Research Article

Interaction of Nitrogen and Tricho Compost Dosages on Sinhas 1 as Synthetic Maize Variety

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Abstract | Optimizing synthetic maize varieties can be applied with chemical fertilizers, such as nitrogen, and organic fertilizers, such as tricho compost. Therefore, the interaction of nitrogen fertilizer and compost fertilizer is essential research in supporting the yield of synthetic varieties of maize, Cv Sinhas1. This study aimed to determine the interaction of tricho compost and nitrogen fertilizer doses in producing synthetic maize varieties of Sinhas 1. This study was designed with a split-plot design and a randomized complete block design as an environmental design. The main plot was tricho compost, which consisted of three dosage levels (0 t ha^{-1}, 3 t ha^{-1}, and 6 t ha^{-1}). The subplot was a nitrogen dose comprising seven doses (0 kg ha^{-1}, 50 kg ha^{-1}, 100 kg ha^{-1}, 150 kg ha^{-1}, 200 kg ha^{-1}, 250 kg ha^{-1}, 300 kg ha^{-1}). The combination of all treatments resulted in 21 combinations and was repeated thrice, so there were 63 experimental units. All data were analyzed using analysis of variance and orthogonal-polynomial interaction. Based on the results of this study, plant height (cm) and cob weight (g) characters can be used as evaluation criteria to assist the yield. The tricho compost fertilizer dose of 3 t ha-1 was optimal for the growth and yield of Sinhas. In addition, the interaction of tricho compost fertilizer with a dose of nitrogen fertilizer of 150 kg ha-1 is the optimal interaction in inducing the growth and yield of Sinhas synthetic maize. Combining the two fertilizers can be recommended in cultivating Sinhas 1 synthetic maize, especially in Gowa Regency.

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Introduction

Maize yield development is a priority part of maintaining economic stability in Indonesia. Population growth and demand for chicken protein indirectly affect the need for feed maize. Although the maize commodity has vast potential, the largest allocation of this commodity is still dominated by feed (Panikkai *et al*., 2017; Kaul *et al*., 2019). In general, chicken feed is highly dependent on maize, so an increase in demand for chicken and its feed will indirectly correlate with an increase in maize demand (Kayad *et al*., 2021; Wicaksana *et al*., 2022). Based on data from the Data Center and Information System of the Indonesian Ministry of Agriculture (Ministry, 2020) reported that the national maize demand in 2018 for raw materials for independent animal feed was 4.83 million tons and 8.30 million tons for the feed industry. It is projected to increase to 5.12 million tons (independent animal feed) and 9.75 million tons (animal feed industry) in 2020. These achievements will continue to grow along with population growth. Meanwhile, national maize production with 14% moisture content reached 12.93 million tons in 2020 (Statistics Indonesia, 2023). This shows that there is an imbalance between demand and production. So, the maize's availability must also increase yearly. However, climate change is causing feed maize yield to decline. This poses a challenge in maintaining stable maize yield. Therefore, developing adaptive maize varieties promotes climate change resilience and supports the sustainability of maize yield.

The development of maize varieties that are adaptive to climate change can be done through synthetic open-pollinated varieties. This variety development concept is considered population-based to increase horizontal resistance and tolerance. This can maintain the yield potential of maize plants in suboptimal conditions so that maize yield can still be profitable and minimize losses due to this non-optimality. The development of synthetic maize has been reported by several researchers, including (Farid *et al*., 2022), who developed a synthetic maize variety named Sinhas 1. The Sinhas 1 synthetic maize has a potential yield of 10.71 t ha-1 with an average yield of ± 7.82 t ha-1. In addition, this variety is adaptive to suboptimal conditions but still quite responsive to optimal environments, where in drought conditions, this variety has an average yield of ± 6.27 t ha^{-1}, low nitrogen stress conditions has ± 6.41 t ha^{-1}, and the combination of drought and low nitrogen stress has ± 4.75 t ha^{-1}. Farmers will generally try to optimize their growing land through fertilization even though macro-environmental conditions are less favorable for maize cultivation. Therefore, the development of fertilization on synthetic maize varieties, including the Sinhas 1 maize variety, is still needed.

Optimizing the cultivation of synthetic maize varieties, Sinhas 1, can be done with organic and non-organic fertilization approaches. Organic fertilization is a fertilization activity that involves natural concepts, both from raw materials and processes. The fertilizer can be in liquid or solid form, which also consists of the potential of microorganisms (Yessoufou *et al*., 2015; Farid *et al*., 2022). One potential type of organic fertilizer is tricho compost. This fertilizer combines Trichoderma microbes in the decomposition process of compost from organic matter. Compost is a potential organic material that can improve soil's physical, biological, and chemical properties. This is even more effective when combined with tricoderma. This combination will create a high Trichoderma population, so root growth will be more active in absorbing nutrients. In addition, an optimal population of Trichoderma can help fight other microorganisms that hurt plants. Some studies showed that the high doses in 10-20 tons per ha (Meilin *et al*., 2020; Nascimento *et al*., 2020). However, the minimum dosage ranges from 3 to 5 tons, depending on the crop (Akter *et al*., 2017; Suryani *et al*., 2023). Therefore, the combination of tricho compost needs to be optimized in cultivating Sinhas 1 maize variety.

