Ann
PUBLISHER
Journal of Agricultural Sciences
(Agrosci)
e ISSN 3074-2423
p ISSN 3032-7547

Effect Of Arbuscular Mycorrhizal Fungi And Cytokinins On Growth And Yield Of Sorghum Plants (*Sorghum bicolor* (L.) Moench)

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Abstract. Sorghum has many advantages, including high adaptability, drought resistance, high productivity, and resistance to pests and diseases. This makes sorghum a potential cereal crop to be developed on marginal land. Efforts to increase the growth and yield of sorghum plants include the use of biological fertilizers based on arbuscular mycorrhizal fungi (FMA) and adding cytokinin hormones. FMA can increase nutrient uptake and increase plant resistance to drought, while cytokinin hormones can increase cell division and growth. This research was conducted in June-September 2024 in Pancalang Village, Pancalang District, Kuningan, West Java. The research method used was experimental method, with randomized group design (RAK), 16 treatment combinations of FMA dose and Cytokinin concentration and repeated twice. Variables observed included root length and volume, flowering age, sap volume, Brix content, panicle length, fresh weight, testing was done through analysis of variance and Scott-Knott cluster test. The results showed that the combination of FMA dose treatment and Cytokinin concentration gave a significant effect on all variables. High weight per plot results were obtained in the application of FMA doses of 15, 30 and 45 g/plant combined with cytokinin concentration of 15 ppm which amounted to 1,148.00 grams, 1,118.00 grams and 1,090.00 grams, respectively.

Keywords: FMA, Cytokinins, Growth, Results, Sorghum.

INTRODUCTION

Sorghum (*Sorghum bicolor L.*) is a type of cereal plant originating from the African continent and grows in many countries, including Indonesia. Sorghum plants grow in many regions in Indonesia, including Java, Kalimantan, Papua, South Sulawesi, Southeast Sulawesi, West Nusa Tenggara, and East Nusa Tenggara (Harmini., 2021). One of the cereal crops, sorghum, has many adaptations. Sorghum is resistant to marginal land, drought, and waterlogging, and is almost unaffected by pests and diseases. Current underutilized land can be used to develop sorghum (Rifa'i et al., 2015).

Sorghum plants have high adaptability, which means that sorghum can grow on land that is not ideal (Lestari & Dewi., 2015). Sorghum plants are used as food, animal feed, raw materials for the bioethanol industry, and syrup because of their adaptiveness (Khaidir et al., 2021). Thus, sorghum has enormous potential to be developed to achieve food security in Indonesia. However, currently the development of food commodities is still focused on other food commodities such as rice and corn, so sorghum cultivation is still minimal and has not been carried out consistently by Indonesian farmers (Kurniasari et al., 2023).

The yield and productivity values of sorghum in Indonesia increased significantly between 2005 and 2011. In 2011, Indonesia's sorghum production was 7,695 tons, with productivity reaching 1.30 tons/ha Suarni, (2017). This productivity figure is still relatively low compared to the potential yield, which can reach 9.3 tons/ha. Therefore, sorghum productivity can still be increased to achieve optimum results (Kurniasari et al., 2023).

According to (Bai et al., 2020), efforts to meet the nutrient needs of sorghum plants using chemical fertilizers can increase plant productivity. However, excessive use of chemical fertilizers can have adverse effects on the environment such as soil pollution, changes in biodiversity, eutrophication, water contamination, and decreased fertilizer use efficiency. There is also evidence that ineffective use of chemical fertilizers can harm human health. Therefore, chemical fertilizers used on sorghum crops can succeed better by using appropriate and environmentally friendly management. One of them is the use of arbuscular mycorrhizal fungi (FMA) (Putri et al., 2022).

Arbuscular mycorrhizal fungi (FMA) have a mutualistic symbiosis with plants in the root system. The formation of hyphae, spores, vesicles, and arbuscules are signs of FMA symbiosis in plants. Plants derive many benefits from this symbiosis. These include enhancing plant resistance to marginal soils, increasing nutrient uptake, and improving resistance to pathogens, drought, and salinity stress. Furthermore, within plant roots, the symbiotic mechanism occurs through hyphal colonization in the apoplast and cortex cells of the plant to obtain carbon from plant photosynthetic products (Prihantoro et al., 2023).

