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Growth and Yield of Tomato (*Lycopersicum esculentum* Mill.) Due to Application of Hormonic PGR and NPK Fertilizer

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ABSTRACT

Tomatoes have high economic value with community demands increases every year. However, the productivity of tomatoes farmers in Indonesia can not meet the demands of Indonesian consumers. Efforts to solve low productivity in tomatoes cultivation can be made through certains cultivation techniques. The intention of this study is to acquire appropriate combination of "Hormonik" Plant Growth Regulator (PGR) concentrations and NPK fertilizer dosages for the optimum growth and yield of tomato plants. This study used a factorial experimental method with a completely randomized design (CRD). The first factor is Hormonik PGR concentrations (H) in 4 different treatment levels that consist of control variable (no PGR added) (H0), 6 ml/l (H1), 7 ml/l (H2), and 8 ml/l (H3). The second factor is NPK fertilizer dosages (N) in 4 different treatment levels that consist of 24 g/ plant (N1), 32 g/plant (N2), 40 g/plant (N3), and 48 g/plant (N4). This study showed that combination of 6 ml/l Hormonik PGR and 40 g/plant of NPK fertilizer provide the highest number of fruits per plant by 49.0 and the weight of fruit per plant by 1,572.3 g.

1. INTRODUCTION

Tomato plants (*Lycopersicum esculentum* Mill.) are a type of horticultural plant in the *Solanaceae* family and have the potential to be developed because they have a promising market share. Market demand for tomatoes is increasing every year. Meanwhile, production is decreasing and agricultural land in the East Java region continues to shrink. According to data from the Central Statistics Agency (BPS, 2021), tomato production in East Java, especially in the city of Surabaya, declined significantly, namely from 431.7 tonnes in 2019 to 296.1 tonnes in 2020. Therefore, efforts are needed to improve cultivation techniques on narrow but still productive land to create food independence. One of the things that is being done is implementing the urban farming concept by

cultivating using polybags and using materials that are adapted to support plant growth. Input materials that can be applied are through the application of growth regulators and fertilization.

Growth regulators (PGR) can be defined as natural compounds that are not nutrients and are applied to plants in small quantities with the aim of influencing physiological processes that play a role in encouraging or inhibiting plant growth and development (Ariyanti *et al*., 2020). The use of PGR which aims to increase plant productivity is organic hormones (hormonics). Organic hormones are hormones that come from plants or other living creatures (Hasibuan *et al*., 2019). The advantage of this PGR is that it contains quite a complete set of hormones, namely auxin, gibberellins and cytokinins, so it is hoped that it will be able to increase overall plant growth and development (Mutryarny & Lidar, 2018). The hormone auxin plays a role in root elongation, differentiation of xylem and phloem tissue, inhibited leaf shedding, and development of the root and shoot system (Arif *et al*., 2016). Cytokinin hormones have a role in stimulating cell division, shoot formation, inhibiting yellowing of leaves, and organ formation (Muslimah *et al*., 2016). The formation of plant organs is greatly influenced by the use of growth regulators at the right concentration. According to Triani *et al*. (2020), gibberellins can encourage stem elongation, stimulate flowering and fruit development. Based on research data according to (Amiroh, 2016), giving a PGR concentration of 6 ml/l to tomato plants resulted in a fruit weight per plot of 178.3 g in the first harvest observation which was significantly different from a concentration of 2 ml/l of 128.8 g and 4 ml/l is 153.3 g. The gibberellin content in hormonic PGRs functions to increase fruit yields on plants, thereby influencing the weight of fruit per plot.

