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Strategies for improving yield and quality of Chrysanthemum By combining growth regulator and Inorganic Fertilizer

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This experiment was carried out at Sidomulyo Village, Batu, East Java, to investigate the effect of growth regulator (Gibberellin) and inorganic fertilizer on the growth, yield and quality of Chrysanthemum (*Chrysanthemum* sp.). A non-factorial Randomized Block Design was used by combining three Gibberellin levels (150 ppm, 250 ppm and 350 ppm) and three inorganic (NPK) fertilizer (16:16:16) levels (1000, 1500 and 2000 kg.ha^{-1}). The combinations were as follows: GP1 = GA_3 150 ppm + NPK 1000 kg.ha^{-1}, GP2 = GA_3 250 ppm + NPK 1000 kg.ha^{-1}, GP3 = GA_3 350 ppm + NPK 1000 kg.ha^{-1}, GP4 = GA_3 150 ppm + NPK 1500 kg.ha^{-1}, GP5 = GA_3 250 ppm + NPK 1500 kg.ha^{-1}, GP6 = GA_3 350 ppm + NPK 1500 kg.ha^{-1}, GP7 = GA_3 150 ppm + NPK 2000 kg.ha^{-1}, GP8 = GA_3 250 ppm + NPK 2000 kg.ha^{-1}, and GP9 = GA_3 350 ppm + NPK 2000 kg.ha^{-1}. The result showed that combination of 350 ppm Gibberellin with 1000 kg.ha^{-1} NPK fertilizer gave the best growth and quality, especially on the parameters of plant height, stalk diameter, and stalk length.

Keywords: Chrysanthemum, growth hormone, Gibberellins, NPK fertilizer, quality

INTRODUCTION

The ornamental plant industry in Indonesia is currently one of the horticultural products that are starting to be favored by many people. One of the ornamental plants that are quite popular with the community is the chrysanthemum plant. Chrysanthemum (Chrysanthemum sp.) Is one of the many ornamental plants that have high potential in the market. In international trade, chrysanthemums are the most popular flower plants other than roses and carnations (Nxmalo and Wahome, 2010). The number of chrysanthemum enthusiasts can be proven by the fluctuating availability of chrysanthemum statistics from year to year. According to Pusdatin (2015), the development of chrysanthemum availability in Indonesia during the 2007–2012 period increased, slightly decreased in 2013 by 2.59%. In 2014 it increased again by 10.35%, then from 2015 to 2016, it continued to decline. The growth in consumption of chrysanthemum per year in the 2007–2016 period fluctuated by an average of 26.06%. However, the fluctuating growth in chrysanthemum consumption is not supported by the stable percentage of chrysanthemum availability in the market. This can be due to several factors related to the constraints of the chrysanthemum production itself. These constraints are in the form of a low level of technological skills controlled by farmers, which causes the quality and quantity of chrysanthemum to decline.

Increasing the quality and quantity of chrysanthemum plants can be carried out by correcting the correct cultivation technique. One of the efforts that can be done is to stimulate plant growth by providing a Plant Growth Regulator (PGR) in the form of GA_3 and NPK fertilizer. The application of GA_3 can stimulate the growth of chrysanthemum plants by optimizing growth in vegetative and generative organs. This is due to the role of exogenous GA_3 which can help increase photosynthate and can accelerate the process of photosynthate translocation in plants so that plants can grow faster and avoid stunting, and the flowering process can run faster. Giving GA_3 with a concentration of 150 ppm in chrysanthemum plants can accelerate the division of meristem cells to increase plant height, accelerate flowering, and shorten harvest life (Nasihin, 2008).

The application of NPK fertilizer is intended as an effort to increase the growth and yield of chrysanthemums. According to Sukmana (2014), NPK 16:16:16 compound fertilizer at a dose of 1600 kg.ha-1 can provide optimal growth and yields on chrysanthemum plants. NPK fertilizer as a compound fertilizer has an important role in providing sufficient nutrient needs because compound fertilizers contain more than 1 kinds of nutrients (macro and micro), especially the content of N, P, and K which is needed by plants. With the use of NPK fertilizer, it is expected that chrysanthemum plants can provide crop yields following quality standards.

MATERIALS AND METHODS

This research was carried out on farms at Bumiaji, Batu from January to May 2020. To be precise, the farm was located at Jalan Cemara Kipas RT 03 RW 1 No 106 Sidomulyo, Batu, East Java with an altitude of 750 m above sea level.

