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Effect of Peptide Application and Dosage of NPK Fertilizer on the Growth and Yield of Shallot Plants (*Allium ascalonium* L. var. *Bima Brebes*)

Modesta Sriayuningsi Todo[1]*, Ni Komang Alit Astiari[1], Anak Agung Ngurah Mayun Wirajaya[1]
[1]Agrotechnology Study Program, Faculty of Agriculture, Warmadewa University, Indonesia
* Corresponding author : alit.astiari@gmail.com

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Abstract
Shallots are an important commodity with numerous health benefits. Shallot production, particularly in Bali, fluctuates due to limited land and declining soil fertility. This decline in soil fertility is caused by the excessive and continuous use of high doses of inorganic fertilizers, which can negatively impact soil health over time. This study aimed to determine the effect of peptides and NPK fertilizer doses and their interactions on the growth and yield of shallots (Allium ascalonium L. var. Bima Brebes). The study was conducted from February to May 2025, in the greenhouse of the Faculty of Agriculture, Science and Technology, Warmadewa University, Denpasar. The design used was a Randomized Block Design (RAK) with 2 factors arranged in a factorial manner. The first factor was peptide (P) consisting of 3 concentration levels, namely 0, 2 and 4 ml $l^{-1.}$ The second factor was NPK fertilizer (N) consisting of 4 dosage levels, namely: 0, 100, 200 and 300 kg ha^{-1}. There were 12 treatment combinations repeated 3 times, so 36 polybags were needed. From the research results, it was obtained that the interaction between peptides and NPK fertilizer had a significant effect on almost all observed variables except for the variables of number of seeds, number of tubers and dry weight of oven tubers per clump which had no significant effect. The highest fresh weight of tubers per clump was obtained in the interaction between the peptide treatment of 4 ml l^{-1} and the NPK fertilizer dose treatment of 200 kg ha^{-1}, namely 20.63 g, an increase of 98.37% when compared to the treatment without peptide and without NPK, namely 10.40 g.
Keywords : Shallots, peptides, NPK and yield

1. Introduction

Shallots (Allium ascalonium L.) are one of the superior commodities in several regions in Indonesia which are used as cooking spices and contain several substances that are beneficial for health, their properties as anti-cancer and antibiotic substitutes, lowering blood pressure, cholesterol and reducing blood sugar levels [1]. Shallots are also one of the priority and superior national vegetable commodities that can be developed by increasing planting areas, productivity, production stability, and quality [2]; [3].

Based on data from the Central Statistics Agency of Bali Province in 2024, in 2023, shallot production will reach 33,430 tons, which is the highest figure in recent years. When compared to previous production, such as in 2022 which only reached 31,492 tons, production in 2023 shows a significant increase. However, this does not make Bali one of the 6 provinces that provide national shallot production [4]. There are many factors that affect the small amount of onion production in Bali when compared to other provinces, in addition to the lack of land, soil fertility is also an important thing that affects the production of shallots [5]. Based on production data, even though production has increased, fluctuations in production and distribution between regions mean that the availability of shallots is not yet completely stable, so that at certain times there is still dependence on supplies from outside the region or imports [6].

The decline in soil fertility in the long term is caused by the intensive and continuous use of inorganic fertilizers, the use of inorganic fertilizers in high doses and for a long time can have a bad impact on microorganisms in the soil and if left unchecked, the natural fertility of the soil will be lost, therefore the combination of organic and inorganic fertilization can be used to increase productivity and maintain soil health [7]. In addition, [8] states that the use of organic fertilizers in the long term and sustainably can maintain soil fertility in a balanced manner, both in terms of physical, chemical and biological properties.

