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Effect of Gibberellin and Nitrogen Fertilizer on Growth and Zucchini (*Cucurbita pepo* L.) Yield In Tropical Regions

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Abstract *— Zucchini is the Cucurbitaceae family and rich in nutrients. In Indonesia, cultivation of zucchini is still low and zucchini has the potential to be developed. Improvement of cultivation technology is required to ensure optimal growth and yield of zucchini. The research to study effect of gibberellin and nitrogen fertilizer on growth and yield of zucchini plants. Was conducted from July to October 2023 in Batu City, East Java, Indonesia. The Research was a factorial experiment using a randomized complete block design with two factors, first factor was gibberellin concentration with 3 treatment levels (0, 150 and 300 ppm) and the second factor was the dose of nitrogen fertilization with 5 treatment levels (50, 100, 150, 200 and 250 kg/ha). The observation data results were analyzed using analysis of variance (ANOVA) and continued honest significant difference test HSD at 5% error level. To determine the relationship pattern between observation variables, regression test was conducted. The results showed that significant effect of gibberellin and nitrogen fertilization on growth and yield of zucchini plants. There were increasing in plant length, number of leaves, leaf area, fresh weight, dry weight, number of fruits and fruit weight. Nitrogen fertilization caused increasing in plant length, number of leaves, leaf area, fresh weight, dry weight, number of fruits, fruit weight and chlorophyll index. The results of this study revealed that gibberellin and nitrogen fertilization positive effect in increasing the growth and yield of zucchini plants. Based on the results of this study recommended that the optimum gibberellin and nitrogen are 150 ppm and 150-250 kg/ha.*

Keywords *— **Zucchini, Gibberellic acid, Nitrogen, Growth and Yield.***

I. INTRODUCTION

Zucchini plants belong to the Cucurbitaceae family. Rich in nutrients and bioactive compounds such as flavonoids, vitamin A, vitamin B2, vitamin C, vitamin E, amino acids, carbohydrates, minerals and high of fiber. (Tamer *et al*., 2010). Zucchini cultivation in Indonesia is still low and have the potential to be developed. Zucchini fruit shows promising results and can be beneficial for health, zucchini has safe components and able to significantly inhibit damage caused by H_2O_2 and shows anti-proliferation properties and pro-apoptotic properties against HL60 tumor cells. (Martínez-Valdivieso *et al*., 2017). Therefore, zucchini plants has the potential to be developed in the Indonesian region. Therefore, zucchini cultivation required the right cultivation technology including the application of gibberellins and nitrogen fertilizers.

Gibberellins is a plant growth regulator group that have a role as growth promoters. One of the important hormones in controlling development and regulating several physiological mechanisms in plants (Miceli *et al*., 2019). Some plant responses controlled by gibberellin hormones include seed germination, stem and root elongation as well as increased leaf area and flowering (Al-Harthi *et al*., 2021). In addition to increasing plant growth and yield

through the addition of growth hormones, plants can also grow optimally due to the availability of sufficient nutrients. Nitrogen is a macro nutrient that needed in large quantities to grow and develop. Nitrogen is required in the formation of proteins that are associated with all important processes in plants therefore nitrogen elements can lead to increased yield and crop quality (Leghari *et al*., 2016). However, fertilization activities are often excessive and have a negative impact on the environment and increase farmers production costs. Impact of excess of inorganic nitrogen fertilizer inputs can reduce the growth and number of soil microbes. (Zhang *et al*., 2018). The study aim to determine the effect of gibberellin concentration and nitrogen fertilizer dosage on growth and yield of zucchini.

II. MATERIALS AND METHODS

2.1. Research Site

The research was conducted in July-October 2023 in Batu City, East Java Province. Batu city has an average air temperature of 22,2ºC with annual rainfall of 2028 mm in 2022 (BPS, 2023). The research site lies at 7°54'35"S 112°31'34"E and 1005 m above sea level.

2.2. Tools and Materials

The tools used in this study ware polybag measuring 40 x 40 cm, hoe, ruler, Oven Memmert type 21037 FNR, Leaf Area Meter type LI – 3100, Scales Nict Voor type PS 1200 and sprayer 2 L. The material used is Zucchini seed variety Jacky Z-6, gibberellin, goat manure, urea fertilizer 46 % N, Fertiphos fertilizer 20 % P_2O_5 dan ZK fertilizer 50 % K_2O.

