ketapang leaves at a dose of 1 kg per plot (10 tons-1) seven days before planting. Before sowing shallot seeds, one-third of the end of the tuber is cut off, done three hours before planting. The seeds are then mixed with 20 grammes of Dithane M45 per kilogramme of shallots to prevent fungus development on the bulbs. The spacing between seedlings is 25 cm x 25 centimetres. Giving treatment according to treatment, namely concentrations of river fish waste of 0, 22,5, 45, 67.5, and 90 ml-1 and frequency of once (7 days after planting), twice (7 days after planting and 14 days after planting), three times (7, 14, and 21 days after planting), and four times (7, 14, 21, and 28 days after planting). The volume of watering at ages 7 and 14 days was 100 ml per plant, while at ages 21 and 28 days, the volume of watering was 150 ml per plant. Watering, weeding, and controlling pests and plant maladies constitute maintenance. .

Plant height, age of tuber formation, number of leaves, number of tubers, wet tuber weight, and dried tuber weight were observed as parameters. Observations of each treatment were statistically analyzed. If the calculated F is greater than the F table, a further test of the Honest Significant Difference (BNJ) at the 5% significance level is conducted.

The research phases are depicted in the accompanying flowchart.:

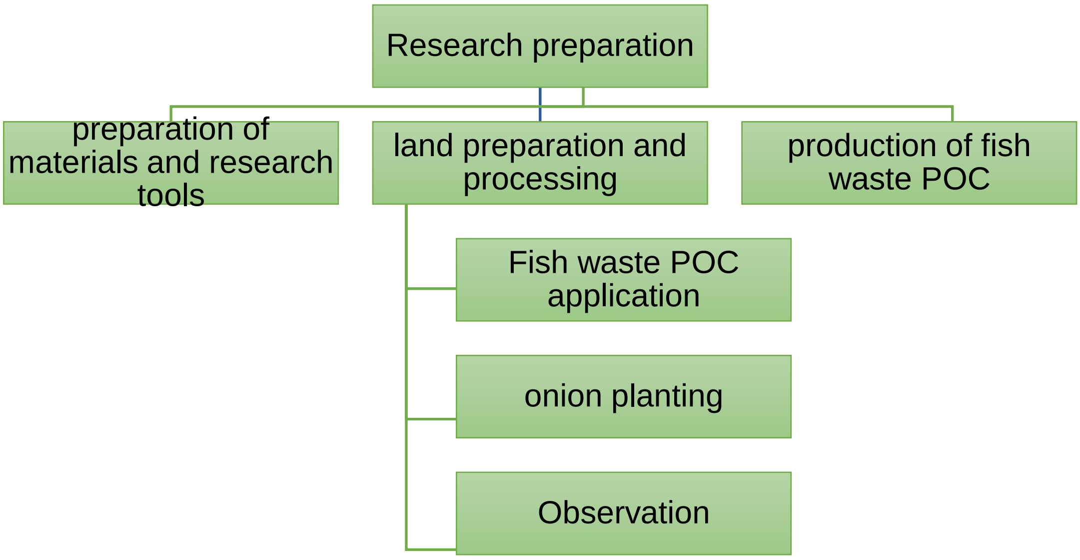

Figure 1. Research flowchart

3. RESULT AND DISCUSSION

1. Plant Height

The results of the analysis of variance revealed that the interaction between the main treatment and the concentration and frequency of fish refuse from the Kampar River on Ultisol soil significantly affected the height of 30-day-old shallot plants. Table 1 displays the average results of measuring the height of 30 day-old shallot plants using the BNJ test at a 5% significance level.