Organic fertilizer is a fertilizer made from natural materials and has the characteristic of having a lot of nutrients but in small amounts. The use of organic fertilizers in plants not only provides the elements that plants need, but can also improve soil structure. This is also supported by [9];[which states that the high content of organic matter in the soil contributes to the addition of nutrients and as a buffer of nutrients, which supports soil fertility by influencing the biological, physical, and chemical factors of the soil. Organic fertilizers have two types, namely liquid organic fertilizers and solid organic fertilizers [10]. Solid fertilizer comes from organic matter derived from plant residues and animal manure which is solid in form, while liquid organic fertilizer is a fertilizer that has one and more nutrient content in a form that is easily soluble and absorbed by plants. The advantage of liquid organic fertilizer is that the nutrients contained in it are easier to be absorbed by plants, while solid organic fertilizer comes from organic matter from plant residues and animal manure in solid form. Liquid organic fertilizers can minimize nutrient deficiencies quickly compared to solid types [11].

Liquid organic fertilizer can be applied through the leaves or referred to as foliar liquid fertilizer, which is applied directly to the leaves of the plant, so that the absorption of nutrients through the stomata runs quickly and nutrients can be absorbed immediately. However, the use of liquid organic fertilizers may not necessarily improve soil structure as well as solid organic fertilizers [12].

One type of liquid organic fertilizer that can be used to maintain soil fertility and increase production is peptides. Peptide compounds are the result of a high-pressure hydrolysis process using a mixture of poultry feathers and water. Poultry wool contains, nitrogen, sulfur, and is rich in amino acids that play an important role in increasing the physiological accumulation, development, and defense of plants. The composition of the nutrient content contained in peptides includes C – organic, N – organic, P2O5, K2O, Fe, Mn and Zn [13]; [14]. The application of peptides produced by degrading proteins in poultry feathers using environmentally friendly hydrolysis technology has been proven to be able to increase plant resistance to stress and improve the plant's defense system which at the same time increases the efficiency of fertilizer use and increases the yield and quality of various types of plants. Peptide application can be done by spraying the solution over the entire plant crown starting from the beginning of growth (vegetative vase to the generative phase) with a peptide solution concentration of 2 ml 1-1 [15]. Research by [16] reported that peptide application to coffee plants in China increased flowering by up to 20% and improved fruit quality. These findings suggest that peptide application has the potential to influence the phenological phases of Arabica coffee. Plant phenology is the study of the natural stages of plant development and growth, such as tillering, tuber formation, fruiting, and fruit ripening, which are influenced by genetic and environmental factors [17]; [18] Information on plant phenology is crucial for determining cultivation strategies, fertilization timing, and yield estimation [19].

The results of the study [20] on rice plants were obtained in the treatment of reducing the dose of NPK fertilizer by 30% + spraying of peptide 2 ml l^{-1} did not reduce the yield (5.67 tons/ha), the yield of the rubbing (3.54 kg), the yield per clump (54.22 g), the number of productive saplings (25.67 pieces). Peptides resulting from the decomposition of poultry wool waste offer a sustainable solution to promote plant growth. By utilizing this waste as a source of organic nutrients, farmers can reduce their reliance on synthetic chemical fertilizers and increase soil fertility naturally.

In addition to the application of peptide organic fertilizers, the use of inorganic fertilizers is also needed which has the advantage of being absorbed faster and increasing plant productivity. The combination of organic fertilizers and inorganic fertilizers can have a beneficial effect on plant nutrient balance and improve soil fertility [21]. One of the inorganic fertilizers that can be used is NPK 16:16:16 fertilizer. NPK 16:16:16 fertilizer is a compound fertilizer that contains 3 nutrients, namely Nitrogen 16%, Phoste 16%, Potassium 16%, Calcium 6% and Magnesium 0.5%. This fertilizer is hydroscopic or easily soluble so that it is easily absorbed by plants and is neutral or does not acidify the soil [22]; [23].

The optimal application of NPK 16:16:16 inorganic fertilizer can increase the development and growth of shallot plants. Nutrients N can increase protein development and chlorophyll formation so as to stimulate growth in plants. The element P is important in the process of fruit formation and tuber ripening. Nutrient K plays an important role in the metabolic process of plants [24]; [25]. The results of the study [26] the application of NPK fertilizer of 200 kg ha^{-1} provides the highest results for the growth and production of shallots which include tuber diameter, tuber weight/clump, dry tuber weight. Then the research results recommend fertilizing shallot plants, according to [27], the best NPK pearl fertilizer (16-16-16) dose treatment for shallot growth is a dose of 250-400 kg ha^{-1}, significantly affecting plant height, number of leaves per clump, number of bulbs per clump, bulb weight per clump, and yield tons ha^{-1}.