Regeneration of the embryogenic callus of sorghum plants can be improved by adding cytokinin and auxin growth regulators (ZPT) at the right concentration (Mawaddah et al., 2021). Cytokinins, compounds derived from adenine, are responsible for morphogenesis and regulation of cell division (Widiastoety., 2016). Cytokinin helps bud formation, root and stem formation, protein synthesis, and chloroplast growth (Khoti et al., 2015).

Several studies have shown that the use of Arbuscular Mycorrhizal Fungi and Cytokinin in plants can increase growth components, yield components and plant yields. Therefore, to add information about the use of Arbuscular Mycorrhizal Fungi and Cytokinin, it is necessary to conduct research on the effect of Arbuscular Mycorrhizal Fungi dosage and Cytokinin concentration on sorghum plants.

LITERATURE

In Indonesia, sorghum development has not been prioritized, as indicated by the fact that sorghum data has not been included in agricultural statistics on the development of national sorghum yields. Due to various cultivation techniques and agroecologies, the average productivity and planted area of sorghum in Indonesia varies. Differences in the use of varieties, doses, and types of fertilizers also enhance the variability. To ensure that Indonesia can meet domestic and international demand for sorghum, advances in sorghum cultivation and processing technologies must be supported by significant growth and optimal yields (Khotimah and Suwarto., 2024).

According to (Susilo et al., 2023), sorghum in Indonesia is considered to have a low level of production and productivity. This is due to limited cultivation and limited land, production and productivity are still low below the average description capacity of sorghum varieties. Data on national sorghum production is unclear from BPS and Balitsereal. All aspects of sorghum production and capacity data that have not yet emerged nationally are of concern. Thus, Indonesian sorghum production is not yet present in the global market.

To obtain satisfactory crop production or yield, the growth and production of sorghum requires proper and effective control over the cultivation system. Administration of the hormone cytokinin to arbuscular mycorrhizal fungi is one method that can be used to achieve this.

According to research conducted by (Rupaedah et al., 2016), arbuscular mycorrhizal fungi (FMA) can increase the growth and productivity of sweet sorghum (biomass and sugar content), photosynthetic processes (CO2 gas exchange and chlorophyll content), and leaf nutrient content. Therefore, the use of Arbuscular Mycorrhizal Fungi both with rhizobacteria and with the addition of chemical fertilizers can be developed to increase sweet sorghum stem sugar production.

Furthermore, the results of research by Yunedi & Perdana (2023), found that a dose of 30 grams of Arbuscular Mycorrhizal Fungi (FMA) per plant and 15 grams of FMA per plant can each increase all parameters of growth variables and yield of soybean plants when compared to the application of FMA independently.

The results of research by Halim et al. (2020), showed that the use of arbuscular mycorrhizal fungi was very effective in stopping weed growth and increasing the growth and yield of corn plants. In general, the yield of corn plants treated with mycorrhizal fungi increased between 2.70 and 3.10 tons/ha or an average of 2.86 tons/ha. The highest percentage of mycorrhizal fungi colonization in the roots of maize plants with FMA 45 g/plant hole, which is 94%, is in line with research by (Mustapa et al., 2014) showing that the higher the level of mycorrhizal infection, the higher the yield of maize plants.

(Wahyu Kurniawardani and Adi Kristanto., 2023), in their research showed that the application of cytokinin hormones at a concentration of 15 ppm gave the best results in the parameters of the number of leaves and the number of green leaves. Furthermore (Pan et al., 2013), concluded that spraying with 30 mg/liter at the heading stage can increase grain per panicle, seed formation rate, and grain production for Peizataifeng and Huayou 86 cultivars in both seasons. Cytokinin can increase plant biomass, flag leaf length, reduce drought damage, number of secondary tillers, and yield in other graminae crops such as wheat (Wicaksono et al., 2016).

The results of the study (Bahri et al., 2023) showed that each of the four rice varieties studied could increase the value of BWD, flag leaf length, and 1,000 grain weight. Furthermore, the results (Rohmawati and Ulfah., 2018) showed that changes in the concentration of cytokinin hormone really affected the growth and production of edamame. The addition of one milliliter of cytokinin hormone has a significant effect at the age of 48 hst with the administration of one milliliter of hormone, the plant has an average height of 28.8 cm, an average number of leaves of 15 hela i, and an average fruit weight of 17.43 grams.has an average plant height of 28.8 cm, an average number of leaves of 15 hela i, and a fruit weight of 17.43 grams.