Table 1. Average height of shallot plants aged 30 days with treatment of concentration and frequency of Kampar river fish waste on Ultisol soil (cm)

Concentration ($ml\ l^{-1}$)	Frequency (times) 1	2	3	4	Average
0.0	15.04 c	17.71 bc	17.79 bc	17.54 bc	17.02 c
22.5	17.79 bc	18.08 bc	18.29 bc	18.79 bc	18.24 bc
45.0	18.21 bc	18.50 bc	19.25 bc	19.21 bc	18.79 bc
67.5	18.58 bc	18.87 bc	19.74 bc	19.79 bc	19.25 ab
90.0	18.87 bc	18.58 bc	21.00 b	26.87 a	21.33 a
Average	17.70 b	18.35 b	19.21 ab	20.44 a	
KK = 9.97%	BNJ KF = 5.84	BNJ K= 2.20	BNJ F = 1.85		

Numbers followed by the same letters in rows and columns are not significantly different based on the 5% BNJ test

According to Table 1, the interaction effect of treatment concentration and frequency of Kampar river fish refuse on ultisol soil was significant on the height of 30 day-old shallot plants, with the optimal treatment at a concentration of 90 ml-1 and a frequency of four times. This treatment's ability to increase ultisol soil fertility and vegetative shallot growth contributed to its high yield. Even though the description of the Brebes variety indicates that the plant height ranges from 25 to 44 centimetres, the high yields attained are still far below the target or extremely low, at 26.87 centimetres. One of the causes of low plant height is the fact that the elemental nitrogen content of river fish refuse is only 0.25 percent, which is so low that it inhibits the growth of shallot plants (Wahidiyah, 2021).

The study results (Hardiansyah, R., 2020) indicate that the response to plant height must be sustained by the nutrient content and availability of liquid organic fertilizer made from fish waste. The growth of the onion plant's height necessitates essential nutrients, including nitrogen. N serves a crucial role in the process of cell division and enlargement; therefore, a deficiency in N can inhibit the vegetative development of plants.

During the vegetative growth period of shallot plants, which occurs between 0 and 30 days after sowing, nitrogen (N) is essential because it plays a crucial role in forming chlorophyll, which is essential for photosynthesis. The purpose of the nutrients given to shallot plants is to stimulate the growth of their vegetative organs.

Even though the percentage of nutrients in POC fish waste is low, it can still provide nutrients and rapidly overcome nutrient deficiencies. In addition, the continuous use of POC does not harm soil, vegetation, or the environment, nor does it negatively affect human health.

2. Tubers Formation Age

The analysis of variance indicated that the effect of interaction and main treatment on the concentration and frequency of fish refuse from the Kampar River on ultisol soil had a significant impact on the age at which shallot bulbs formed. Table 2 displays the average age of the observed results of the formation of shallot bulbs after the BNJ test was conducted at a 5% significance level.

Table 2. The average age of the formation of shallot bulbs by treating the concentration and frequency of Kampar river fish waste on Ultisol soil (days)

Concentration ($ml\ l^{-1}$)	Frequency (times)				
	1	2	3	4	Average
0.0	49.17 c	46.89 c	46.67 c	46.92 c	47.41 c
22.5	45.58 bc	44.67 bc	43.25 bc	44.42 bc	44.48 b
45.0	43.92 bc	42.83 bc	42.58 bc	42.42 bc	42.94 b
67.5	43.25 bc	42.25 bc	42.08 bc	42.00 bc	42.40 b
90.0	42.42 bc	40.00 bc	39.17 b	31.83 a	38.35 a
Average	44.87 b	43.33 ab	42.75 ab	41.52 a	
KK = 5.30%	BNJ KF = 7.07	BNJ K= 2.67	BNJ F = 2.24		

Numbers followed by the same letters in rows and columns are not significantly different based on the 5% BNJ test

According to Table 2, the interaction effect of treatment concentration and frequency of Kampar River fish refuse on ultisol soil was significant on the age of shallot bulb formation, with the optimal treatment being a concentration of 90 ml-1 applied four times. The rapid age of tuber formation in this treatment was due to the adequate nutrient content of the fish waste POC, where the percentage of Kampar river fish waste after laboratory analysis was as follows: N 0.25 percent, P 1.05 parts per million, and K 1626 parts per million. Then, 1.25 g of NPK 16:16:16 basic inorganic fertilizer was added per plant. (200 kg^{-1}).