Another obstacle that hinders increasing tomato yields is that nutrients are less available for plant absorption. Plant nutrition can be sourced from fertilization. The fertilizer that can be used is NPK fertilizer. According to Saberan *et al*. (2014), NPK fertilizer is a compound fertilizer that is usually used by farmers for cultivation. The nutrient content in NPK fertilizer functions to help plants increase nutrient uptake which can support plant production results. The advantage of using compound fertilizer is that several nutrients are available in one application, making it more time, space and cost efficient in the transportation and storage process. The form of NPK fertilizer is granules with a uniform size and has hygroscopic or water-soluble properties (Khafie *et al*., 2021). The application of chemical fertilizers in cultivation using polybags aims to reduce the impact of residues on the environment because chemicals are only limited to polybags so they do not spread compared to cultivation in rice fields or gardens. Fertilizer must be given in accordance with the dosage so that it can meet the plant's nutrient needs which are used for growth and development because if there is a shortage or excess of fertilizer dosage it will result in the plant not growing optimally and becoming stunted. Research by Khafie *et al*. (2021) show that a dose of NPK fertilizer of 36 g/plant applied to cayenne pepper plants can increase plant yields such as total fruit weight per plant of 220.58 g compared to a fertilizer dose of 21.6 g/plant which obtained a value of 135,456. g. This shows that a lower fertilizer dose causes less fruit weight. Increasing the dose of NPK fertilizer can increase fruit weight per plant so that it can support better plant yields. This research was conducted to determine the appropriate combination of hormonic PGR concentration and the best dose of NPK fertilizer to be applied to tomato plants.

2. MATERIALS AND METHODS

This research was carried out from April to July 2022. The place where the research was carried out was on land in Made Village, Sambikerep Subdistrict, Surabaya City, East Java with an altitude of ±12 meters above sea level. The materials needed for the research included tomato seeds (Servo F1 variety), Nasa hormonic PGR, Phonska Plus NPK fertilizer, 40 x 40 cm polybags, Amistartop 325 SC fungicide, and Curacron 500 EC insecticide. The tools needed for research included graduated measuring glass, measuring tape, analytical scales, and calipers.

2.1. Research Procedure

The research began with sowing seeds in polybags using media in the form of a mixture of soil, manure and husks (1:1:1). Nursery activities lasted for 21 days. Next, the tomato seeds were planted in polybags containing a composition of soil, husks and manure (2:1:1). The criteria for planted seeds were that they have 4-5 leaves, healthy, fresh and had uniform growth. Maintenance activities consisted of watering tomato plants every day, namely in the morning and afternoon, but if the media is still damp, watering was performed once. Apart from watering, maintaining tomato plants also included weeding, replanting plants that grow abnormally or die, installing stakes to support the plants so they grow upright. NPK granule fertilizer was used as basic and supplementary fertilizer. Basic fertilizer was applied 2 days before transplanting, ¼ of each dose by making a circular line around the center and then covering it again so that the fertilizer does not evaporate. Additional fertilization was applied 10 times when the plants were 14 day after transplanting (DAT) to 77 DAT with 10 day intervals. The follow-up fertilizer dose was ¾ of the remaining dose by diluting it with 200 ml of water. The doses used were 24 g/plant, 32 g/plant, 40 g/plant, and 48 g/plant. PGR application was carried out by spraying it to all parts of the plant, especially the leaves, until they were evenly wet according to the treatment, namely control (water), concentrations of 6 ml/l, 7 ml/l, and 8 ml/l. The spray volume for the first and second applications for each plant was 50 ml, the spray volume for the third application was 100 ml while the fourth and fifth applications was 150 ml. PGR application was carried out when the plants were 10, 20, 30, 40 and 50 DAT in the morning. Apart from that, maintenance also included pest controlling, cuting shoots that grow in the leaf axils. Harvesting was done when the fruit changes color from green to yellowish.

Observation parameters included the number of leaves, number of flowers, number of fruit per plant, fruit weight per plant (g), and fruitset percentage. The number of leaves was calculated done by counting the leaves that open completely when the plant was 7 DAT at 7-day intervals until harvest. The number of flowers was observed by counting the flowers that open completely at intervals of every 7 days starting when the flowers first appear until the last harvest. Meanwhile, the number of fruit per plant was calculated from the first harvest to the last harvest (5^{th} week). Fruit weight per plant was carried out by weighing the fruit from the first harvest to the last, namely the 5^{th} week, using analytical scales. Fruitset is the percentage of flowers becoming fruit where observations were carried out by counting the number of flowers and fruit in each sample using the formula:

$$\text{Fruitset} = \frac{\sum \text{Number of total fruit}}{\sum \text{Number of total flower}} \text{ x } 100\% \quad (1)$$

2.2. Experimental Design and Data analysis

The research used a factorial method based on a Completely Randomized Design (CRD). The first factor was hormonic PGR (H) which consists of for different concentrations, namely 0 or control (H0), 6 ml/l (H1), 7 ml/l (H2), and 8 ml/l (H3). The second factor was NPK fertilizer (N) which consisted of 24 g/plant (N1), 32 g/plant or control (N2), 40 g/plant (N3), and 48 g/plant (N4). The two factors were combined to obtain 16 combination treatments and 3 replications. Each experimental unit was represented by 2 plants.

