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Effect of NPK fertilizer dose and GA_3 concentration on growth, yield, and yield quality of *Coix lacryma-jobi* L. var. *ma-yuen* from ratoons

Abstract. One type of cereal that can be used as a functional food is hanjeli (*Coix lacryma-jobi* L.). Hanjeli production has many problems, i.e., low productivity and long life. Hanjeli cultivation from ratoons has several advantages, including reduced production costs, shorter lifespan, and less water requirement. Fertilization of NPK and application of GA_3 as gibberellin hormone are expected to increase the growth and yield of hanjeli. This study aims to determine the interaction effect between NPK and GA_3 on the growth and yield of hanjeli from ratoon. This experiment was carried out at the Experimental Field of the Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang Regency, West Java, from August to December 2020. The experimental design used a Randomized Block Design, while the treatment design consisted of 2 factors. The first factor was the dose of NPK fertilizer which consisted of 3 levels, namely 100, 200, and 300 kg. The second factor was the concentration of GA_3, consisted of 3 levels, namely 0, 10 and 20 ppm. All treatments were repeated 3 times. The results showed that there was an interaction effect between NPK fertilizer application and GA_3 concentration on growth and yield of hanjeli, namely plant height, number of tillers, number of branches, leaf area index, number of productive tillers, grain weight per plant, harvest index and grain size and hardness. At a high concentration of GA_3, increasing NPK fertilizer dose could improve the growth, yield, and yield quality of the hanjeli.

Keywords: Fertilizer · Functional food · Gibberellin · Ratoon

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Introduction

Hanjeli (*Coix lacryma-jobi* L.) is a cereal plant that is used as an alternative food. Hanjeli has been used to make indigenous porridge for a long time, especially in West Java, Southeast Sulawesi and South Sulawesi. According to Nurmala (2010), hanjeli can be used as an ingredient in brownies and other cakes. Hanjeli also has various health benefits (bin Arif et al., 2014; Afandi et al., 2019; Tensiska, 2017; He et al., 2020; Tensiska et al., 2020; Grubben et al., 1996). One widely cultivated hanjeli variety is *Coix lacryma-jobi* var. *ma-yuen* (Qosim & Nurmala, 2011).

Currently, the hanjeli plant has many problems, namely low productivity and long life. The hanjeli cropping index can be increased by ratooning the plants, thereby shortening the land preparation time and the life of hanjeli plants (Mareza et al., 2016). This is because ratoons can grow new plants by growing shoots from the base of the stem after the plants are cut (Efendi et al., 2013). However, ratoons of hanjeli cause decreasing crop yields, even more than 50%.

To keep decreasing yield not significant, a booster is needed to accelerate hanjeli growth. NPK fertilizer is needed for plant growth. Nitrogen (N) is necessary for the production of carbohydrates, proteins, lipids and other organic substances and is also a component of chlorophyll, which gives green color of leaves (Wang et al., 2021). Phosphorus (P) helps energy transfer in plant cells, encourages root development and early fruiting, strengthens stems to prevent them from breaking, and increases absorption at the start of growth (Balemi & Negisho, 2012). Potassium (K) plays roles in plant growth, for example in encouraging the translocation of carbohydrates from leaves to plant organs (Assagaf, 2017).

On the other hand, gibberellins are known to increase plant growth, both vegetative and generative (Sarwanidas & Setyowati, 2017). Gibberellin is a plant growth regulator which plays a role in stimulating stem segment elongation and increasing leaf size in various plants, which increasing cell elongation and expansion is one of the effects of gibberellins (Wicaksono et al., 2016; Schwechheimer, 2012).

The enlarged cell size as a result of gibberellins will require additional nutrient supply (Ullah et al., 2017; Saleem et al., 2021). The addition of NPK and gibberellin is expected to increase the growth of hanjeli plants, so that the yield and quality of the results will increase. This study aims to determine the interaction effect of NPK fertilizer and gibberellin (GA_3) on the growth, yield, and quality of yield of *Coix lacryma-jobi* L. var. *ma-yuen* from ratoon.