METHOD

The experiment was conducted in June-September 2024 in Pancalang Village, Pancalang Sub-district, Kuningan Regency, West Java Province. The location has an altitude of 337-350 m above sea level (asl), a temperature of 18°C-32°C with rainfall ranging from 2,000 mm-3,000 mm per year.

Materials used in this experiment include Bioguma 2 sorghum seeds, Arbuscular Mycorrhiza (FMA), BAP cytokinin and Urea, KCl, SP36 fertilizers, as basic fertilizers and others that support research. The tools used in include sugar refractometer and sap extractor hoe, hand sprayer, meter, sample pacak, treatment pacak, stationery, labels, sacks, ropes, buckets, knives, plastic, scales, calculators, cell phones for documentaries and other supporting tools.

The experiment used a Randomized Group Design (RAK). Treatments consisted of 16 treatment combinations of FMA dose and Cytokinin concentration, each repeated twice, totaling 32 experimental units.

Observations were made on panicle length, flowering age, root length, root volume, seed weight per panicle, fresh weight, juice volume, Brix content, 100 grain weight and seed weight per plot. The experimental data were analyzed using the F test in the analysis of variance, if the treatment tested showed a significant effect then the test was continued with the Scott-Knott Group Test at a real level of 5%. Data analysis was carried out with the help of MS Excel 2019.

DISCUSSION

Length and Volume of Roots

The results of the analysis of variance showed that the combination of FMA dose and Cytokinin concentration treatment had a significant effect on root length (F = 123.434) and root volume (F = 557.303), which was greater than the F-table = 2.403. Furthermore, the Scott-Knott Cluster Test results are presented in Table 1.

From Table 1, it can be stated that the smallest root length and root volume were obtained in the treatment without the application of Arbuscular Mycorrhizal Fungi (FMA) combined with cytokinin at various concentrations (0, 15, 30, and 45 ppm). Root length in the treatment without cytokinin combined with various doses of mycorrhiza (15, 30, and 45 g) per plant showed significant differences in root length; this indicates that the provision of FMA is very necessary for the development of sorghum plant roots. The highest root length was 40.25 cm in the treatment of FMA 15 g/plant combined with cytokinin at a concentration of 15 ppm, although this treatment was not significantly different from the treatments (F, G, J, K, L, N, O, and P).

Furthermore, the high root volume was produced in treatment F (FMA 15 g/plant and cytokinin concentration 15 ppm), which amounted to 98.50 ml, and treatment J (FMA 15 g/plant and cytokinin concentration 30 ppm), which amounted to 96.50 ml.

Table 1. Root Length and Volume Analysis Results

No.		Treatment	Length (cm)		Volume (ml)	
1	A	FMA 0 g, Cytokinins 0 ppm	23,75	a	54,50	a
2	B	FMA 15 g, Cytokinins 0 ppm	35,25	c	92,50	e
3	C	FMA 30 g, Cytokinins 0 ppm	34,75	c	88,50	d
4	D	FMA 45 g, Cytokinins 0 ppm	33,75	b	86,00	d
5	E	FMA 0 g, Cytokinins 15 ppm	27,25	a	57,75	a
6	F	FMA 15 g, Cytokinins 15 ppm	40,25	**d**	98,50	**f**
7	G	FMA 30 g, Cytokinins 15 ppm	39,00	**d**	92,50	e
8	H	FMA 45 g, Cytokinins 15 ppm	33,50	b	74,00	c
9	I	FMA 0 g, Cytokinins 30 ppm	27,00	a	59,00	a
10	J	FMA 15 g, Cytokinins 30 ppm	40,50	**d**	96,50	**f**
11	K	FMA 30 g, Cytokinins 30 ppm	40,00	**d**	89,00	d
12	L	FMA 45 g, Cytokinins 30 ppm	38,75	**d**	87,50	d
13	M	FMA 0 g, Cytokinins 45 ppm	29,25	a	57,00	a
14	N	FMA 15 g, Cytokinins 45 ppm	38,25	**d**	92,50	e
15	O	FMA 30 g, Cytokinins 45 ppm	39,75	**d**	84,50	d
16	P	FMA 45 g, Cytokinins 45 ppm	37,50	**d**	68,00	d

Information : Mean numbers accompanied by letters in the same column indicate that they are not significantly different based on the Scott-Knott Cluster Test at a 5% real level.