2.3. Experimental Design and Treatments

The Research was a factorial experiment using a randomized block design with two factors and three replications. The first factor is gibberellin concentration with three level is G0 (0 ppm), G1 (150 ppm) and G2 (300 ppm). The second factor is dose of nitrogen fertilizer with five level N50 (50 kg/ha), N100 (100 kg/ha), N150 (150 kg/ha), N200 (200 kg/ha) and N250 (250 kg/ha). There are 15 treatment combination units so that there are 45 treatment units. Each treatment combination has 8 plant sample.

Gibberellin application was carried out at 14, 28, 35 and 42 day after planting by spraying the plant until the gibberellin was evenly distributed to all part of the plants. Gibberellin application at 07:00 – 09:00 AM.

Fertilization is applied at a distance of 5 cm from the base of stem. Phosphorus and potassium fertilizers according to the recommendation of 150 kg/ha. Fertilization is done at 7 and 21 day after planting each 50 % dose of fertilizer.

Fig. 1: Fertilization and gibberellin application

Growth observation variable include plant length, number of leaves and leaf area observed periodically at 14, 28 and 42 day after planting. Fresh weight, dry weight and chlorophyll index at 30 day after planting and yield variables include number of fruits and fruit weight.

Leaf area observations were made using the ALA method (*Average Leaf Area*). Calculation of plant leaf area with the ALA method using the formula showed below Widaryanto *et al.* (2019) :

$$LA\ (cm^2\ plant^{-1}) = ALA\ (cm^2\ leaf^{-1}) \times \sum \text{Number of leaf (leaf plant}^{-1})$$

2.4. Data Collection and Analysis

The results of the observation data were analyze using analysis of variance (ANOVA) and carried out with the F test at the 5% error level, then if there is an effect, continued honest significant difference test (HSD) at the 5% error level and linear regression test to determine relationship between the two variable

III. RESULTS

3.1. Effect of Gibberellin and Nitrogen on Growth of Zucchini

Gibberellin and nitrogen treatments showed that no significant interaction on plant length but gibberellin and nitrogen had significant effect on plant length of zucchini. Plant length due to gibberellin and nitrogen fertilizer is show in (Table 1).

Gibberellin concentration showed no significant effect at 14 DAP, but at 28 and 42 DAP the concentration of gibberellin increased the length of zucchini plants compared to plants without gibberellin. The difference in gibberellin concentrations of 150 ppm and 300 ppm did not show significant differences in the length of zucchini plants. Increasing the dose of nitrogen fertilizer increased the length of zucchini plants.

Nitrogen fertilizer 150 kg/ha produced higher plant length than nitrogen fertilizer 50 kg/ha but did not show significant difference with nitrogen fertilizer 100, 200 and 250 kg/ha at 14 and 42 DAP (Tabel 1).

Table 1: The Effect of Gibberellin and Nitrogen on Plant Length

Treatment	Plant length (cm) at age (DAP)		
	14	28	42
Gibberellin			
G0	20,21	41,77 a	62,73 a
G1	20,73	46,99 b	66,13 b
G2	20,76	47,56 b	66,08 b
HSD (5%)	ns	3,070	3,091
Nitrogen			
N50	18,67 a	40,91 a	60,91 a
N100	19,65 ab	43,24 ab	63,96 ab
N150	21,33 b	48,00 c	66,85 b
N200	21,63 b	47,39 bc	66,48 b
N250	21,56 b	47,56 bc	66,79 b
HSD (5%)	2,103	4,667	4,698

*means followed by the same letter in the same column are not significantly different according to HSD test at 5% level.

Observation at 28 DAP, 150 kg/ha fertilizer showed higher plant length than 50 and 100 kg/ha fertilizer doses, but did not show significant differences with 200 and 250 kg/ha nitrogen fertilizer. Nitrogen fertilizer 50 kg/ha had the lowest plant length compared to other fertilizer doses.

Gibberellin and nitrogen treatment showed that no significant interaction on the number of leaves but gibberellin and nitrogen had significant effect on the number of leaves of zucchini. The number of leaves as effect of gibberellin and nitrogen fertilizer is presented at (Table 2).