Materials and Methods

This research was conducted from August to December 2020 at the Experimental Field of the Faculty of Agriculture, Padjadjaran University, Jatinangor, Sumedang Regency, West Java. The altitude of the research location is around 737 m asl, the soil order is Inceptisols and climate type is C3 according to Oldeman's classification. The tools used in this study was a meter gauge, analitycal scale with 0.01 gram accuracy, camera, Irfan view software, huller machine, caliper, and penetrometer. The materials used are the seeds of hanjeli var. *ma-yuen*, plant growth regulator GA_3 10%, NPK 16 – 16 – 16 fertilizer, and Profenofos insecticide.

This research used experimental method. The experimental design used factorial Randomized Block Design (RBD) consisting of 2 factors: NPK fertilizer dose as the first factor and gibberellin concentration (GA3) as the second factor. The first factor consisted of 3 levels, namely 100 (p1), 200 (p2), and 300 (p3) kg ha^{-1}, while the second factor consisted of 3 levels, namely 0 (g0), 10 (g1), and 20 (g2) ppm . All treatments were repeated three times. The samples observed for each plot were 6 plants.

Observations were made on growth characteristics (plant height, number of tillers, number of branch and leaf area index), yield components (number of productive tillers, grain weight per plant and harvest index), and yield quality (grain size and grain hardness). Plant height was measured using a meter gauge at the end of the vegetative stage (14 weeks after ratooning). The number of tillers and the number of branches were counted at the age of 14 weeks after ratooning. The leaf area index was measured by comparing the leaf area with the canopy area. Leaf area was measured using the regression equation y = 0.277 + 0.68 (lxw) (R^2 = 94.5%), where l is leaf length while w is the leaf width. Canopy area was measured using a photo of area covered by plants, that converted into pixel by Irfan view software. The number of productive tillers is counted based on the number of tillers that produce flowers at the reproductive stage. Grain weight per plant was measured after harvest using an analytical scale at 14% moisture content. The harvest index is measured by comparing grain weight with plant biological weight. Grain size was measured using a caliper, while grain hardness was measured using a penetrometer.

Experimental data were analyzed using the ANOVA test. Differences at each level were analyzed using Duncan's test at a significant level of 5%.

Results and Discussions

Results. Tables 1 and 2 showed the interaction effect between NPK fertilizer doses and gibberellin (GA_3) concentrations on plant height and number of tillers. In the observation of plant height, doses of p3 and p2 gave higher plant height than p1 at the g0 and g1 levels, but the p2 treatment was not different from p1 at the g2 level. Meanwhile, in observing the number of tillers at the g0 level, the p1 and p2 doses were not different, although they differed from the p3 dose. At the g1 and g2 levels, all treatments gave different number of tillers. The increasing number of tillers occurred with the addition of gibberellin concentrations and NPK fertilizer.

Table 1. Interaction effect of NPK fertilizer and gibberellin concentration on plant height (cm)

NPK Fertilizer (P)	Gibberellin (G)		
	g_0 (0 ppm)	g_1 (10 ppm)	g_2 (20 ppm)
p_1	136.44 a	135.89 a	144.83 a
(100 kg ha^{-1})	A	A	B
p_2	162.50 b	155.44 b	150.50 a
(200 kg ha^{-1})	B	AB	A
p_3	155.56 b	154.28 b	174.44 b
(300 kg ha^{-1})	A	A	B

Note: The mean value followed by the same capital letter (horizontal direction) or the same lowercase letter (vertical direction) is not significantly different according to Duncan's test at 0.05 significant level

Likewise with the number of branches and leaf area index, an increase in the number of branches or leaf area index occurred at high concentrations of gibberellin with the addition of NPK fertilizer. The number of branch and leaf area index at the g0 level showed no difference in the dose of fertilizer treatment, but the p3 dose gave a different number of branch or leaf area index with the doses of p1 and p2 at the g1 and g2 levels (Tables 3 and 4).

Table 2. Interaction effect of NPK fertilizer and gibberellin concentration on number of tillers

NPK Fertilizer (P)	Gibberellin (G)		
	g_1 (0 ppm)	g_2 (10 ppm)	g_3 (20 ppm)
p_1	13.33 a	10.06 a	17.06 a
(100 kg ha^{-1})	B	A	C
p_2	13.11 a	14.11 b	18.33 b
(200 kg ha^{-1})	A	A	B
p_3	17.56 b	19.11 c	24.56 c
(300 kg ha^{-1})	A	B	C

Note: The mean value followed by the same capital letter (horizontal direction) or the same lowercase letter (vertical direction) is not significantly different according to Duncan's test at 0.05 significant level