The data obtained were analyzed using variance (ANOVA) at the 5% level. Based on the analysis of variance, if the treatment has a significant effect (F count > F table 5%) then the Tukey test was carried out at the 5% level.

3. RESULTS AND DISCUSSION

3.1. Effect of Treatments on Tomato Yield

The results obtained from the combination of hormonic PGR and NPK fertilizer did not have a significant effect on the number of leaves and had a very significant effect on the number of fruit per plant and the weight of fruit per plant as in Table 1. It shows the significant effect of Phonska Plus NPK fertilizer dosage on the number of tomato fruit per plant and fruit weight per plant at different concentrations of hormonic PGR application. The treatment dose of Phonska Plus NPK fertilizer 40 g/plant gave a positive response at a PGR concentration of 6 ml/l with an average yield of 49.0 fruits which was significantly different from control (0 hormonic PGR) and other concentrations (7 ml/l and 8 ml/l). Meanwhile, a concentration of 6 ml/l had a good effect on NPK fertilizer at a dose of 40 g/plant, which was significantly different from those of 24 g/plant, 32 g/plant, and 48 g/plant.

Table 1. Average effect of the interaction of hormonic PGR and NPK fertilizer on tomato plant yield

Parameter	NPK dose (g/plant)	Hormonik PGR concentration (ml/l)			
		0 (control)	6	7	8
Number of fruit/ plant	24	35,83 cde	36,67 de	36,50 de	35,67 bcde
	32	29,33 ab	41,33 e	36,50 de	29,83 abc
	40	36,17 de	49,00 f	41,00 e	31,50 abcd
	48	31,50 abcd	39,33 e	29,17 a	28,33 a
	Tukey 5%	**6,43**			
Fruit weight/ plant (g)	24	1078,9 abc	1240,9 cdef	1227,7 bcdef	1177,3 abcde
	32	1051,6 ab	1388,2 f	1315,2 ef	1018,6 a
	40	1068,2 abc	1572,3 g	1268,9 def	1068,6 abc
	48	1030,8 a	1122,8 abcd	1090 abcd	1126,2 abcd
	Tukey 5%	**192,86**			

Note: Numbers followed by the same letter indicate results that are not significantly different in the 5% Tukey test

This shows that the best treatment combination for plant yield components was obtained in the hormonic PGR treatment of 6 ml/l + 40 g/plant NPK fertilizer. These results were influenced by a combination of treatments that were able to balance the availability of growth regulators and nutrients, thereby triggering the generative growth of tomato plants and resulting in the formation, increase in fruit number and

maximum fruit weight. Providing 40 g of fertilizer/plant was able to increase the number of tomato fruits per plant, which shows that this dose was able to stimulate tomato fruit formation. Sugiharto *et al.* (2022) added that if NPK fertilizer is sufficient for the plant's needs, it can provide a positive response that affects the growth and yield of tomato plants. Phosphorus contained in NPK fertilizer has an important role in the generative phase of plants because it accelerates the emergence of flowers, fruit ripening and seed formation. The potassium element is able to increase the growth of assimilate and facilitate the distribution of assimilate, so that the availability of carbohydrates as food reserves can be stored in the fruit and then increased. According to Harpitaningrum *et al.*, (2014), if carbohydrates are stored in larger quantities, the weight of the fruit will also be greater. In addition, the gibberellin content in hormonic PGR functions to increase fruit yield in plants which has an effect on increasing the number and weight of fruit. PGR, however, must be given according to proper concentration. According to Rajiman (2018) the concentration level will influence the effectiveness of PGR. Too high PGR concentrations can interfere with cell division, causing stunted growth. Too small PGR concentrations, on the other side, causes no respond of the plant to PGR. In general, the provision of gibberellin plays a role in boosting fruit development which is supported by the provision of appropriate nutrients, so that if the number of fruit is large and the weight is high, the yield will increase.