According to Omirou et al. (2016), the addition of arbuscular mycorrhizal fungi to the soil can increase plant root colonization and affect the relationship with soil microorganisms for agricultural sustainability. Furthermore, Setiawati et al. (2019) stated that the cytokinin BAP has the ability to increase the growth and development of plant tissues. In addition, BAP affects shoot height levels. Therefore, adding BAP to the culture medium will help plant tissue growth.

(Army and Jeka., 2019), Stated that mycorrhizal plants can extend their root system because mycorrhiza enters the plant tissue and penetrates the cortex to form a mycelium, which will spur the extension of the root coat, thus making the plant roots longer. Furthermore, according to Admaja et al. (2015), cytokinin helps the formation of buds, root and stem formation, protein synthesis, and chloroplast growth.

Flowering Age

Based on the results of the variance analysis, the combination of FMA dosage and cytokinin concentration had a significant effect on flowering age. Scott-Knott cluster test results are presented in Table 2.

Fast flowering age was produced in FMA treatments of 0, 15, 30, and 45 g/plant combined with cytokinin concentrations of 15 and 30 ppm. However, all levels of FMA dosage combined with no cytokinin and 45 ppm concentration tended to slow down flowering. This is by the opinion (Suwardi and Suwarti., 2020) that the right fertilizer recommendations are needed to get sorghum yields, both for the nira taken from the stems and seeds.

Table 2. Flowering Age Analysis Results

No.		Treatment	Age (Day)	
1	A	FMA 0 g, Cytokinins 0 ppm	63,50	c
2	B	FMA 15 g, Cytokinins 0 ppm	62,00	b
3	C	FMA 30 g, Cytokinins 0 ppm	62,00	b
4	D	FMA 45 g, Cytokinins 0 ppm	63,50	c
5	E	FMA 0 g, Cytokinins 15 ppm	60,50	**a**
6	F	FMA 15 g, Cytokinins 15 ppm	60,00	**a**
7	G	FMA 30 g, Cytokinins 15 ppm	60,00	**a**
8	H	FMA 45 g, Cytokinins 15 ppm	60,00	**a**
9	I	FMA 0 g, Cytokinins 30 ppm	60,50	**a**
10	J	FMA 15 g, Cytokinins 30 ppm	60,00	**a**
11	K	FMA 30 g, Cytokinins 30 ppm	60,00	**a**
12	L	FMA 45 g, Cytokinins 30 ppm	60,50	**a**
13	M	FMA 0 g, Cytokinins 45 ppm	63,50	c
14	N	FMA 15 g, Cytokinins 45 ppm	63,00	c
15	O	FMA 30 g, Cytokinins 45 ppm	64,50	c
16	P	FMA 45 g, Cytokinins 45 ppm	65,50	c

Information: Mean numbers accompanied by letters in the same column indicate that they are not significantly different based on the Scott-Knott Cluster Test at 5% real level

P nutrient content is high in the soil at the experimental location, affecting the flowering process and fruit maturity. High P nutrients in the soil can increase and accelerate the process of flowering and fruit ripening. The availability of P nutrients in the soil can accelerate the flowering process of tomato plants; p nutrients are needed in the process of assimilation and respiration and play a role in accelerating the flowering process and ripening of fruits or seeds. The element P plays a very important role in plant maturation (flower formation), so adequate P for plants will provide a faster flowering age (Lukistasari et al., 2015).

This is in accordance with the role of mycorrhizal fertilizers, which is to accelerate flowering age, carbohydrate synthesis, and spur flower formation. According to Rosliani et al. (2006), mycorrhiza and manure at the required dose can accelerate the age of flowering and fruiting, as well as the ripening of seeds and fruits.

Juice Volume and Brix Level

The result of the variance analysis showed that the combination of FMA dosage and cytokinin concentration significantly affected the volume of juice and Brix content produced. The average Brix content of sorghum seeds ranged from 9.25 to 14.00. The results of the Scott-Knott cluster test analysis are presented in Table 3.