The peptide organic fertilizer used in this study is a new innovation product and has just been tried only on rice plants combined with NPK application, the author wants to research the application of peptides combined with NPK fertilizer on onion plants.

2. Material and Methods

This research is located in the green house of Faculty of Agriculture, Science and Technology, Warmadewa University, Jalan Terompong No 24 Denpasar, Tanjung Bungkak area, Sumerta Village, East Denpasar District, Denpasar City, with an altitude of 40 meters above sea level. The research time starts in February – May 2025. The method used in this study is a quantitative method. This study is a factorial experiment with a basic design of the Group Random Design (RAK) with 2 factors tested. The first factor is the application of peptide (P) with nutrient content (C - organic 10.07%; N - organic 0.96%; N + P2O5 + K2O 2.66%; Fe total 329.84 ppm; Mn total 49.98 ppm and Zn total 49.95 ppm), while the second factor is the dose of NPK fertilizer (P). The first factor of peptide (P) administration consists of 3 concentration levels, namely P0 (0 ml 1^{-1}), P1 (2 ml 1^{-1}), P2 (4 ml 1^{-1}). The basis for selecting the peptide dose is based on the results of previous research by researchers. The second factor tested is the use of NPK 16-16-16 fertilizer (N) which consists of 4 dose levels, namely N0 (0 kg ha^{-1}), N1 (100 kg ha^{-1}), N2 (200 kg ha^{-1}), N3 (300 kg ha^{-1}). Thus, there are 12 combination treatments that are repeated 3 times so that 36 polybags of shallot plants are needed. The soil used is air-dried, mixed evenly with compost, charcoal, husks with a ratio of 2:1:1 and then weighed each polybag filled with 5 kg of soil. The onion seeds used in this study were selected with uniform sizes with seed weight criteria ranging from (7.5 – 8.0 g), with seed diameter (2.20 – 2.54 cm) and healthy and thoughtful seed conditions. Before the seeds are planted in polybags, there is a cutting of the seedling ends or break-ups and the seedlings are planted with the position of the roots facing down and part of the seedling ends on the ground level. The fertilization process with NPK16-16-16 was carried out twice during the study, namely at the age of 14 hst and 28 hst, while the application of peptides to plants was carried out at the age of 15 hst and repeated every 2 weeks until before harvest.

The variables observed in this study included maximum plant height (cm), number of leaves per clump (leaf), number of saplings per clump (tiller), number of tubers per clump (tubers), fresh weight of tubers per clump (g), dry weight of tuber oven per clump (g), fresh weight of pruning per clump (g), dry weight of pruning oven (g), and harvest index (%).

The observation data was tabulated, then statistically analyzed using multiple fingerprint analysis in accordance with the design used. First, a diversity test was carried out so that a variety fingerprint was obtained. If the treatment has a real effect, then it is analyzed to look for the single influence of each factor with a BNT test of 5% and 1%, after which a correlation analysis is carried out to find out the relationship between the observed variables.

3. Results and Discussion

Based on the results of statistical analysis, the significance of the effect of peptide (P) and NPK (N) fertilizer treatment and their interaction (PxN) on all observed variables is presented in Table 1.

Table 1.
The significance of the influence of peptide (P) and NPK (N) fertilizer treatment on the observed variables

No.	Variabel	Treatment		
		Peptide (P)	NPK Dosage (N)	Interaction (P x N)
1.	Maximum Plant Height (cm)	**	*	**
2.	Maximum Number of Leaves Per Clump (Strands)	**	**	**
3.	Number of Saplings Per Clump (Saplings)	*	**	ns
4.	Number of Tubers Per Clump (tubers)	*	**	ns
5.	Fresh Weight of Tubers Per Clump (g)	**	**	*
6.	Dry Weight of Tuber Oven Per Clump (g)	**	**	ns
7.	Fresh Weight Per Clump (g)	*	**	*
8.	Dry Weight of Pruning Oven Per Clump (g)	**	**	*
9.	Yield Index (%)	ns	ns	ns

