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IMPACT OF ARBUSCULAR MYCORRHIZAL FUNGI AND COW MANURE FERTILIZER ON THE GROWTH OF GLUTINOUS CORN PLANTS (*Zea mays* L. var. *Ceratina* Kulesh)

By

Nurmawati¹, Halim², Abdul Madiki², Sarawa², Rachmawati Hasid², Dirvamena Boer²

¹Postgraduate Student of Agronomy, Faculty of Agriculture, Halu Oleo University, Southeast Sulawesi, Indonesia

²Department of Agrotechnology, Faculty of Agriculture, Halu Oleo University, Southeast Sulawesi, Indonesia



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Abstract

This study aimed to examine the effect of arbuscular mycorrhizal fungi and cow manure on the growth of glutinous corn plants. This study was conducted at the Field Laboratory of the Faculty of Agriculture, Halu Oleo University, Kendari, Southeast Sulawesi Province, from May to July 2025. The study used a factorial Randomized Block Design (RBD) consisting of two factors. The first factor was arbuscular mycorrhizal fungi, consisting of four levels: without AMF (M0), 10 g AMF/planting hole (M1), 20 g AMF/planting hole (M2), and 30 g AMF/planting hole (M3). The second factor was cow manure, which consisted of four levels: without cow manure (P0), 4.59 kg of cow manure/plot equivalent to 10 tons ha⁻¹ (P1), 9.18 kg of cow manure/plot equivalent to 20 tons ha⁻¹ (P2), and 13.77 kg of cow manure/plot equivalent to 30 tons ha⁻¹ (P3). The observed variables were plant height, number of leaves, stem diameter, and leaf area. The results showed that the combination of 30 g of arbuscular mycorrhizal fungi/planting hole and 13.77 kg of cow manure/plot (M3P1) had a better effect on the growth of glutinous corn plants.

Keywords: Arbuscular mycorrhizal fungi, cow manure, glutinous corn, organic farming

INTRODUCTION

Corn is a widely cultivated crop in Indonesia and a staple food for many Indonesians. Corn is also a staple crop with a high carbohydrate content. Besides being a staple food substitute for rice, corn can also be used as animal feed. According to Alhenc et al. (2021), protein in glutinous corn can bind calcium ions (free) to reduce ionic calcium levels because more than 50% of plasma calcium is bound to albumin. It also contains vitamins and substances with specific functions, such as xanthophylls and beta-carotene (Hanik et al., 2022).

One factor influencing corn plant growth is meeting business objectives, which are achieved through the resulting product. This factor is a driving force that requires every company to adapt to every change to remain viable. Change is no longer an obstacle or threat, but rather an opportunity to grow the business and achieve significant profits. According to Rahim et al. (2021), food security has been improved thanks to technological advances, innovation, and agronomic development, as well as renewable crops such as glutinous corn.

One effort to improve the growth of glutinous corn plants is through proper fertilization. Fertilization is a production input that plays a crucial role in increasing crop production and quality (Revilla et al., 2021). Types of fertilizers that can be used include arbuscular mycorrhizal fungi combined with cow manure. The arbuscular mycorrhizal fungi are beneficial microorganisms that form a symbiotic relationship with plant roots. Arbuscular mycorrhizal fungi infect plant roots and help maximize nutrient uptake by the root. Their activity can solubilize phosphorus (P) available to plants (Gholamhoseini et al., 2013). The use of biofertilizer in the form of mycorrhizal fungi can make the plant more able to absorb nutrients and hold more water (Sarawa and Halim, 2020). Plant roots with mycorrhizae can absorb nutrients in a bound form and are not available to plants, and mycorrhizal fungi can also function as biological protection against root pathogen infections (Davamani et al., 2010). According to Ayamba et al. (2021), that's cow manure has the potential to be used as a source of material to make organic fertilizer. Meanwhile, the advantages of using manure include improving soil structure and serving as a decomposer of organic matter by soil microorganisms. According to Font-

*Corresponding Author: Nurmawati.



Palma (2019), the manure contains nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, sodium, iron, and copper.