Table 3. Interaction effect of NPK fertilizer and gibberellin concentration on number of branch

NPK Fertilizer (P)	Gibberellin (G)		
	g_1 (0 ppm)	g_2 (10 ppm)	g_3 (20 ppm)
p_1	3.17 a	3.22 a	4.33 a
(100 kg ha^{-1})	A	A	B
p_2	3.28 a	3.28 a	4.22 a
(200 kg ha^{-1})	A	A	B
p_3	3.33 a	4.22 b	5.28 b
(300 kg ha^{-1})	A	B	C

Note: The mean value followed by the same capital letter (horizontal direction) or the same lowercase letter (vertical direction) is not significantly different according to Duncan's test at 0.05 significant level

Table 4. Interaction effect of NPK fertilizer and gibberellin concentration on leaf area index

NPK Fertilizer (P)	Gibberellin (G)		
	g_1 (0 ppm)	g_2 (10 ppm)	g_3 (20 ppm)
p_1	3.212 a	2.190 a	3.845 a
(100 kg ha^{-1})	B	A	B
p_2	2.532 a	2.705 a	4.183 a
(200 kg ha^{-1})	A	A	B
p_3	3.437 a	5.182 b	7.791 b
(300 kg ha^{-1})	A	B	C

Note: The mean value followed by the same capital letter (horizontal direction) or the same lowercase letter (vertical direction) is not significantly different according to Duncan's test at 0.05 significant level

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In observing the yield characters, there was an interaction effect between NPK fertilizer and gibberellin on the number of productive tillers (Table 5). At the g0 level, the p1 and p2 doses did not differ, although they were different from the p3 dose. All treatments were different at the g1 and g2 levels. The same pattern occurs as in the observation of the number of tillers.

Table 5. Interaction effect of NPK fertilizer and gibberellin concentration on number of productive tillers

NPK Fertilizer (P)	Gibberellin (G)		
	g_1 (0 ppm)	g_2 (10 ppm)	g_3 (20 ppm)
p_1	12.06 a	9.44 a	14.00 a
(100 kg ha^{-1})	B	A	C
p_2	11.06 a	11.56 b	17.00 b
(200 kg ha^{-1})	A	A	B
p_3	17.44 b	17.56 c	20.61 c
(300 kg ha^{-1})	A	A	B

Note: The mean value followed by the same capital letter (horizontal direction) or the same lowercase letter (vertical direction) is not significantly different according to Duncan's test at 0.05 significant level

Other yield characters were also affected by the interaction between NPK fertilizer and gibberellin, one of which is grain weight and harvest index. The NPK fertilizer treatment did not affect grain weight at the g1 and g2 levels, but the p3 dose gave the best seed weight at the g3 level. Similarly to the observation of grain weight, NPK fertilizer treatment increased the harvest index at high doses of gibberellins (Tables 6 and 7).

Table 6. Interaction effect of NPK fertilizer and gibberellin concentration on grain weight (g)

NPK Fertilizer (P)	Gibberellin (G)		
	g_1 (0 ppm)	g_2 (10 ppm)	g_3 (20 ppm)
p_1	51.22 a	60.41 a	68.27 b
(100 kg ha^{-1})	A	B	B
p_2	52.84 a	58.01 a	51.66 a
(200 kg ha^{-1})	A	A	A
p_3	57.38 a	61.99 a	98.82 c
(300 kg ha^{-1})	A	A	B

Note: The mean value followed by the same capital letter (horizontal direction) or the same lowercase letter (vertical direction) is not significantly different according to Duncan's test at 0.05 significant level

Table 7. Interaction effect of NPK fertilizer and gibberellin concentration on harvest index

NPK Fertilizer (P)	Gibberellin (G)		
	g_1 (0 ppm)	g_2 (10 ppm)	g_3 (20 ppm)
p_1	0.22 a	0.26 a	0.21 a
(100 kg ha^{-1})	A	B	A
p_2	0.23 a	0.26 a	0.19 a
(200 kg ha^{-1})	B	B	A
p_3	0.22 a	0.24 a	0.34 b
(300 kg ha^{-1})	A	A	B

Note: The mean value followed by the same capital letter (horizontal direction) or the same lowercase letter (vertical direction) is not significantly different according to Duncan's test at 0.05 significant level

Table 8. Interaction effect of NPK fertilizer and gibberellin concentration on grain size (mm)