Table 2: The Effect of Gibberellin and Nitrogen on Number of leaf

Treatment	Number of Leaf (*leaf*) at age (DAP)		
	14	28	42
Gibberellin			
G0	3,24	6,27 a	8,91 a
G1	3,33	6,93 b	9,57 b
G2	3,33	7,00 b	10,1 b
HSD (5%)	ns	0,33	0,60
Nitrogen			
N50	3,37	5,51 a	8,92 a
N100	3,37	6,51 b	9,37 ab
N150	3,29	6,92 bc	9,77 ab
N200	3,03	7,14 cd	9,74 ab
N250	3,44	7,55 d	9,96 b
HSD (5%)	ns	0,51	0,92

* means followed by the same letter in the same column are not significantly different according to HSD test at 5% level.

Gibberellin and nitrogen had no significant in 14 DAP. Gibberellin concentration increased the number of plant leaves compared without gibberellin. The difference between gibberellin concentrations of 150 and 300 ppm showed no significant difference. Plants without gibberellin application produced a lower number of leaves than the gibberellin application treatment. Increasing the dose of nitrogen fertilizer increases the number of leaves of zucchini plants and 250 kg/ha nitrogen fertilizer produces the highest number of leaves. Observation at 28 DAP showed that nitrogen fertilizer 250 and 200 kg/ha no significant difference but nitrogen application 250 kg/ha was significantly different from nitrogen 50, 100 and 150 kg/ha. Observation at 42 DAP, nitrogen 250 kg/ha produced a higher number of leaves than nitrogen 50 kg/ha, but with nitrogen 250 kg/ha was not significantly different from nitrogen 100, 150 and 200 kg/ha.

Gibberellin and nitrogen showed were no significant interaction on the leaf area but gibberellin and nitrogen had significant effect on leaf area of zucchini. The leaf area as effect gibberellin and nitrogen fertilizer is presented at (Table 3).

Table 3: The Effect of Gibberellin and Nitrogen on leaf area

Treatment	Leaf area (cm^2/plant) at age (DAP)		
	14	28	42
Gibberellin			
G0	313,77	1630,51 a	2649,79 a
G1	322,37	2281,02 b	3602,34 b
G2	322,37	2751,68 c	4182,97 c
HSD (5%)	ns	181,44	240,99
Nitrogen			

N50	325,95	1916,85 a	3247,86 a
N100	325,95	2138,25 ab	3414,36 ab
N150	318,79	2255,81 bc	3559,80 ab
N200	293,71	2325,32 bc	3547,49 ab
N250	333,11	2469,12 c	3622,33 b
HSD (5%)	ns	275,82	366,33

*Means followed by the same letter in the same column are not significantly different according to HSD test at 5% level.

Gibberellin and nitrogen showed no significant effect at 14 DAP. Increasing the concentration of gibberellin causes an increase in leaf area of zucchini plants. gibberellin concentration at 300 ppm produced a higher leaf area than the concentration at 150 ppm. Plants without gibberellin produced lower leaf area compared with gibberellin. Increasing nitrogen fertilizer dose increases leaf area of zucchini plants. Nitrogen fertilizer dose of 250 kg/ha produces higher leaf area. Observation at 28 DAP the dose of 250 kg/ha is significantly different from nitrogen 50 and 100 kg/ha but not significantly different from nitrogen 150 and 200 kg/ha. Observation 42 DAP, nitrogen fertilizer 250 kg/ha was only significantly different from nitrogen 50 kg/ha and not significantly different from nitrogen 100, 150 and 200 kg/ha.

Gibberellin and nitrogen treatments showed that no significant interaction on plant fresh weight but gibberellin and nitrogen had significant effect on fresh weight of zucchini. Fresh weight due to gibberellin and nitrogen fertilizer are presented (Fig. 2 & Fig. 3).

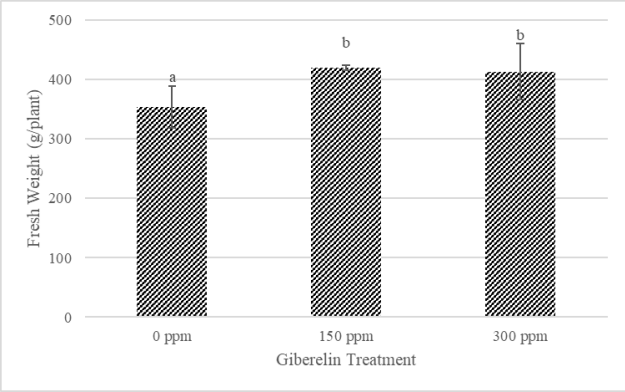

Fig. 2: The Effect of gibberellin on fresh weight

Gibberellin concentration increased the fresh weight of zucchini plants (fig 2). The difference between 150 ppm and 300 ppm gibberellin concentration showed no significant. Zucchini plants without gibberellin had a lower fresh weight than plants with gibberellin application.