This was likely due to the use of ultisol soil for the first time in plant cultivation, which slowed the formation of tubers. It is conceivable that the organic matter provided was insufficient and the study was conducted during the rainy season.

Novianto (2022) stated that liquid organic fertilizer could be applied to plants or soil. The greater the frequency and intervals of application to plants, the greater the availability of nutrients for plants and the age at which shallot bulbs form, which will occur rapidly if the nutrients are applied at the recommended frequency.

3. Number of Leaves

According to the analysis of variance, the effect of interaction and the main treatment on the concentration and frequency of fish refuse from the Kampar River on ultisol soil was significant on the number of shallots. Table 3 displays the average age at which shallot bulbs formed after the BNJ test was conducted at the 5% significance level..

Table 3. The average number of shallot leaves with the treatment of the concentration and frequency of Kampar river fish waste on Ultisol soil

Concentration ($ml\ l^{-1}$)	Frequency (times)				
	1	2	3	4	Average
0.0	16.75 d	18.08 cd	18.42 cd	18.50 cd	17.94 d
22.5	23.00 c	23.42 c	24.42 bc	25.75 bc	24.15 c
45.0	27.75 bc	27.92 bc	28.33 bc	28.92 bc	28.23 b
67.5	27.42 bc	28.17 bc	28.25 bc	28.67 bc	28.13 b
90.0	27.33 bc	28.00 bc	31.08 b	39.00 a	31.35 a
Average	24.45 b	25.12 b	26.10 b	28.17 a	
KK = 7.69%	BNJ KF = 6.17	BNJ K= 2.33	BNJ F = 1.95		

Numbers followed by the same letters in rows and columns are not significantly different based on the 5% BNJ test

According to Table 3, the interaction effect of the treatment concentration and frequency of Kampar river fish refuse on ultisol soil significantly impacted the number of shallot leaves when the optimal treatment concentration was 90 ml-1 applied four times. Because the POC of river fish waste at these concentrations and frequencies was able to increase the number of shallots, the treatment produced a significant number of leaves. Then, each nutrient in the POC of fish effluent plays a role in determining the number of leaves. The nitrogen nutrient present in detritus plays a role in accelerating the formation of cells, tissues, and organs, as well as influencing the chlorophyll content of leaves. The element K regulates assimilate translocation for the development of new organs, particularly the formation of leaves.

The correct concentration and frequency of fish waste POC play a role in the formation of plant leaves, and there is a tendency for the number of leaves to increase as the dose of organic fish fertilizer is increased. According to Mutryarny et al. (2014), organic fertilizers can stimulate the growth of soil microorganisms that decompose actively and release nutrients during the weathering process. So that the decomposition process will combine porous soil grains, resulting in improved water absorption, thereby improving the plant growth medium.

According to Pramana and Heriko (2020), the nitrogen nutrient in liquid organic fertilizer promotes plant growth, chlorophyll production, protein accumulation, and accelerated leaf growth.

Sutiyoso (2008) explained that Ca influences cell division and elongation, as well as the formation of young leaves in general, so that juvenile leaves are well-formed and not curly or wavy. Potassium (K) regulates the translocation of assimilate results to the parts of the plant that require it so that the growth of the entire plant advances uniformly. According to Rosmarkam (2002), Potassium's other function is to strengthen the stem's uprightness (due to turgor) so that plants do not collapse readily, and to increase the levels of carbohydrates and sugar in fruit.

4. Number of Tubers Per Clump

The analysis of variance revealed that the interaction effect and the main treatment concentration and frequency of Kampar river fish refuse on ultisol soil significantly influenced the number of shallot bulbs per hill. Table 4 displays the average number of shallot bulbs observed after the BNJ test was conducted at a 5% significance level..