Methodology

Study Area and Experimental Setup

This research was conducted at the Field Laboratory of the Faculty of Agriculture, Halu Oleo University, Kendari, Southeast Sulawesi Province, from May to July 2025. The research used a Randomized Block Design (RBD) with a Factorial pattern consisting of 2 factors. The first factor is arbuscular mycorrhizal fungi, with 4 levels: without AMF (M0), AMF 10 g/planting hole (M1), AMF 20 g/planting hole (M2), and AMF 30 g/planting hole (M3). The second factor is cow manure, consisting of 4 levels, namely: without cow manure (P0), cow manure 4.59 kg/plot equivalent to 10 tons ha⁻¹ (P1), cow manure 9.18 kg/plot equivalent to 20 tons ha⁻¹ (P2), cow manure 13.77 kg/plot equivalent to 30 tons ha⁻¹ (P3).

Research Procedures

The land was cleared of weeds. The initial soil preparation involved turning the soil using a Kubota M9540 tractor. Next, 48 plots, each measuring 3 m x 1.5 m, were created. Manure was applied one week after land preparation and one week before planting. Fertilizer was applied according to the treatment by spreading it evenly over the plot surface and then mixing it with the soil using a hoe.

The planted seeds were pre-mixed with insecticide (Marshal) to prevent pest infestation after planting. Seeds were planted by digging holes with a digger. Two seeds were planted in each hole, spaced 30 cm x 70 cm apart, with 12 plants per plot. Plant maintenance in this study included watering, replanting, weeding, loosening, hilling, and pest and disease control. Watering was done twice daily, in the morning and evening, if there was no rain. Replanting was carried out seven days after planting to replace plants that did not grow. Weeding is done manually by pulling weeds by hand or using a sickle. Loosening and hilling are done simultaneously. The hilling serves to cover the roots that emerge above the soil surface, and the loosening serves to improve the soil pores so that water can easily penetrate the soil. Loosening and hilling are carried out around the plant stems. Pest control is carried out using chemical pesticides such as Kovin plus 80 P, 15 grams of Zinc Phosphide Rodenticide mixed with dried fish as bait for rat pests.

Observation of Variables

Corn growth variables were observed at 14, 28, 42, and 56 days after planting (DAP).

1. Plant height (cm): measured from the base of the stem to the tallest leaf.
2. Stem diameter (cm): measured using a vernier caliper at the base of the plant (approximately 3 cm above the soil surface).
3. Number of leaves (leaflets): counted from the lowest leaf on the plant to the topmost fully formed leaf.

4. Leaf area: measured by measuring the length and width of corn leaves and then multiplying by the corn plant's constant. Leaf area = L x W x k (0.75)

Where: L = Leaf length (cm), L = Leaf width (cm), k = constanta (0.75)

Data Analysis

Observational data were analyzed using analysis of variance. If the calculated F-value was greater than the F-table, then the Duncan Multiple Range Test (DMRT) was continued at a 95% confidence level.

Result and Discussion

Table 1 shows that arbuscular mycorrhizal fungi significantly affected plant height at 14-28 days after planting, leaf number at 42 and 56 DAP, leaf area at 14-42 DAP, and stem diameter at 14 and 42 DAP. Cow manure significantly affected plant height and leaf number at 28-56 DAP, leaf area at 14-56 DAP, and stem diameter at 28 and 42 DAP. The combination of mycorrhizal fungi and cow manure significantly affected plant height at 14-56 DAP, leaf number at 28-56 DAP, leaf area at 14-42 DAP, and stem diameter at 14 and 28 DAP. This indicates that mycorrhizal fungi and manure are essential for plants during their growth, with indications of significant effects on all observed variables. The increased growth of glutinous corn due to AMF and cow manure occurs due to changes in the physical properties of the soil, making it looser due to the addition of cow manure, allowing the corn roots to penetrate the soil more easily to absorb water and nutrients. Furthermore, the symbiosis between corn roots and mycorrhizal fungi increases the plant's ability to absorb water and nutrients. According to Rachmawati et al. (2020), the activity of mycorrhizal fungi is strongly influenced by the availability of organic matter in the soil, where mycorrhizal fungi are ineffective in soils with high organic matter.