Information : ns = Influence is not real (P≥0.05)
** = very real impact (P<0.01)
* = Have a real impact (P<0.05)

Based on Table 1, it can be seen that the interaction between peptide treatment with NPK fertilizer (PxN) has an intangible effect on most of the observed variables, except for the variable of maximum plant height and the maximum number of leaves per clump has a very real effect (P<0.01), and has a real effect (P<0.05) on the fresh weight of tubers per clump, the weight of fresh pruning per clump, and the dry weight of the oven is spaced per clump. Meanwhile, in the treatment of peptides and NPK fertilizers, the effect was real to very real on all observed variables except for the variable of the harvest index had an unreal effect.

3.1 Maximum Plant Height (cm)

The maximum plant height in the peptide treatment of 4 ml 1^{-1} with an NPK fertilizer dose of 200 kg ha^{-1} (P2N2) was 48.23 cm, which was not significantly different from other treatments, and in the treatment without peptide and without NPK (P0N0) it was 35.70 cm (Table 2).

Table 2.
Average maximum height (cm) due to the effect of interaction between peptide treatment and NPK fertilizer (PxN)

Treatment	NPK Fertilizer							
	N0		N1		N2		N3	
Peptida								
P0	35,70 b	B	42,83 b	A	44,47 a	A	46,43 a	A
P1	45,47 a	A	47,37 a	A	47,30 a	A	46,27 a	A
P2	47,67 a	A	47,07 a	A	48,23 a	A	45,53 a	A
BNT 0,05	4,00							

Information:

1. Numbers followed by the same lowercase letters in the same column, differ not significantly at the level of the 5% BNT test
2. Numbers followed by the same capital letters in the same line, differ not significantly at the 5% BNT test level

3.2 Maximum Number of Leaves

The average maximum number of leaves per clump was obtained in the peptide treatment of 4 ml 1^{-1} with an NPK fertilizer dose of 200 kg ha^{-1} (P2N2), namely 35.33 leaves, which was not significantly different from other treatments and in the treatment without peptide with no NPK dose (P0N0), 18.67 leaves were obtained (Table 3).

Table 3.
Average maximum number of leaves per clump (strand) due to the effect of interaction between peptide treatment and NPK fertilizer (PxN)

Treatment	NPK Fertilizer							
	N0		N1		N2		N3	
Peptida								
P0	18,67 b	B	31,33 a	A	31,67 a	A	28,33 a	A
P1	28,00 a	A	30,33 a	A	34,33 a	A	34,67 a	A
P2	30,33 a	A	33,00 a	A	35,33 a	A	35,00 a	A
BNT 0,05	7,54							

Information:

1. Numbers followed by the same lowercase letters in the same column, differ not significantly at the level of the 5% BNT test
2. Numbers followed by the same capital letters in the same line, differ not significantly at the 5% BNT test level

3.3 Number of Saplings Per Clump (Saplings)

The average number of saplings per clump was higher in the 4 ml 1^{-1} (P2) peptide treatment, which was 7.75 saplings, and the lowest was obtained in the peptide-free treatment (P0), which was 4.33 saplings. The average number of saplings per clump was obtained in the treatment of the NPK dose of 200 kg $^{ha-1}$ (P2), which was 8.22 saplings, and the lowest was obtained in the treatment without a dose of NPK fertilizer (N0), which was 4.89 saplings (Table 7).

3.4 Number of Tubers Per Clump (Tubers)

The average number of tubersper clump was the highest obtained in the 4 ml 1^{-1} (P2) peptide treatment, which was 9.08 tubers, and the lowest was obtained in the peptide-free treatment (P0), which was 5.58 tubers. The average number of tubers per clump obtained in the NPK treatment at a dose of 200 kg $^{ha-1}$ (N2), which was 9.13 tubers, was not real from the N1 treatment, which was 9.11 tubers and the lowest was obtained in the treatment without a dose of NPK fertilizer (N0), which was 5.22 tubers (Table 7).