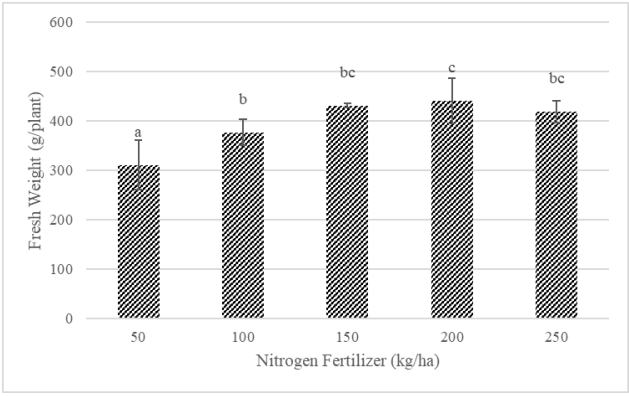

Fig. 3: The Effect of nitrogen in fresh weight

Increasing the dose of nitrogen fertilizer increased the fresh weight of zucchini plants (fig 3). Nitrogen dose of 200 kg/ha produced higher fresh weight than 50 and 100 kg/ha nitrogen fertilizer but not significantly different from 150 and 250 kg/ha fertilizer. Nitrogen fertilizer 50 kg/ha produced lowest plant fresh weight than other nitrogen fertilizer doses.

Gibberellin and nitrogen fertilizer interaction on dry weight of zucchini showed at (Table 4).

Table 4: The Effect of gibberellin and Nitrogen on Dry Weight

Treatment	Dry weight (g/plant)				
	Dose of nitrogen fertilizer				
Gibberellin	N50	N100	N150	N200	N250
G0	22,40 a A	30,56 b A	38,10 c A	35,90 bc A	36,13 bc A
G1	33,06 a B	42,10 b B	43,93 b AB	45,33 b B	42,30 b A
G2	43,26 a C	43,73 a B	47,93 a B	45,06 a B	49,40 a B
HSD (5%)	6,671				

* means followed by the same letter in one column or same letter in one row are not significantly different according to the HSD test at 5% level.

Gibberellin concentration increased the dry weight of zucchini plants at each nitrogen fertilization level and

nitrogen fertilizer increased the dry weight of zucchini plants in plants without gibberellin and 150 ppm gibberellin concentration. At 300 ppm gibberellin concentration application, nitrogen fertilizer showed no significant effect.

The response of zucchini plants without gibberellin, increasing nitrogen fertilizer dose increases dry weight of zucchini. Nitrogen fertilizer 150 kg/ha produced higher dry weight than nitrogen fertilizer 50 and 100 kg/ha, but not significant from nitrogen 200 and 250 kg/ha. And 50 kg/ha nitrogen fertilizer produced the lowest dry weight compared to other nitrogen fertilizer doses. At 150 ppm gibberellin concentration, 100 kg/ha nitrogen fertilizer produced higher dry weight than 50 kg/ha nitrogen fertilizer and was not significantly different from 150, 200 and 250 kg/ha nitrogen fertilizer, and at concentration of gibberellin 300 ppm nitrogen fertilizer not showed a significant effect.

The response of gibberellin concentration at each fertilization level showed that gibberellin treatments increases the dry weight of zucchini plants. At 50 kg/ha nitrogen fertilizer, the concentration 150 and 300 ppm showed a significant difference but at 100, 150 and 200 kg/ha nitrogen, the concentration difference did not show a significant difference and at 250 kg/ha nitrogen, the increase in plant dry weight occurred at 300 ppm gibberellin concentration.

3.2. Effect of Gibberellin and Nitrogen on Yield of Zucchini

Gibberellin and nitrogen treatment showed no significant interaction on fruit number and fruit weight but gibberellin and nitrogen had significant effect on fruit number and fruit weight of zucchini. Number and weight of plant fruits due to gibberellin and nitrogen fertilizer are presented (Table 5).