Table 1: Recapitulation of the results of the investigation of the various effects of arbuscular mycorrhizal fungi (AMF) and cow manure on the growth of glutinous corn plants

No	Observation Variables	Treatment		
		Arbuscula Mycorrhiza Fungi (M)	Cow Manure (P)	Interaction (M*P)
1	Plant Height			
	14 DAP	*	ns	**
	28 DAP	**	*	**
	42 DAP	**	**	**
	56 DAP	**	**	**
2	Number of leaves			
	14 DAP	ns	ns	ns

28 DAP	ns	*	*
42 DAP	*	*	*
56 DAP	**	**	**
3 Leaf area			
14 DAP	*	**	**
28 DAP	**	**	**
42 DAP	*	**	**
56 DAP	ns	**	ns
4 Stem diameter			
14 DAP	*	ns	**
28 DAP	ns	**	**
42 DAP	**	**	ns
56 DAP	ns	ns	ns

Notes: ns = not significant, * = significant, ** = very significant, DAP = day after planting

Plant Height

Table 2 Effect of the combination of arbuscular mycorrhizal fungi and cow manure on corn plant height (cm) at 14-56 DAP

Treatments	Observation at			
	14 DAP	28 DAP	42 DAP	56 DAP
M0P0	27.41 ^c	45.04 ^c	87.29 ^a	135.42 ^c
M0P1	46.41 ^a	73.56 ^a	139.17 ^a	182.08 ^a
M0P2	29.44 ^c	43.48 ^d	91.07 ^d	119.92 ^d
M0P3	42.39 ^a	71.21 ^b	115.63 ^b	159.42 ^c
M1P0	33.78 ^c	67.71 ^a	88.18 ^a	170.50 ^a
M1P1	40.33 ^a	68.67 ^a	97.16 ^c	166.75 ^b
M1P2	32.40 ^c	58.89 ^c	108.94 ^c	143.58 ^c
M1P3	37.77 ^b	60.92 ^c	123.58 ^b	172.83 ^b
M2P0	27.52 ^b	43.93 ^c	98.33 ^a	135.17 ^c
M2P1	33.99 ^b	62.51 ^c	114.58 ^b	171.42 ^a
M2P2	51.29 ^a	102.41 ^a	156.93 ^a	192.50 ^a
M2P3	44.51 ^a	83.24 ^b	154.63 ^a	185.02 ^a
M3P0	41.00 ^a	55.14 ^b	92.67 ^a	141.83 ^b
M3P1	40.73 ^{ab}	74.92 ^c	126.33 ^a	174.33 ^a
M3P2	40.23 ^b	67.94 ^b	138.39 ^b	174.08 ^b
M3P3	42.52 ^a	96.95 ^a	149.50 ^a	198.42 ^a
	DRMT 95	DRMT	DRMT 95	DRMT

	%	95 %	%	95 %
	2 = 5.73	2 = 10.64	2 = 12.13	2 = 14.13
	3 = 6.04	3 = 11.64	3 = 12.75	3 = 14.85
	4 =			
	6.22	4 = 11.54	4 = 13.16	4 = 15.32

Notes: Numbers followed by different letters are significantly different based on the DRMT at the 95% confidence level

The results of the study (Table 2) showed that the best height of glutinous corn plants at 14, 28, and 42 DAP was found in the combination of AMF 20 g/planting hole and 9.18 kg/plot (M2P2) treatments, respectively, of 51.29 cm, 102.41 cm, and 156.93 cm. Meanwhile, the best plant height at 56 DAP was obtained in the combination of AMF 30 g/hole and 13.77 kg/plot (M3P3) treatments of 198.4 cm. This indicates that the application of cow manure and mycorrhizal fungi can increase the effectiveness of nutrient and water absorption. The increase in plant height is due to cell division at the apical growth point of the stem, consisting of meristem tissue, thus encouraging stem growth. The roots of plants infected by arbuscular mycorrhizal fungi grow larger due to the development of hyphae outside the roots, which increases the retention of plant nutrient absorption. According to Halim et al. (2023), the arbuscular mycorrhizal fungi form a symbiotic association with plant roots by helping the absorption of P available in the soil.