Table 3. Nira Volume and Brix Level Analysis Results

No.		Treatment	Volume (ml)		Kadar Brix	
1	A	FMA 0 g, Cytokinins 0 ppm	100,50	a	9,75	a
2	B	FMA 15 g, Cytokinins 0 ppm	115,75	b	11,75	**b**
3	C	FMA 30 g, Cytokinins 0 ppm	117,00	b	11,25	**b**
4	D	FMA 45 g, Cytokinins 0 ppm	117,50	b	11,50	**b**
5	E	FMA 0 g, Cytokinins 15 ppm	101,50	a	9,25	a
6	F	FMA 15 g, Cytokinins 15 ppm	139,25	**d**	13,00	**b**
7	G	FMA 30 g, Cytokinins 15 ppm	138,50	**d**	14,00	**b**
8	H	FMA 45 g, Cytokinins 15 ppm	136,75	**d**	13,00	**b**
9	I	FMA 0 g, Cytokinins 30 ppm	102,50	a	9,50	a
10	J	FMA 15 g, Cytokinins 30 ppm	134,50	**d**	12,50	**b**
11	K	FMA 30 g, Cytokinins 30 ppm	132,00	c	12,25	**b**
12	L	FMA 45 g, Cytokinins 30 ppm	128,75	c	11,75	**b**
13	M	FMA 0 g, Cytokinins 45 ppm	101,50	a	9,75	a
14	N	FMA 15 g, Cytokinins 45 ppm	138,00	**d**	12,00	**b**
15	O	FMA 30 g, Cytokinins 45 ppm	136,00	**d**	12,25	**b**
16	P	FMA 45 g, Cytokinins 45 ppm	132,50	**d**	11,75	**b**

Information : Mean numbers accompanied by letters in the column indicate that they are not significantly different based on the Scott-Knott Cluster Test at 5% real level.

Table 3 shows that the volume of juice produced and the low brix content of sorghum juice were obtained in the combination of treatments without FMA and Cytokinin at various concentrations (treatments A, E, I, and M). High juice volume was obtained in the FMA treatments of 15, 30, and 45 g/plant combined with cytokinin concentrations of 15 and 45 ppm, and in the treatment of 15 g/plant combined with a cytokinin concentration of 30 ppm. Furthermore, high brix content was obtained in the treatment of FMA 15, 30, and 45 g/plant combined at each level of cytokinin concentration treatment (0, 15, 30, and 45). The low brix content was shown in the treatment without FMA (0 g/plant) combined at every level of cytokinin concentration (0, 15, 30, and 45 ppm).

The existence of a real effect on mycorrhiza with the provision of 15, 30, and 45 g per plant on the volume of nira and brix levels is thought to be due to the provision of mycorrhizal fungi that have a use in increasing nutrient uptake due to external hyphae that have a wide range that can accelerate nutrient absorption throughout the plant tissue. According to (Muis et al. 2016), mycorrhizal fungi can increase the ability of roots to absorb nutrients and water to support plant growth and development.

The process of nutrient uptake by mycorrhizae involves hyphae taking up nutrients in the soil, passing them through the hyphae, and eventually channeling them into root cells. The flow of phosphorus in the hyphae follows the flow of cytoplasm, while the transfer of nutrients from the fungus to the host plant is considered arbuscular (Kurni and Haris., 2017).

According to research conducted by (Rupaedah et al., 2016), arbuscular mycorrhizal fungi (FMA) can increase the growth and productivity of sweet sorghum (biomass and sugar content), photosynthetic processes (CO2 gas exchange and chlorophyll content), and leaf nutrient content. Therefore, using FMA either with rhizobacteria or with chemical fertilizers can be developed to increase sweet sorghum stem sugar production. Furthermore (Zegada and Monti., 2013), suggested that the structure of mycorrhiza can be a bridge or entrance for rhizobacteria to interact with plants so that it can contribute to increasing the sugar content of sweet sorghum stems.

Panicle Length and Fresh Weight

The variance analysis results showed that the combination of FMA dosage and cytokinin concentration significantly affected panicle length and fresh weight. The average panicle length ranged from 21.10 cm to 26.90 cm, while the fresh weight ranged from 103.20 g to 151.80 g. The results of the Scott-Knott cluster test analysis of panicle length and fresh weight are presented in Table 4.