Table 5. The Effect of Gibberellin and Nitrogen on Number of Fruit and Fruit Weight

Treatment	Number of fruit	Fruit weight (g)
Gibberellin		
G0	2,22 a	327,30 a
G1	2,44 b	346,50 b
G2	2,51 b	351,60 b
HSD (5%)	0,17	18,59
Nitrogen		
N50	2,07 a	306,45 a
N100	2,29 ab	319,55 ab
N150	2,48 b	342,05 bc
N200	2,55 b	354,05 c
N250	2,55 b	386,90 d
HSD (5%)	0,27	28,42

*means followed by the same letter in the same column are not significantly different according to HSD test at 5% level.

Gibberellin concentration increased fruit weight and fruit number of zucchini plants. However, differences in gibberellin concentrations of 150 and 300 ppm did not show significantly different in fruit number and fruit weight. Increasing the dose of nitrogen fertilizer also increased the number of fruits and fruit weight of zucchini. The number of fruits at 150 kg/ha nitrogen fertilizer significantly different compared with 50 kg/ha, but not different from 100, 200 and 250 kg/ha fertilizer. On fruit weight, 250 kg/ha nitrogen fertilizer produced the highest fruit weight. In addition, 150 kg/ha nitrogen fertilizer showed no significantly different with 100 and 200 kg/ha nitrogen fertilizer. And 50 kg/ha nitrogen fertilizer resulted in lower fruit number and weight compared to higher nitrogen fertilizer doses.

3.3. Effect of Gibberelin and Nitrogen on Chlorophyll Index

Gibberelin and nitrogen treatments showed no significant interaction on leaf chlorophyll index and gibberellin concentration showed no significant effect but nitrogen had significant effect on leaf chlorophyll index. Leaf chlorophyll index due to nitrogen fertilizer is presented (*fig. 4).*

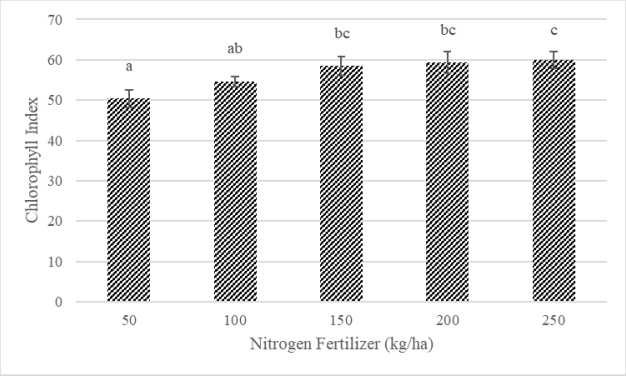

Fig. 4: The Effect of nitrogen on chlorophyll index

Increasing the dose of nitrogen fertilizer increased the chlorophyll index (fig 4). At 250 kg/ha nitrogen fertilizer produced the higher chlorophyll index but not significantly different with 150 and 200 kg/ha nitrogen. Nitrogen

fertilizer 50 kg/ha had a lower chlorophyll index compared to higher fertilizer doses.

IV. DISCUSSION

Gibberellin is one of the hormones in plants that regulates plant life from germination, growth to flowering. The research showed that gibberellin application increased the growth and yield of zucchini plants. Increase in growth due to gibberellin concentration can be seen from the increase in plant length, number of leaves, leaf area, fresh weight and dry weight of cultivated plants. Gibberellin hormone has a role to trigger stem elongation, roots, leaf expansion and dormancy in cultivated plants (Hedden & Sponsel, 2015). The increase in growth is due to gibberellin hormone inducing the transcription of genes involved in cell elongation and cell division that occur during the growth process (Miceli *et al*., 2019). In addition, gibberellin hormone is also able to increase components in the photosynthesis process such as stomatal conductance, water use efficiency and transpiration rate (Emamverdian *et al*., 2020) This certainly increases the ability of plants to carry out the photosynthesis process. The increase in plant photosynthesis 6% and 10% results in a 30% increase in plant biomass (Lawson *et al*., 2012). This is in line with the results of the research, which showed an increase in fresh and dry weight of plants due to the application of gibberellin.