Number of Leaves

Table 3 Effect of the combination of arbuscular mycorrhizal fungi and cow manure on the number of leaves of corn plants at 28, 42, and 56 DAP

Treatments	Observation at		
	28 DAP	42 DAP	56 DAP
M0P0	5.75 ^b	8.00 ^b	10.67 ^a
M0P1	6.50 ^a	8.25 ^b	12.33 ^a
M0P2	4.42 ^b	7.83 ^b	9.67 ^b
M0P3	6.17 ^b	8.67 ^b	12.67 ^a
M1P0	6.67 ^a	8.83 ^a	11.17 ^a
M1P1	6.58 ^a	8.75 ^a	11.67 ^b
M1P2	6.42 ^a	9.50 ^a	10.83 ^b
M1P3	6.58 ^b	8.67 ^b	12.08 ^b
M2P0	5.67 ^b	7.75 ^b	10.08 ^b
M2P1	5.33 ^b	8.83 ^a	11.42 ^b
M2P2	6.83 ^a	9.58 ^a	12.67 ^a
M2P3	6.50 ^b	8.25 ^b	12.17 ^{ab}
M3P0	6.33 ^a	7.58 ^b	11.25 ^a
M3P1	6.50 ^b	8.25 ^b	12.50 ^a

M3P2	6.17 ^{ab}	8.50 ^b	13.25 ^a
M3P3	7.58 ^a	9.58 ^a	12.83 ^a
	DRMT 95 %	DRMT 95 %	DRMT 95 %
	2 = 0.64	2 = 0.52	2 = 0.67
	3 = 0.67	3 = 0.55	3 = 0.70
	4 = 0.70	4 = 0.56	4 = 0.73

Notes: Numbers followed by different letters are significantly different based on the DRMT at the 95% confidence level

Based on Table 3, it shows that the highest number of leaves at the age of 28 and 42 DAP was obtained in the combination of AMF 30 g/planting hole and 13.77 kg/plot (M3P3) treatment of 7.58 leaves each. While at the age of 56 DAP, the most leaves were obtained in the combination of AMF 30 g/planting hole and 9.18 kg/plot (M3P2) treatment of 13.25 leaves. The number of leaves of corn plants given arbuscular mycorrhizal fungi and cow manure treatment gave the best growth response, resulting in the highest yield. The main cause is that mycorrhizae can effectively increase the absorption of nutrients, both macro and micro nutrients. The photosynthesis process is influenced by several factors, such as leaf area, the amount of chlorophyll in the leaf, leaf thickness, and the number of stomata, as well as external factors such as sunlight, soil moisture conditions, nutrients in the soil, temperature, and humidity around the plant. In addition, mycorrhizal roots can absorb nutrients in bound form that are not available to plants (Smith et al., 2010).

Leaf Area

Table 4 Effect of the combination of arbuscular mycorrhizal fungi and cow manure on the leaf area of corn plants at 14, 28, and 42 DAP

Treatments	Observation at		
	14 DAP	28 DAP	42 DAP
M0P0	44.64 ^a	101.28 ^b	220.42 ^b
M0P1	47.06 ^b	202.32 ^a	321.59 ^a
M0P2	38.51 ^b	106.39 ^c	230.75 ^c
M0P3	49.27 ^b	145.36 ^a	442.33 ^a
M1P0	37.75 ^a	141.94 ^a	304.52 ^a
M1P1	56.69 ^a	116.83 ^b	316.75 ^a
M1P2	38.92 ^b	117.26 ^c	289.46 ^b
M1P3	56.61 ^b	187.49 ^c	323.50 ^b
M2P0	28.36 ^c	101.78 ^b	252.08 ^b
M2P1	39.69 ^b	140.43 ^b	307.27 ^a
M2P2	64.56 ^a	197.97 ^b	423.14 ^a
M2P3	69.76 ^a	200.30 ^b	401.15 ^a