The results of the Scott-Knott cluster test analysis on the observation of fresh weight were in line with the results of the analysis on the observation of root length, root volume, flowering age, juice volume, and Brix content, where the lowest results were obtained in the treatment without FMA (0 g/plant) combined with Cytokinin at various concentrations.

Table 4. Results of Analysis of Panicle Length and Fresh Weight

No.		Treatment	Panicle Length (cm)		Panicle Fresh Weight (g)	
1	A	FMA 0 g, Cytokinins 0 ppm	22,20	a	103,20	a
2	B	FMA 15 g, Cytokinins 0 ppm	23,80	a	131,00	b
3	C	FMA 30 g, Cytokinins 0 ppm	23,70	a	130,20	b
4	D	FMA 45 g, Cytokinins 0 ppm	23,00	a	134,70	b
5	E	FMA 0 g, Cytokinins 15 ppm	22,20	a	104,10	a
6	F	FMA 15 g, Cytokinins 15 ppm	26,50	**b**	151,80	**c**
7	G	FMA 30 g, Cytokinins 15 ppm	26,40	**b**	147,50	**c**
8	H	FMA 45 g, Cytokinins 15 ppm	26,90	**b**	141,00	**c**
9	I	FMA 0 g, Cytokinins 30 ppm	22,10	a	106,80	a
10	J	FMA 15 g, Cytokinins 30 ppm	24,80	**b**	140,90	**c**
11	K	FMA 30 g, Cytokinins 30 ppm	24,60	**b**	143,10	**c**
12	L	FMA 45 g, Cytokinins 30 ppm	25,10	**b**	139,80	**c**
13	M	FMA 0 g, Cytokinins 45 ppm	21,10	a	104,00	a
14	N	FMA 15 g, Cytokinins 45 ppm	24,70	**b**	130,40	b
15	O	FMA 30 g, Cytokinins 45 ppm	25,20	b	126,80	b
16	P	FMA 45 g, Cytokinins 45 ppm	25,80	b	135,80	b

Information : Mean numbers accompanied by letters in the same column indicate that they are not significantly different based on the Scott-Knott Cluster Test at a 5% real level.

Short panicle length was obtained at no FMA treatment (0 g/plant) and at every level without cytokinin treatment (0 ppm). High panicle length was produced in FMA treatment (15,30 and 45 g) per plant combined with cytokinin concentration (15,30 and 45 ppm).

The difference in cytokinin concentration at concentrations (15, 30, and 45 ppm) did not give a significant difference to panicle length but was significantly different from the treatment without cytokinin. One of the functions of cytokinin is to increase plant biomass and flag leaf length and reduce drought damage, the number of secondary tillers, and yields in other graminae plants such as wheat (Wicaksono et al., 2016). Furthermore, according to (Poodineh et al. 2013), the application of cytokinin in Hamoon cultivar wheat plants directly impacts the growth process, and the growth period of wheat will be longer due to delayed leaf aging, resulting in a longer growth period. Spraying cytokinin can reduce drought damage, reduce the number of secondary tillers, and increase the yield and biomass of wheat plants.

For fresh weight per panicle produced from FMA treatment (15, 30, and 45 g) per plant combined with the provision of cytokinin concentrations of 15 ppm and 30 ppm, the provision of mycorrhiza with the dose of FMA with the combination of cytokinin is an optimal combination, increasing the ability of plants to absorb nutrients more optimally than those without mycorrhiza treatment.

The fresh weight of plants is influenced by water content and nutrient content in plant tissue cells. This is thought to be due to the role of mycorrhiza, which helps plants supply nutrients through roots that are symbiotic with mycorrhiza. According to (Putri et al., 2022) One of the benefits of arbuscular mycorrhizal fungi (FMA) is to increase the ability of plants to absorb water and nutrients so that it will stimulate important metabolic processes such as carbohydrates, proteins, and regulation of growth in the plant body.

Seed Weight 100 Grains and per Plot

The results of the analysis of variance showed that the combination of FMA dose and Cytokinin concentration significantly affected the weight of 100 grains and seed weight per plot. The average seed weight of 100 grains ranged from 2.95 cm to 3.85 cm, while the seed weight per plot ranged from 845.00 g to 1148.00 g. The results of the Scott-Knott cluster test analysis are presented in Table 5.