This research used a non-factorial randomized block design (RBD) with a combination treatment of 3 levels of GA_3 concentration: 150 ppm, 250 ppm, 350 ppm, and 3 levels of NPK fertilizer (16:16:16) : 1000 kg.ha-1, 1500 kg.ha-1, and 2000 kg.ha-1. So there are 9 different treatments that will be used with each of them having 3 replications. The chrysanthemum seeds used are Fiji White varieties with standard flower forms. The observation variables used were plant height (cm), the number of leaves, flower emergence time (dat), flower bloom time (dat), harvest age (dat), flower freshness duration, flower diameter (cm), stalk diameter (mm), and stalk length (cm).

RESULTS AND DISCUSSION

Plant Height

GA_3 concentration treatment with NPK fertilizer doses significantly affected the plant height parameters at the 49, 63, and 77 dast observations. The application of gibberellin with a concentration of 350 ppm can provide the best average plant height than plants that get a concentration of 150 ppm. Giving the right GA_3 concentration to plants can stimulate plant growth (Maharani, 2018). As in its role, gibberellin is ZPT which functions to spur the growth rate of plants to grow faster so that plants given ZPT in the form of gibberellin have higher plants value than plants that are not given gibberellin. This is under the statement from Yasmin (2014), that the application of the concentration of gibberellin (GA_3) given to plants can stimulate plant growth through increasing plant height or leaf area.

Also, the combination using NPK fertilizer with a fertilizer dosage of 1000 kg.ha-1 gives the best plant height value than the addition of a fertilizer dose of 2000 kg.ha-1. As in Sari's research (2013), where NPK fertilizer treatment of 1.5 g / polybag produced the highest plant height of chrysanthemum than the NPK dose of 6 g / polybag because NPK fertilizer does not always increase growth or increase plant height.

Number of Leaves

The combination treatment between GA_3 concentration and NPK fertilizer dose did not have a significant effect on the parameters of the number of leaves, time of appearance of flowers, time to bloom, age of harvest, and flower diameter. The parameter number of leaves with the results of an analysis of variance that was not significantly different could be due to the concentration of GA_3 and the dosage of NPK fertilizer which was not quite right. Also, when the plant was 20 days after planting, it was attacked by Liriomyza sp. which strikes right at the leaves of the plant. According to Purwanto and Martini (2009) the leaves attacked by Liriomyza sp. has symptoms of damage in the form of white spots caused by punctures of adult insect ovipositor accompanied by irregular winding grooves from larval droppings and forming small tunnels on the leaf surface. These symptoms will make the leaves less optimal in carrying out the photosynthesis process so that the average number of leaves does not increase much in all treatments.

Flower Emerging, Blooming, Freshness Duration and Harvest Time

The addition of GA_3 and NPK fertilizer had a significant effect on the parameters of freshness duration. Where the higher the concentration of GA_3 and the dose of NPK fertilizer given, will be able to increase the average value of long flower freshness. The application of a combination of GA_3 and NPK fertilizer is said to increase freshness time because GA_3 has a role in stimulating the photosynthesis process and accelerating the growth rate of plants, which can increase due to a large amount of photosynthate produced. This is supported by the statement of Priambodo et al. (2014) in their research that the provision of GA_3 at a concentration of 250 ppm to 500 ppm can have a better effect than plants that are not given GA_3. Meanwhile, NPK fertilizer in increasing the average duration of flower freshness is by stimulating plant physiological processes for height increase, as well as an increase in stem diameter. This is because plants in their growth period require a food source from the photosynthesis process which will form carbohydrates, where the production of these carbohydrates will be reformed through the respiration process. Plants that have more carbohydrate reserves will produce flowers that have long-lasting freshness (Dale and Brenner, 1986 in Priambodo et al., 2014).

The insignificant effect on the parameters of flower emergence time, flower bloom time, harvest age, and flower diameter can be caused by several things such as chrysanthemum giving the same response to all parameters, the existence of genetic factor control that is greater than the treatment given, and differences in needs. nutrition during the flowering phase. The nutritional requirements and growth hormones used by plants to increase the value of the generative phase parameters are not the same as the needs of plants during the vegetative phase. In the generative phase, plants require a lot of energy to flower properly. By the statement of Ardie (2006), the shoots that are undergoing the flowering process require a large amount of energy for the cell division process. Lack of sufficient energy can lead to failure of flower development. Regarding the time of initiation and the length of days for flower development, it is also thought that it is influenced by the availability of energy in different plants (Annisa, 2016). Where this energy is used for various cell activities in plants.