3.5 Fresh Weight of TubersPer Clump (g)

The highest average fresh weight of tubers per clump was obtained in the 4 ml 1^{-1} peptide treatment with a dose of NPK fertilizer dose of 200 kg $^{ha-1}$ (P2N2) which was 20.63 g and the lowest in the treatment without peptides with the treatment without NPK fertilizer (P0N0) which was 10.40 g (Table 4).

Table 4.
The average fresh weight of tubers per clump (g) is due to the effect of the interaction between peptide treatment and NPK fertilizer (PxN).

Treatment	NPK Fertilizer							
	N0		N1		N2		N3	
Peptida								
P0	10,40 a	A	11,57 a	A	13,93 b	A	12,87 a	A
P1	12,47 a	B	13,47 a	A	19,77 ab	B	16,67 a	AB
P2	14,20 a	B	16,27 a	AB	20,63 a	A	16,97 a	AB
BNT 0,05	6,33							

Information:

1. Numbers followed by the same lowercase letters in the same column, differ not significantly at the level of the 5% BNT test
2. Numbers followed by the same capital letters in the same line, differ not significantly at the 5% BNT test level

3.6 Dry Weight of Tuber Oven Per Clump (g)

The higher average dry weight of tuber ovens per clump was obtained in the 4 ml 1^{-1} (P2) peptide treatment which was 2.74 g and the lowest was obtained in the peptide-free treatment (P0) which was 1.64 g. The highest average dry weight of tuber ovens per clump was obtained in the treatment of NPK fertilizer at a dose of 200 kg $^{ha-1}$ (N2) which was 2.73 g and the lowest was obtained in the treatment without a dose of NPK fertilizer (N0) which was 1.54 g (Table 7).

3.7 Fresh Weight Per Clump (g)

The highest average weight of fresh cuttings per clump was obtained in the 4 ml 1^{-1} peptide treatment with no NPK fertilizer (P2N0) treatment which was 18.97 g and the lowest in the peptide-free treatment with the treatment without NPK fertilizer (P2N2) which was 12.90 g (Table 5).

Table 5.
The average fresh weight per clump (g) was due to the effect of the interaction between peptide treatment and NPK fertilizer (PxN).

Treatment	NPK Fertilizer							
	N0		N1		N2		N3	
Peptida								
P0	18,30	A	18,77	A	15,30	A	15,10	A
	a		a		a		a	
P1	18,07	A	16,53	A	14,83	A	15,70	A
	a		a		ab		a	
P2	18,27	A	16,80	A	10,02	A	15,33	AB
	a		a		b		a	
BNT 0,05	5,11							

Information:
1. Numbers followed by the same lowercase letters in the same column, differ not significantly at the level of the 5% BNT test
2. Numbers followed by the same capital letters in the same line, differ not significantly at the 5% BNT test level

3.8 Dry Weight of Pruning Oven Per Clump (g)

The highest average dry weight of the plywood oven was obtained in the 4 ml 1^{-1} peptide treatment with NPK fertilizer treatment at a dose of 200 kg $^{ha-1}$ (P2N2) which was 1.77 g and the lowest in the peptide-free treatment with the treatment without NPK fertilizer (P0N0) which was 0.67 g (Table 6).

Table 6.
Average dry weight of pruning oven (g) due to the effect of interaction between peptide treatment and NPK fertilizer (PxN)

Treatment	NPK Fertilizer							
	N0		N1		N2		N3	
Peptida								
P0	1,67	A	1,33	AB	1,07	B	1,40	B
	a		a		a		a	
P1	1,63	A	1,30	A	1,03	A	1,13	A
	a		a		a		ab	
P2	1,77	A	1,17	B	1,01	B	1,09	B
	a		a		a		b	
BNT 0,05	0,30							

Information:
1. Numbers followed by the same lowercase letters in the same column, differ not significantly at the level of the 5% BNT test
2. Numbers followed by the same capital letters in the same line, differ not significantly at the 5% BNT test level

3.9 Yield Index (%)

The average yield index in the treatment without a dose of peptide fertilizer (P2) was 59.87 g, which was not real from the treatment (P1), which was 58.31% and (P0) 57.37%. The average yield index in NPK fertilizer treatment was obtained at 59.97% at a dose of 200 kg $^{ha-1}$ (N2) which is not real from other treatments (Table 7).