Table 4. The average number of shallot bulbs per hill with the treatment of the concentration and frequency of Kampar river fish waste on Ultisol soil

Concentration (ml l^{-1})	Frequency (times)				
	1	2	3	4	Average
0.0	5.75 c	6.75 c	8.17 bc	7.92 c	7.15 d
22.5	8.67 bc	9.00 bc	8.67 bc	9.08 bc	8.85 c
45.0	8.75 bc	9.92 bc	10.42 bc	10.58 bc	9.92 bc
67.5	9.00 bc	10.58 bc	10.25 bc	11.58 b	10.35 b
90.0	9.58 bc	10.75 bc	12.67 ab	15.67 a	12.17 a
Average	8.35 b	9.40 b	10.03 ab	10.97 a	
KK = 11.72%	BNJ KF = 3.51	BNJ K= 1.32	BNJ F = 1.11		

Numbers followed by the same letters in rows and columns are not significantly different based on the 5% BNJ test

Table 4 indicates that the interaction effect of treatment concentration and frequency of Kampar river fish waste on ultisol soil significantly affected the number of shallot bulbs when the optimal treatment concentration was between 67.5 and 90 ml-1 and the frequency was between 3 and 4 times. Because the ultisol soil to which POC nutrients from fish waste had been added had a loose enough texture, the number of shallot bulbs was greater than it would have been without POC application and the periodicity was insufficient. Then POC dissolves more rapidly in the soil, making plant nutrients more readily accessible.

With the addition of POC, the investigation conducted by Setiyowati et al. (2010) produced the greatest number of tubers, 9.75. This indicates that the POC treatment can increase shallot bulb yield. Shallot bulbs develop from the base of a leaf, which expands in layers to form a pseudo-stem that serves as a food reserve storage organ. The provision of POC with its nutrient content will stimulate photosynthesis, with the resulting carbohydrates being transported to all plant organs. This is corroborated by Dwidjoseputro (1988), who stated that the results of photosynthesis are transported from the leaves to the meristems via respiration, which generates ATP at the growing point and stimulates the division of primordial cells/leaf shoots. The more trees that flourish, the more tubers there will be.

The number of shallot bulbs is influenced by the soil's nutrient availability, which is reflected in the growing medium. The texture of the soil also influences the roots and number of shallot tillers. The more robust the roots, the more robust the tuber development.

The environment also plays a role in the formation and maturation of tubers; according to BMKG data, the average daily temperature at the study site from October to December ranges between 25 °C and 28 °C. The optimal temperature for shallot development is between 25 and 32 °C.

5. Weight of Wet Tubers Per Clump

The analysis of variance revealed that the principal treatment concentration and frequency of Kampar river fish waste on ultisol soil had a significant effect on the weight of wet tubers per clump. Table 5 displays the average observed weight of moist shallot tubers per cluster as determined by the BNJ test at the 5% significance level..

Table 5. Average wet bulb weight of shallots per clump with treatment of the concentration and frequency of Kampar river fish waste on PMK soil (g)

Concentration ($ml\ l^{-1}$)	Frequency (times)				
	1	2	3	4	Average
0.0	26.62 d	26.94 d	28.55 d	30.95 cd	28.26 e
22.5	31.33 cd	32.02 cd	35.94 cd	36.67 cd	33.99 d
45.0	32.10 cd	39.31 c	40.82 c	45.88 bc	39.52 c
67.5	44.32 bc	44.85 bc	50.37 b	58.99 ab	49.63 b
90.0	48.83 bc	53.33 b	58.58 ab	64.75 a	56.37 a
Average	36.64 c	39.29 c	42.85 b	47.45 a	
KK = 7.42%	BNJ KF = 9.54	BNJ K= 3.60	BNJ F = 3.02		

Numbers followed by the same letters in rows and columns are not significantly different based on the 5% BNJ test

Based on the data in Table 5, it shows that the interaction effect of the treatment concentration and frequency of Kampar river fish waste on ultisol soil was significant on the wet bulb weight of shallots with the best treatment concentration of 67.5 – 90 ml^{-1} with a frequency of 3 – 4 times. The high yield of wet bulbs in this treatment compared to other treatments was because ultisol soil media and fish waste POC could provide good nutrient availability on the weight of shallots wet bulbs. If the nutrient needs of a plant are met, the metabolic processes in the plant will run well too.