Flower Diameter, Stalk Diameter and Stalk Length

The application of a combination of GA_3 and NPK fertilizer has a significant effect on the diameter parameters of chrysanthemum stalks. The high average stalk diameter is found in the treatment combination that has a high NPK fertilizer dosage because the provision of nutrients from the fertilizer makes the stalks enlarge. The elements contained in NPK fertilizer include macro and micronutrients that are much needed by plants. Elemental N functions as a form of chlorophyll which has an important role in the continuation of photosynthesis. The results of photosynthesis will be used for the growth of plant organs, where when the plant organs get bigger, the more water content is stored in the plant, so that the diameter of the stalks becomes large (Koryati, 2004). Then there is the role of the P element as forming ATP for the energy needed by plants in all cell activities. As well as the role of element K to increase the rate of photosynthesis and to produce photosynthate which is used for plant growth needs (Irvandi, 2017). Therefore, the treatment of chrysanthemum plants with a high dose of NPK fertilizer will result in a large diameter of the stalk.

The presence of GA_3 in the treatment combination also affects increasing the diameter of the stalks. As in its role, GA_3 can support cell division and plant growth. Where before cell division occurs, GA_3 plays a role in translating minerals and photosynthate quickly and well from the roots to other parts of the plant through the phloem. The increase in the diameter of the stalks is due to the differentiation of meristem cells on the internode section, which in turn can spur cell division and elongation (Puspitasari, 2008).

The combined application of GA_3 concentration and NPK fertilizer dosage had a significant effect on the stalk length parameter. The difference in the NPK fertilizer dosage which has the highest average of stalk length and plant height parameters can be due to when the plant enters the generative phase the need for NPK fertilizer is greater than before because the supply of nutrients will be more focused on the growth of generative organs. However, even though the vegetative phase has stopped, it certainly does not mean that the growth of the vegetative organs of the chrysanthemum has also stopped. Vegetative organs still grow in the generative phase, but their growth is not as fast as during the vegetative phase because plants will focus more on the growth of sexual organs. Also, the

treatment combined with a GA_3 concentration of 350 ppm also affects the increase in stalk length. The increase in stalk length from GA_3 can be due to the role of GA_3 being able to increase plant growth because it can stimulate the photosynthetic process by increasing the rate of photosynthesis and can increase the availability of carbohydrates which play a role in plant development and growth (Deninta, 2017).

Table 1: Chrysanthemum plant height as a result of Gibberellin and NPK Fertilizers Combination

Treatments	Plant Height (cm) at …				
	21 dat	35 dat	49 dat	63 dat	77 dat
GA_3 150 ppm + NPK 1000 kg.ha^{-1}	13,56	32,92	45,07 b	51,93 bc	56,05 bc
GA_3 250 ppm + NPK 1000 kg.ha^{-1}	11,72	31,05	44,62 b	49,86 b	54,87 bc
GA_3 350 ppm + NPK 1000 kg.ha^{-1}	14,16	39,46	57,14 c	62,88 c	68,21 c
GA_3 150 ppm + NPK 1500 kg.ha^{-1}	12,89	31,6	44,01 b	51,28 bc	57,25 bc
GA_3 250 ppm + NPK 1500 kg.ha^{-1}	13,61	30,85	42,7 ab	46,92 ab	51,61 ab
GA_3 350 ppm + NPK 1500 kg.ha^{-1}	12,86	31,66	45,44 bc	49,44 b	56,22 bc
GA_3 150 ppm + NPK 2000 kg.ha^{-1}	10,97	22,6	31,54 a	36,35 a	40,75 a
GA_3 250 ppm + NPK 2000 kg.ha^{-1}	11,39	29,63	43,69 b	48,49 ab	53,43 ab
GA_3 350 ppm + NPK 2000 kg.ha^{-1}	13,31	34,7	50,16 bc	55,03 bc	62,02 bc
LSD 5%	tn	tn	12,019	12,869	13,6198

Means followed by the same letter in a column are not significantly different (Tukey, $P > 0.05$).

Tabel 2: Chrysanthemum number of leaves as a result of Gibberellin and NPK Fertilizers Combination

Treatments	Number of leaves at …				
	21 dat	35 dat	49 dat	63 dat	77 dat
GA_3 150 ppm + NPK 1000 kg.ha-1	11,5	19,06	26,83	33,44	39,33
GA_3 250 ppm + NPK 1000 kg.ha-1	10,44	17,5	28,17	32,78	44,83
GA_3 350 ppm + NPK 1000 kg.ha-1	12,11	21,11	30,11	35,56	39,67
GA_3 150 ppm + NPK 1500 kg.ha-1	11,72	19,17	25,11	30,94	48,56
GA_3 250 ppm + NPK 1500 kg.ha-1	11,83	18,44	26,39	28,99	38,49
GA_3 350 ppm + NPK 1500 kg.ha-1	11,11	17,94	24,17	28,78	31,94
GA_3 150 ppm + NPK 2000 kg.ha-1	9,78	16,89	25,83	33	35,67
GA_3 250 ppm + NPK 2000 kg.ha-1	9,44	16,83	24,72	30,11	35,11
GA_3 350 ppm + NPK 2000 kg.ha-1	11,17	19,22	28,11	31,22	45,99
LSD 5%	ns	ns	ns	ns	ns

Means followed by the same letter in a column are not significantly different (Tukey, $P > 0.05$).