Positive effects were also seen with increasing doses of nitrogen fertilization. The application of nitrogen fertilizer is effective in supporting plant growth because it causes an increase in plant length, number of leaves, leaf area, fresh weight and dry weight and leaf chlorophyll index. Nitrogen fertilization will cause an increase in nitrogen nutrients in the plant, making it easier for plants to absorb nitrogen nutrients. Nitrogen is an essential element in the formation of chlorophyll and protein and is related to leaf color, plant vigor, N content in plants, yield and crop quality (Syed *et al*., 2016). in line with the results of the study showed that plants given 150 kg/ha nitrogen fertilizer had a higher chlorophyll index of 15.95% compared to zucchini plants with 50 kg/ha fertilizer. According to research Liu *et al*. (2017), 240 kg/ha nitrogen fertilizer on rice plants caused an increase in chlorophyll content by 68.99% compared to plants without nitrogen fertilization. Chlorophyll is an important part of the Calvin cycle which is responsible for receiving light in the photosynthesis process and the photosynthesis process is the most significant factor in grain yield and plant biomass (Liu *et al*., 2019).

Gibberellin application and nitrogen fertilization produce a higher number and area of leaves, the number of leaves and leaf area will affect the yield of zucchini plants. The effect is related to the ability of the leaves to carry out the photosynthesis process, the process of photosynthesis will produce photosynthate and will be transported from the leaves to all parts of the plant organs and stored as food reserves in the fruit (Nasrulloh *et al*., 2016). Fruit weight is related to the amount of photosynthate translocated to the fruit. The greater the photosynthate that is translocated to the fruit caused fruit weight will increase (Waskito *et al*., 2017). In addition, nitrogen fertilizer also causes an increase in leaf chlorophyll index. Total chlorophyll in plants shows a positive correlation with photosynthetic rate, so increasing photosynthetic rate has a significant impact on growth, development and yield (Gai *et al*., 2017). It can be seen from the results of the fruit weight of zucchini, there is an increase in fruit weight along with the provision of gibberellins and an increase in the dose of nitrogen fertilizer.

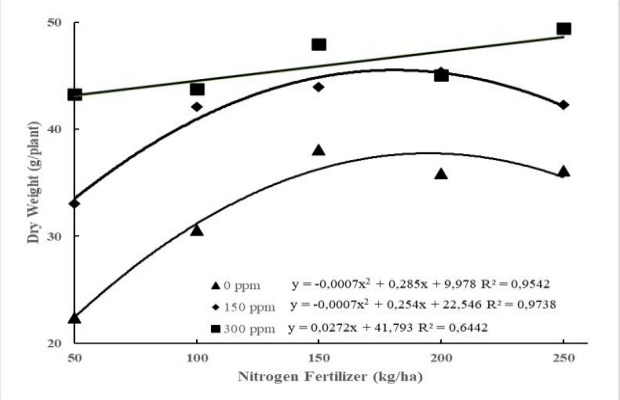

Fig. 5: The Effect of nitrogen fertilization on dry weight of zucchini plants in each gibberellin treatment

Fig 5. is a regression analysis to determine the optimal fertilizer dose at gibberellin concentration by looking at plant dry weight. The increase in dry weight occurred along with the increase in nitrogen fertilization dose in the condition without gibberellin and gibberellin 150 ppm. The resulting equation for the effect of nitrogen fertilization on plant dry weight in conditions without gibberellin is $y = -0{,}0007x^2 + 0{,}285x + 9{,}978$ from the equation the optimal nitrogen fertilization value is 203,5 kg/ha to produce maximum dry weight. While in plants with 150 ppm gibberellin the equation is $y = -0{,}0007x^2 + 0{,}254x + 22{,}546$ so that the optimal nitrogen fertilizer dose is 181,4 kg/ha nitrogen. To produce optimal dry weight, plants without gibberellin application need higher nitrogen fertilizer than plants with 150 ppm gibberellin application.

The application of gibberellin can reduce the need for nitrogen fertilizer and produce a higher dry weight than the dry weight of plants without gibberellin application. Therefore, the application of gibberellin with a concentration of 150 ppm with the optimal nitrogen fertilization dose can increase the growth and yield of zucchini plants.

V. CONCLUSION

Gibberellin application increased the growth and yield of zucchini plants, the effect of gibberellin was seen at 7 days after application. The recommended concentration of gibberellin is 150 ppm. The optimal nitrogen fertilizer is 150-250 kg/ha. The application of gibberellin is effective in reducing the use of nitrogen fertilizers. Further research needs to determine the type of organic fertilizer that can have a positive effect on plant growth and yield with the aim of reducing the use of inorganic nitrogen fertilizers.

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