In Table 5, the weight of 100 sorghum grains and the high weight per plot were shown in the FMA treatment (15, 30, and 45) per plant combined with a cytokinin concentration of 15 ppm. The weight of 100 grains was 3.65 g—3.85 g, while the weight per plot was 1,090.0 grams—1,148.0 grams.

The treatment without FMA (0 g) per plant combined with each level of cytokinin concentration (0, 15, 30, and 45 ppm) showed a weight of 100 grains and low seed weight per plot.

The treatment of FMA at doses (15, 30, and 45 g) per plant in combination with cytokinin at concentrations (0 ppm, 30 ppm, and 45 ppm) showed no significant difference in the weight of 100 grains of sorghum, but it was significantly different in the treatment without FMA with various concentrations of cytokinin (0 - 45 ppm) and FMA at doses (15, 30, and 45 g) per plant in combination with cytokinin at a concentration of 15 ppm.

The highest weight per plot was in the treatment of FMA 15 g per plant combined with cytokinin at a concentration of 15 ppm, which amounted to 1,148.00 grams. Furthermore, when converted into 1 ha, the treatment resulted in 2,624 kg.

Table 5. Results of Analysis of 100 Grain Seed Weight and per Plot

No.		Treatment	100 Grains (g)		Seed weight per plot (g)	
1	A	FMA 0 g, Cytokinins 0 ppm	2,95	a	845,00	a
2	B	FMA 15 g, Cytokinins 0 ppm	3,30	b	872,00	b
3	C	FMA 30 g, Cytokinins 0 ppm	3,35	b	876,00	b
4	D	FMA 45 g, Cytokinins 0 ppm	3,35	b	867,50	b
5	E	FMA 0 g, Cytokinins 15 ppm	3,05	a	845,50	a
6	F	FMA 15 g, Cytokinins 15 ppm	3,75	**c**	1.148,00	**d**
7	G	FMA 30 g, Cytokinins 15 ppm	3,85	**c**	1.118,00	**d**
8	H	FMA 45 g, Cytokinins 15 ppm	3,65	**c**	1.090,00	**d**
9	I	FMA 0 g, Cytokinins 30 ppm	2,95	a	847,50	a
10	J	FMA 15 g, Cytokinins 30 ppm	3,55	b	1.010,00	c
11	K	FMA 30 g, Cytokinins 30 ppm	3,55	b	1.040,50	c
12	L	FMA 45 g, Cytokinins 30 ppm	3,55	b	1.064,50	c
13	M	FMA 0 g, Cytokinins 45 ppm	3,05	a	850,00	a
14	N	FMA 15 g, Cytokinins 45 ppm	3,55	b	1.024,50	c
15	O	FMA 30 g, Cytokinins 45 ppm	3,50	b	991,00	c
16	P	FMA 45 g, Cytokinins 45 ppm	3,45	b	1.039,00	c

Information : Mean numbers accompanied by letters in the same column indicate that they are not significantly different based on the Scott-Knott Cluster Test at 5% real level.

(Yunedi and Perdana., 2023) In their research showed that a dose of 30 grams of FMA per plant and 15 grams of FMA per plant can each increase all parameters of growth variables and yield of soybean plants. In contrast, the results of research (Halim et al. 2020) showed that using arbuscular mycorrhizal fungi was very effective in increasing the growth and yield of corn plants. Furthermore, the results of research (Wahyu Kurniawardani and Adi Kristanto., 2023) showed that the application of cytokinin hormones at a concentration of 15 ppm gave the best results in the parameters of the number of leaves and the number of green leaves.

According to Husein et al. (2022), one factor affecting the weight of 100 seeds in sorghum is that factors such as water availability, nutrient content, and soil characteristics affect the development of mycorrhizal spores, which impact low biomass.

CONCLUSION

1. Different treatment combinations of doses of FMA arbuscular mycorrhizal fungi and Cytokinin concentrations significantly influence the growth and yield of sorghum plants.

2. Arbuscular mycorrhizal fungus (FMA) treatment at doses (15.30 and 45 grams) per planting (F, G, and H), combined with a cytokinin concentration of 15 ppm, produces high seed weight per plot (1,090.0 grams—1,148.0 grams).

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