NPK Fertilizer (P)	Gibberellin (G)		
	g_1 (0 ppm)	g_2 (10 ppm)	g_3 (20 ppm)
p_1	5.22 a	6.76 a	7.04 a
(100 kg ha^{-1})	A	B	B
p_2	6.90 b	6.90 a	7.05 a
(200 kg ha^{-1})	A	A	A
p_3	7.40 b	7.10 a	7.84 b
(300 kg ha^{-1})	AB	A	B

Note: The mean value followed by the same capital letter (horizontal direction) or the same lowercase letter (vertical direction) is not significantly different according to Duncan's test at 0.05 significant level

Table 9. Interaction effect of NPK fertilizer and gibberellin concentration on grain hardness (kgF)

NPK Fertilizer (P)	Gibberellin (G)		
	g_1 (0 ppm)	g_2 (10 ppm)	g_3 (20 ppm)
p_1	4.42 a	4.47 a	4.75 a
(100 kg ha^{-1})	A	A	B
p_2	4.46 a	4.63 b	5.08 b
(200 kg ha^{-1})	A	B	C
p_3	4.55 a	5.06 c	6.15 c
(300 kg ha^{-1})	A	B	C

Note: The mean value followed by the same capital letter (horizontal direction) or the same lowercase letter (vertical direction) is not significantly different according to Duncan's test at 0.05 significant level

In observing the yield quality, NPK and gibberellins had an interaction effect on grain size, but this did not appear to be consistent (Table 8). The increase in grain size at the g1 level was due to p2 and p3 doses, but all NPK doses did not differ at the g2 level, then the p3 dose increased seed size again at the g3 level. On the other hand, increasing NPK fertilizer increased grain hardness at high doses of gibberellins (Table 9).

Discussion. The effect of gibberellin concentration occurred on growth, yield, and yield quality. This can happen because gibberellins can increase cell enlargement (Schwechheimer, 2012). Gibberellins are known to increase plant growth, both vegetative and generative (Sarwanidas & Setyowati, 2017). Gibberellins can increase the height and number of tillers of cereal plants (Wicaksono et al., 2016; Maharani et al., 2018). Gibberellins can also increase leaf area (Wicaksono et al., 2016). According to Pratama's research (2019), the GA_3 treatment had a significant effect on the weight of edamame seeds. The addition of GA_3 at the beginning of the seed formation process can accelerate cell proliferation and expansion, resulting in larger seeds and increased seed weight (Yasmin et al., 2014). Putra et al.'s research (2014) stated that giving gibberellins (GA_3) increased the harvest index on soybeans. Sriyanto et al. (2019) and Rasyad & Nurbaiti (2014) stated that the application of GA_3 resulted in a larger size and harder seed hardness.

Based on the results of the study, increased growth, yield, and yield quality through higher application concentrations of GA_3 were obtained at higher doses of NPK fertilizer as well. The increase in growth and yield causes the supply of nutrients to be increased. According to Wahyudi et al. (2012), the more adequate the dose of fertilizer given, the better the effect on growth because plants will not be able to grow and develop properly if the nitrogen, phosphorus and potassium needed are insufficient.

Increases in growth, yield, and yield quality in cereal crops have been widely reported as a result of NPK fertilization. The number of tillers of paddy rice increases with higher NPK fertilization (Mahmud, 2015). Research by Pusparini et al. (2018) and Assagaf (2017) stated that the growth and yield of maize plants showed optimum results with higher NPK doses. The elements of nitrogen, phosphorus, and potassium can affect the formation of hanjeli branch (Ruminta et al., 2017). According to Murtilaksono et al. (2014), the number of branch and panicles that grow is due to the large number of tillers that grow and are formed due to excess photosynthate. Nitrogen nutrients affect the leaf area index (Irwan & Nurmala, 2018). Yelis (2011) stated that the elements P and K are needed for the formation of hanjeli grains which causes the grains to be fuller. Kurniadie's research (2002) showed that applying NPK fertilizer to lowland rice at a dose of 300 kg/ha gave the highest average harvest index.

Conclusion

There were interaction effect between NPK fertilizer dose and GA_3 concentration of *Coix lacryma-jobi* L. var. ma-yuen produced from ratoons on plant height, number of tillers, number of branch, leaf area index, number of productive tillers, grain weight, harvest index, grain size and hardness.

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