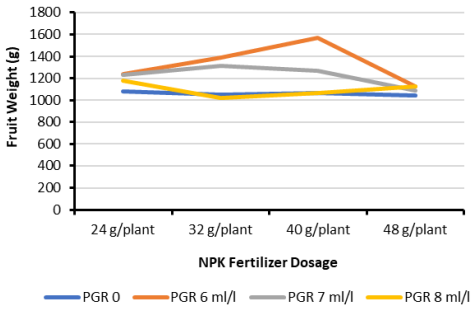

Figure 1. Effect of NPK fertilizer dosage on fruit weight per plant at different PGR concentrations

Figure 1 shows the influence of NPK fertilizer dosage on fruit weight per plant at different hormonic PGR concentrations. The figure shows that all Phonska Plus NPK treatments without giving hormonic PGR showed no effect even though the fertilizer dose was increased. At a PGR concentration of 6 ml/l, if the NPK fertilizer dose is increased, the fruit weight will also increase, but if too much dose is given, such as 48 g/plant, the fruit weight will decrease quite significantly. Therefore, the fertilizer dose and PGR concentration must be appropriate to obtain maximum results.

Combination of hormonic PGR and NPK fertilizer obtained results that were not significantly different in the parameters of number of flowers and fruit set percentage. There was no real difference between the combination treatments, indicating that PGR and nutrients can both increase the number of flowers on tomato plants by a not too big difference. Furthermore, the fruitset percentage is not significantly different because there is no harmony between the number of flowers and fruit due to some flowers falling so that the number of fruitset decreases which can be influenced by several factors, one of which is environmental factors such as wind, temperature, rainfall and humidity which is a result of climatic conditions. uncertain during the

research. According to Kusumayati *et al*. (2015), high temperatures accompanied by low humidity cause flowers to fail easily, thereby reducing the fruitset percentage.

This research shows that the combination of hormonic PGR and NPK fertilizer can synergize with each other in encouraging the growth and development of tomato plants. According to Febriantini (2013), the use of PGR must pay attention to the correct concentration and additional fertilizer in the form of fertilizer because fertilizer is an important component for plants as a contributor of nutrients. The use of PGR that is not balanced with fertilizer causes plants to become weak. Therefore, the combination of PGR and NPK fertilizer must be suitable for maximum tomato plant yields. Irvandi & Nurbaiti (2017) added that plant growth and development occurs well if PGR and nutrient supply are available in compatible amounts for plant absorption.

3.2. Effect of Hormonic PGR on Growth and Yield of Tomato Plants

Figure 2 depicts the average number of leaves of tomato due to application of hormonic PGR. Leaves are vital organs for plants and places where the photosynthesis process takes place. Addition of hormonic PGR 7 ml/l provides optimal results compared to other treatments from 14 DAT to 84 DAT. The results of this research form plant organs and stimulate cell division due to the effects of giving PGR including leaves so that the number of leaves increases. Kurniawati *et al*. (2023) stated that the number of leaves affects the photosynthesis process because the greater the number of leaves, the greater the food produced by the plant. The maximum role of PGR is seen at the age of 42 DAT because it shows the most significant amount compared to other plant ages. This shows that the role of PGR is maximally absorbed at that age because there is a fairly high increment.

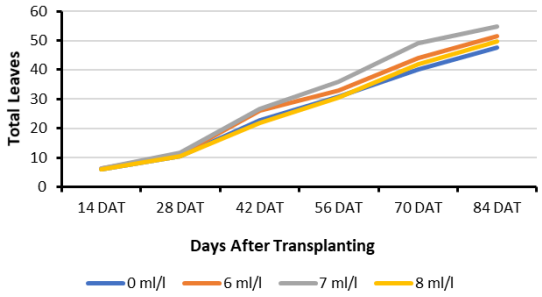

Figure 3. Total leaves counts due to application of hormonic PGR

The treatments also resulted in significant effect on the fruitset percentage (Table 2). The results of providing hormonic PGR 6 ml/l showed maximum results compared to other treatments on plant yield components. Plants given hormonic PGR have a higher chlorophyll content due to the response from auxin, cytokinin and gibberellin so that the photosynthesis and assimilate processes produced also increase which affects production components such as fruit, one of which is the fruitset percentage. This shows that addition of hormonic PGR can reduce flower fall so that more flowers that succeed become fruit. Giving PGR at concentration of 6 ml/l resulted the fruitset percentage that is very significantly different to other concentration (7 ml/l, 8 ml/l, and control).