Table 7.
The average number of saplings per clump, the number of tubers per clump, the dry weight of the tuber oven per clump, and the harvest index due to the effect of applying peptides (P) and NPK fertilizers (N)

Treatment	Number of Saplings Per Clump (Saplings)	Number of Tubers Per Clump (tubers)	Dry Weight of Tuber Oven Per Clump (g)	Yield Index (%)
Peptida (P)				
P0 (0 ml 1^{-1})	4,33 b	5,58 b	1,64 c	57,37 a
P1 (2 ml 1^{-1})	7,33 a	7,92 a	2,20 b	58,31 a
P2 (4 ml 1^{-1})	7,75 a	9,08 a	2,74 a	59,87 a
BNT 5%	**1,30**	**1,42**	**0,50**	**-**
NPK Fertilizer (N)				
N0 (0 kg $^{ha-1}$)	4,89 c	5,22 b	1,54 b	58,51 a
N1 (100 kg $^{ha-1}$)	7,44 ab	9,11 a	2,57 a	57,59 a
N2 (200 kg $^{ha-1}$)	8,22 a	9,13 a	2,73 a	59,97 a
N3 (300 kg $^{ha-1}$)	7,00 b	8,33 a	1,93 b	57,98 a
BNT 5%	**1,12**	**1,34**	**0,43**	**-**

Note: The average value followed by the same letter in the same treatment and column, means that it is not significantly different at the 5% BNT test level.

The highest fresh weight of tubers per clump was obtained at the interaction between the The highest fresh weight of tubers per clump was obtained at the interaction between the treatment of 4 ml 1^{-1} peptide and the treatment of NPK fertilizer with a dose of 200 kg ha^{-1} (P_2N_2) which was 20.63 g, an increase of 98.37% when compared to the treatment without peptide and without NPK fertilizer (P_0N_0) which was 10.40 g (Table 4). This shows that the increasing number of saplings and the number of tubers formed per clump will support the increase in the fresh weight of tubers per clump. The number of tubers and the number of saplings formed per clump were seen from single-factor treatment, the highest was obtained in the treatment of 4 ml 1^{-1} (P_2) peptides, namely 7.55 saplings and 9.08 tubers compared to the treatment without peptides, which was 4.33 saplings of 5.58 tubers, while the number of tubers and number of saplings per cluster in the NPK fertilizer treatment was the highest of 8.22 saplings and 9.13 tubers compared to the treatment without NPK fertilizer, which was 4.89 saplings and 5.22 tubers (Table 7). The increasing fresh weight of tubers per clump in P_2N_2 was supported by the increasing number of leaves per clump. The highest number of leaves per clump was obtained in the treatment of 4 ml 1^{-1} peptide with a dose of NPK fertilizer at a dose of 200 kg ha^{-1} (P_2N_2) which was 35.33 sheets and the lowest was obtained in the treatment without peptides and without NPK fertilizer (P_0N_0) which was 18.67 sheets (Table 3). The increasing number of leaves formed will support the photosynthate produced the higher so that the potential number of productive saplings formed is increasing, the number of saplings formed more will support the formation of more tubers which will ultimately be able to increase the fresh weight of tubers per clump. This is supported by research [28] that the number of leaves on onions is directly proportional to the high photosynthesis production, which ultimately supports increased plant production, especially the number of productive shoots and bulbs. This is due to the results of photosynthesis which must be divided between the growth of leaves, stems, branches, and tubers. When plants produce very high space, this is due to the fact that most photosynthates are allocated for vegetative growth so that the allocation for tubers can be reduced, making the fresh weight of the tubers lower [29].