Applying organic matter to ultisols plays an important role in improving soil structure so that air aeration and water movement is smooth, thereby increasing the absorption of water in the soil and increasing plant growth and production. Furthermore, the application of organic fertilizers has the benefit of increasing the amount of water that can be retained in the soil and the amount of water available to plants as well as a source of energy for microorganisms so that without organic fertilizer all biochemical activities will stop (Nizar, 2011).

According to Mukhlis and Anggorowati (2011) the large number of leaves formed means that the leaf area becomes larger, so the ability of the leaves to receive light for the photosynthesis process becomes greater in Tuber Weight (g) produces carbohydrates and will be translocated to parts of the tuber so that it affects the size and weight of the tuber.

The wet weight of the tubers is the weight of the tubers when the plant is still alive and is measured promptly following harvest. According to Carora, F., et al. (2014), tuber enlargement is primarily induced by cell enlargement rather than cell division. The quantity of water absorption and the accumulation of photosynthetic products in the leaves to be translocated for tuber formation influenced the increase in tuber wet weight. Therefore, the difference in water content will impact the wet weight of the produced tubers..

6. Weight of Dry Tuber Per Clump

The results of analysis of variance showed that the effect of interaction and main treatment on the concentration and frequency of Kampar river fish waste on PMK soil was significant on the weight of dry tubers per clump. The average observed dry tuber weight per shallot clump after the BNJ test at the 5% level can be seen in Table 6.

Table 6. Average dry onion bulb weight per hill with concentration and frequency treatment of Kampar river fish waste on PMK soil (g)

Concentration (ml l^{-1})	Frequency (times)				
	1	2	1	4	Average
0.0	13.35 d	14.88 d	16.10 d	17.76 d	15.52 e
22.5	21.74 cd	22.59 cd	26.93 c	28.26 c	24.88 d
45.0	25.84 cd	33.66 c	34.50 c	38.55 c	33.14 c
67.5	37.14 c	38.91 c	44.42 bc	51.57 ab	43.06 b
90.0	43.83 bc	48.62 b	51.88 ab	58.45 a	50.70 a
Average	28.38 d	31.73 c	34.77 b	38.95 a	
KK = 8.48%	BNJ KF = 8.78	BNJ K= 3.31	BNJ F = 2.78		

Numbers followed by the same letters in rows and columns are not significantly different based on the 5% BNJ test

Based on the data in Table 6, it shows that the interaction effect of the concentration and frequency of Kampar river fish waste on PMK soil was significant on the weight of dry onion bulbs with the best treatment concentration of 67.5 – 90 ml-1 with a frequency of 3 – 4 times. The high yield of dried tubers in this treatment was due to the nutrients contained in the fish waste fertilizer and the correct frequency of application, which increased soil fertility, microbial activity, and nutrient availability in the soil.

According to Suryana (2008), a plant will flourish if its roots can absorb the nutrients supplied and are in an absorbable form. Additionally, the inability to produce tubers is associated with the discolouration of shallot plant leaves. discoloration of plant leaves leads to decreased chlorophyll and photosynthesis, resulting in a deficiency of essential nutrients for plant growth and development, particularly tuber formation.

Lakitan (1996) defines dry weight as the accumulation of organic compounds effectively synthesized by plants from inorganic compounds. The small dimension of the tubers suggests that the content of organic compounds in the tubers, such as carbohydrates, proteins, and fats, is shallow, so the dry weight components obtained are comparable and small.

4. CONCLUSION

The results indicated that the interaction and main effects were significant for plant height, number of leaves, age of tuber formation, number of tubers, wet tuber weight and dried tuber weight, with the optimal treatment consisting of 67.5 – 90 ml-1 applied three to four times.

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