Table 2. Effect of hormonik PGR concentration on the average fruitset percentage

Hormonik PGR concentration (ml/l)	Fruitset percentage
0 (control)	0,62 b
6	0,70 c
7	0,64 b
8	0,54 a
Tukey 5%	0,05

Note: Numbers followed by the same letter indicate results that are not significantly different in the 5% Tukey test

3.3. Effect of NPK Fertilizer on Growth and Yield of Tomato Plants

The average results of NPK fertilizer application show a significant influence on plant growth, namely the number of leaves (Figure 3) and have a very high influence on yield components (Table 3). Providing 40 g of NPK fertilizer/plant is the maximum dose compared to other treatments. The fertilizer provides optimal results in the number of leaves from 14 DAT to 84 DAT. The results prove that the provision of NPK fertilizer has an important role in contributing plant nutrition, especially nitrogen elements to accelerate plant growth such as the number of leaves. The maximum role of NPK fertilizer is at 42 DAT because it shows the most significant number of leaves compared to other plant ages. Kurniawati *et al*., (2015) explained that the right dose of fertilizer will have an effect in the form of optimal growth and development results in plants, because NPK fertilizer has a role in encouraging and increasing the growth and yield of tomato plants if the fertilizer is applied correctly and not excessively. Rahayu *et al*., (2022) added that excessive application of nutrients causes the xylem tissue to become damaged, so that the plant's function to absorb water and nutrients is reduced, resulting in dryness, stomata closing, and the photosynthesis process being hampered. However, if optimal fertilizer is applied it will have an impact on high tomato yields.

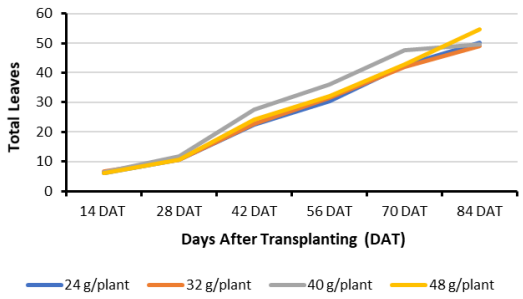

Figure 3. Total leaves counts due to application of NPK fertilizer

Table 3. Effect of NPK dose on the average fruitset percentage

NPK dose (g/plant)	Fruitset percentage
24	0,63 ab
32	0,61 a
40	0,67 b
48	0,59 a
Tukey 5%	0,05

Note: Numbers followed by the same letter indicate results that are not significantly different in the 5% Tukey test

Giving NPK fertilizer at dose of 40 g/plant gave a positive response to the fruit set percentage which showed a significantly different interaction at a fertilizer dose of 32 g/plant and a fertilizer dose of 48 g/plant. The highest fruitset percentage was found at a dose of 40 g/plant, namely 67%. The number of flowers affects the fruit set percentage because if many of the flowers that appear abort, the number of flowers that become fruit will be low. Flower abortion in the study was caused by several factors such as environmental conditions and nutrient availability. The nutrient that plays a role in reducing flower loss is the element potassium. According to (Prasetyo, 2014), the nutrients N, P, and K have a role in flower formation, reducing the risk of fewer flowers falling, as well as filling the fruit in the photosynthesis process, namely as a constituent of fats, proteins, carbohydrates, and minerals and then translocated to storage part in the form of fruit.

4. CONCLUSION

The combination of Hormonic PGR and NPK fertilizer provision did not show a significantly different interaction on tomato plant growth parameters, but showed a significantly different interaction on plant yield parameters which included the number of fruit per plant and fruit weight per plant. Treatment with a Hormonic PGR concentration of 6 ml/l + 40 g/plant dose of NPK fertilizer obtained the best results, namely the number of fruit per plant obtained a value of 49 fruits and the weight of fruit per plant was 1572.37 g. Meanwhile, the combination treatment did not show a significant interaction on the number of flowers and fruitset percentage. The PGR concentration treatment showed a significantly different interaction at the age of 28-70 DAT, while the NPK fertilizer dose was significantly different at the age of 28-56 DAT.

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