Table 3. Chrysanthemum flower emerging, blooming, freshness duration and harvest time as a Result of Gibberellin and NPK Fertilizers Combination

Treatments	Flower Emerging (dat)	Flower Blooming (dat)	Harvest Time (dat)	Freshness Duration (day)
GA_3 150 ppm + NPK 1000 kg.ha-1	71,33	84,67	111,33	5,67 a
GA_3 250 ppm + NPK 1000 kg.ha-1	76	90,67	112,67	5,67 a
GA_3 350 ppm + NPK 1000 kg.ha-1	75,67	89,33	111,67	6,67 bc
GA_3 150 ppm + NPK 1500 kg.ha-1	76,33	90,33	118,33	6 ab
GA_3 250 ppm + NPK 1500 kg.ha-1	79,67	91	119	7,33 cde
GA_3 350 ppm + NPK 1500 kg.ha-1	78	89,67	120,33	7,33 cde
GA_3 150 ppm + NPK 2000 kg.ha-1	75	89,33	116	7 cd
GA_3 250 ppm + NPK 2000 kg.ha-1	81	95,33	118,33	7,67 de
GA_3 350 ppm + NPK 2000 kg.ha-1	74,33	90,67	123	8 e
LSD 5%	ns	ns	ns	0,89

Means followed by the same letter in a column are not significantly different (Tukey, $P > 0.05$).

Table 4: Chrysanthemum flower diameter, stalk diameter and stalk length as a result of Gibberellin and NPK Fertilizers Combination

Treatments	Flower Diameter (cm)	Stalk Diameter (mm)	Stalk Length (cm)
GA_3 150 ppm + NPK 1000 kg.ha-1	41,23	4,46 ab	63,19 ab
GA_3 250 ppm + NPK 1000 kg.ha-1	41,99	4,86 bc	69,86 bc
GA_3 350 ppm + NPK 1000 kg.ha-1	39,63	4,26 a	71,46 c
GA_3 150 ppm + NPK 1500 kg.ha-1	36,13	4,46 ab	62,83 ab
GA_3 250 ppm + NPK 1500 kg.ha-1	36,75	4,47 ab	65,59 abc
GA_3 350 ppm + NPK 1500 kg.ha-1	34,69	4,55 abc	66,51 abc
GA_3 150 ppm + NPK 2000 kg.ha-1	43,35	4,83 bc	61,59 a
GA_3 250 ppm + NPK 2000 kg.ha-1	41,43	4,92 c	68,39 abc
GA_3 350 ppm + NPK 2000 kg.ha-1	37,81	4,45 ab	72,62 c
LSD 5%	ns	0,424	7,328

Means followed by the same letter in a column are not significantly different (Tukey, $P > 0.05$).

Flower Yield and Quality

Based on the results of the analysis of variance on the parameters of freshness duration, the AA quality class is fresh, but the quality class cannot be used as a consideration in choosing recommendation treatment because the category is not specific. In the diameter of the stalk parameters, the quality class A was obtained with the category 4.1-5 mm for all combination treatments. Whereas for the stalk length parameter that got quality class A with 70 cm category only 2 combination treatments were GA_3 350 ppm + NPK fertilizer 2000 kg.ha^{-1}, and GA_3 350 ppm + NPK fertilizer 1000 kg.ha^{-1}. So that according to the overall results of the quality standard it can be said that the parameter that can represent the overall quality class is the stalk length parameter, where GA_3 treatment with a concentration of 350 ppm and NPK fertilizer of 1000 kg.ha^{-1} is a recommendation for the right treatment. Because in this treatment, besides being able to represent the quality class of all parameters, it is also more economical because the addition of NPK fertilizer at a dose of 2000 kg.ha^{-1} does not provide growth and flowering yields that are significantly different from the NPK fertilizer dosage of 1000 kg.ha^{-1}

CONCLUSION

The result showed that combination of 350 ppm Gibberellin with 1000 kg.ha^{-1} NPK fertilizer gave the best growth and quality, especially on the parameters of plant height, stalk diameter, and stalk length.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

WEM, DA and APR designed the experiment. WEM and HPJ performed the field experiment, while DA and APR performed the data analysis and wrote the manuscript. All authors read and approved the final version.

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