The highest average fresh weight per clump was obtained in the non-peptide treatment with a dose of 100 kg ha^{-1} (P_0N_1) NPK fertilizer treatment which was 18.77 g and the lowest in the 4 ml 1^{-1} peptide treatment with NPK fertilizer with a dose of 200 kg ha^{-1} (P_2N_2) NPK fertilizer which was 10.02 g (Table 5). The highest average dry weight of the pruning oven was obtained in the 4 ml 1^{-1} peptide treatment with no NPK fertilizer (P_2N_0) treatment which was 1.77 g and the lowest in the 4 ml 1^{-1} peptide treatment with the NPK fertilizer treatment at a dose of 200 kg ha^{-1} (P_2N_2) which was 1.01 g (Table 6), and the highest dry weight of the tuber oven per clump was obtained in the 4 ml l^{-1} peptide treatment (P_2) was 2.57 g, and the lowest was in the non-peptide treatment (P_0) which was 1.64 g. Meanwhile, in the treatment of dry weight NPK fertilizer per clump, the highest dose of NPK was obtained at the NPK dose of 200 kg ha^{-1} (N_2) which was 2.73 g and the lowest in the treatment without NPK fertilizer (N_0) which was 1.54 g (Table 7).

Peptide treatment of 4 ml 1-1 with NPK 200 kg ha-1 gave a higher fresh weight of tubers compared to the control due to the influence of peptide and NPK which work together in influencing the growth of onion plants, especially in the tuber formation process.. This is in line with research from [30] which states that the combination of organic fertilizers containing C-organic and N-organic elements with NPK fertilizer provides better growth and shallot tuber results compared to the application of a single NPK fertilizer. The relationship between peptide content and NPK fertilizer in the formation of onion tubers is synergistic, where peptides containing C-organic and N-organic elements act as a source of organic nutrients and bioactive compounds that stimulate cell division and plant tissue growth.

Meanwhile, NPK fertilizer provides primary macronutrients, namely nitrogen (N), phosphorus (P), and potassium (K) which are very important for plant metabolic processes, especially in the vegetative and generative phases. Phosphorus plays a role in accelerating the formation of roots and tubers, while potassium regulates the translocation of photosynthesis results to the tubers as a storage organ. Microelements such as Fe, Zn, and Mn contained in peptides also function as enzyme cofactors that support the process of bulb formation and maturation. Supported by [31] it is stated that the peptides given contain nutrients such as C – organic, N – organic, P2O5, K2O, Fe, Mn and Zn. These elements contained are very functional in the growth and development of plants. Nitrogen from NPKs and peptides stimulates leaf and sapling growth, increasing leaf area which plays a role in photosynthesis resulting in more carbohydrates. This is in line with research [32] which proves that the administration of high N organic matter increases the number of leaves by up to 45% and saplings by 32% through auxin hormone stimulation. The simultaneous application of organic nitrogen and inorganic nitrogen to plants has a positive synergistic effect on plant growth and soil fertility. It is also supported by [33] that inorganic nitrogen such as NPK is available in a form that can be directly absorbed by plants thus providing a rapid growth response, especially in the early phases. The addition of C-organic from liquid organic fertilizer combined with NPK fertilizer has a positive effect on the fresh weight of the tubers and soil fertility. Liquid organic fertilizers that contain organic matter and macro-micronutrients are able to improve soil structure, increase the activity of microorganisms, and increase the availability of nutrients for plants [34]. Thus, the interaction of peptide content and NPK fertilizer can increase the availability of nitrogen stably and sustainably, increase nutrient absorption efficiency, improve soil physical and chemical conditions, support the activity of microorganisms, and optimize plant physiological processes so as to produce tubers with high fresh weight. This is supported by a statement [35] stating that the application of exogenous peptides can significantly increase nutrient uptake at low nutrient levels while minimizing nutrient loss so that the availability of nutrients in the soil is maintained thereby improving yield quality.

4. Conclusion

Based on the results of this study, it can be concluded that the interaction between peptides and NPK fertilizers had a significant effect on almost all observed variables except for the number of seeds, the number of tubers and the dry weight of oven-dried tubers per clump which had no significant effect. The highest fresh weight of tubers per clump was obtained in the interaction between the peptide treatment of 4 ml l-1 with the NPK fertilizer dose treatment of 200 kg ha-1 (P2N2), namely 20.63 g, an increase of 98.37% when compared to the treatment without peptides and without NPK (P0N0), namely 10.40 g.

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