M3P0	36.00 ^b	121.90 ^a	245.95 ^b
M3P1	62.19 ^a	209.20 ^a	241.47 ^b
M3P2	65.92 ^a	238.93 ^a	290.94 ^b
M3P3	62.25 ^a	237.08 ^a	356.04 ^b
	DRMT 95 %	DRMT 95 %	DRMT 95 %
	2 = 7.87	2 = 24.70	2 = 41.18
	3 = 8.27	3 = 25.96	3 = 43.28
	4 = 8.53	4 = 26.78	4 = 44.65

Notes: Numbers followed by different letters are significantly different based on the DRMT at the 95% confidence level

Based on Table 4, it shows that the best leaf area at the age of 14 DAP was found in the combination of AMF 20 g/planting hole and 13.77 kg/plot (M2P3) treatment, namely 69.76 cm², the age of 28 DAP the best leaf area was in the combination of AMF 30 g/planting hole and 9.18 kg/plot (M3P2) treatment, namely 238.93 cm² and 42 DAP was obtained in the combination of treatment without AMF/planting hole and 13.77 kg/plot (M0P3) cow manure, namely 442.33 cm². Leaf area is often used as an observation parameter because of its relationship with the process of photosynthesis. Photosynthesis is the manufacture of food by green plants through a biochemical process in chlorophyll with the help of sunlight. According to Sheoran et al. (2021), that's the availability of nitrogen in plants in sufficient quantities can facilitate the process of cell division because nitrogen has a vital role in stimulating growth.

Stem Diameter

Table 5 Effect of the combination of arbuscular mycorrhizal fungi and cow manure on the stem diameter of corn plants at 14 and 28 DAP

Treatments	Observation at	
	14 DAP	28 DAP
M0P0	3.24 ^b	6.36 ^b
M0P1	4.59 ^b	10.44 ^a
M0P2	3.47 ^b	6.35 ^b
M0P3	4.00 ^b	9.31 ^b
M1P0	3.83 ^b	8.37 ^a
M1P1	5.77 ^a	9.60 ^b
M1P2	3.62 ^b	9.00 ^b
M1P3	4.55 ^b	7.55 ^c
M2P0	3.88 ^b	6.66 ^b
M2P1	4.03 ^b	7.29 ^c
M2P2	6.37 ^a	12.53 ^a

M2P3	4.17 ^b	10.70 ^b
M3P0	4.85 ^a	7.91 ^a
M3P1	4.25 ^b	9.59 ^b
M3P2	4.73 ^b	8.86 ^b
M3P3	5.74 ^a	12.92 ^a
	DRMT 95 %	DRMT 95 %
	2 = 0.69	2 = 1.23
	3 = 0.73	3 = 1.29
	4 = 0.75	4 = 1.33

Notes: Numbers followed by different letters are significantly different based on the DRMT at the 95% confidence level

Based on Table 5, it shows that the largest stem diameter at the age of 14 DAP was found in the combination of AMF 20 g/planting hole and 13.77 kg/plot (M2P2) treatment, namely 6.37 cm, at the age of 28 DAP the largest stem diameter was found in the combination of AMF 30 g/hole and 13.77 kg/plot (M3P3) treatment, namely 12.92 cm. The arbuscular mycorrhizal fungi can produce hormones that play a role in plant growth, namely cytokinins, auxins, gibberellins, and growth-supporting substances, such as vitamins that are beneficial to their hosts, so that plants can grow faster and yields will increase. According to Noli et al. (2011), the benefits of mycorrhizae for the development of the host plant include increasing nutrient absorption from the soil, acting as a biological barrier against root pathogen infection, increasing host resistance to drought, and increasing growth-promoting hormones.

Conclusion and Recommendation

Based on the results and discussion, the following conclusions can be drawn: (a) arbuscular mycorrhizal fungi and cow manure influence the growth of glutinous corn plants. (b) The combination of 30 g of AMF arbuscular mycorrhizal fungi/planting hole and 13.77 kg of cow manure/plot (M3P3) has a better effect on the growth of glutinous corn plants.

Based on the research results, the application of arbuscular mycorrhizal fungi and cow dung fertilizer can be done simultaneously.

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