The yield potential of a superior variety can be achieved under optimal environmental conditions so that yield potential and other exceptional characteristics contribute to increase crop yield (Nascimento *et al*., 2020). One is through an agronomic approach, namely fertilization (Meilin *et al*., 2020; Suryani *et al*., 2023). The use of high non-organic fertilizers without being balanced by the application of organic fertilizers can result in an imbalance of nutrients in soil; the soil structure becomes damaged, and the microbiology in the soil becomes little, while organic matter plays an essential role in improving the physical, chemical and biological properties of the soil (Akter *et al*., 2017; Almansoori *et al*., 2021; Sheng *et al*., 2022). The role of organic matter is huge in increasing soil fertility, increasing yield, reducing environmental pollution, and improving land quality sustainably (Saiful Abedin *et al*., 2018). The disadvantage of using organic fertilizers is that their nutrients are pretty low compared to non-organic fertilizers. This non-organic fertilizer is significant in meeting plants' nutritional needs and will impact increasing yield costs. This fertilizer is also known as chemical fertilizer.

Chemical fertilizers are another part that can support the yield of Sinhas 1 synthetic maize. Nitrogen fertilizer is the most necessary nutrient for plants than other essential nutrients. So, it is key in optimizing growth, especially cereal crops (Sah *et al*., 2020). The imbalance of nitrogen fertilizer content reduces the yield potential of cereal crops, including maize. Research related to nitrogen fertilizer is essential, especially when combined with other fertilizers, such as tricho-compost. Therefore, tricho compost and nitrogen fertilizer doses are critical to Sinhas 1 synthetic maize cultivation. This study aimed to determine the interaction of tricho compost and nitrogen fertilization dosage on the yield of the Sinhas 1 synthetic maize variety.

Materials and Method

Research Design

This research was conducted in Bajeng sub-district, Gowa Regency, South Sulawesi Province, from February to May 2023. This study was designed with a split-plot design and randomized complete block design (RCBD) as the environmental design. The main plot was tricho-compost, which consisted of three dosage levels, namely 0 t ha^{-1}, 3 t ha^{-1}, and 6 t ha^{-1}. The subplot was nitrogen dosage consisting of seven dosage levels (N0: 0 kg ha^{-1}, N1: 50 kg ha^{-1}, N2: 100 kg ha^{-1}, N3: 150 kg ha^{-1}, N4: 200 kg ha^{-1}, N5: 250 kg ha^{-1}, N6: 300 kg ha^{-1}). The combination of all treatments resulted in 21 combinations and was repeated thrice, resulting in 63 experimental units.

Research Procedure

Land preparation started with clearing the land from weeds and then plowing. The land was then made into three blocks with a size of 3 m x 5 m and a distance of 100 cm between blocks. Each variety was planted with 4 rows per row consisting of 25. Two seeds were planted in each planting hole with a 75 x 20 cm spacing. After two weeks, thinning and replanting were done in each planting hole so that each hole contained only one plant.

Maintenance activities carried out in this study include irrigation, weeding, fertilization, pest and disease control, and insect control. Fertilization was done three times using urea, SP36, and Phonska fertilizers at the age of 7 days after planting (DAP), 35 DAP, and 50 DAP. Watering was done every ten days until harvest, depending on weather conditions. Weeding was done when plants were 10 HST and 35 HST by clearing weeds around the maize plants. Hilling is done when the plants are 35 HST by raising the mounds and loosening the soil. Pest and disease control was done by spraying pesticides. Harvesting was done when the cobs reached physiological maturity (black spots at the base of the seeds) or around 100 DAP.

Data Analysis

The parameters observed were plant height (cm), number of leaves, stem diameter (cm), cob height (cm), male flowering age (days), female flowering age (days), cob weight (g), cob diameter (cm), cob length (cm), number of seeds per row, yield percentage (%) and yield (t ha^{-1}) (Anshori *et al*., 2019; Abduh *et al*., 2021; Fikri *et al*., 2023). The sample sizes observed were 10 plant samples per experimental unit. The data obtained were analyzed using analysis of variance (ANOVA) following the split-plot design. Criteria evaluation was determined systematically through Pearson correlation analysis to the yield (Anshori *et al*., 2019; Abduh *et al*., 2021). All selected criteria evaluation continued to orthogonal-polynomial analysis.

Results and Discussion

The correlation analysis of growth and yield characters is shown in Table 1. This analysis focused on yield in identifying potential evaluation criteria. Based on correlation of growth characters to yield, plant height (0.47), stem diameter (0.36), number of leaves (0.40), and cob weight (0.89) correlate significantly to yield. However, plant height and cob weight are significantly higher than stem diameter and number of leaves. Meanwhile, the characteristics of cob diameter, cob length, and 1000 seed weight have a positive correlation but are not significant. In contrast, male and female flowering age, cob height, number of seed rows, and yield negatively correlated with yield. N

Correlation analysis is generally one analysis that shows the potential relationship between one character and another. If a character positively correlates with another character, the two characters are roughly related in the same direction. Conversely, if the correlation is negative, then the relationship is contradictory. This can be an early indication in assessing or evaluating one character's relationship to another (Anshori *et al*., 2019; Abduh *et al*., 2021; Farid *et al*., 2022; Fikri *et al*., 2023). Based on this study, the

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Table 1: *The correlation analysis of ~~maize~~ Sinhas 1 maize variety on growth and yield characteristics.*

	PH	SD	NL	MFA	FFA	CH	CD	CL	NSR	CW	YP	Yield
PH	0.63											
SD	0.32	0.01										
NL	-0.14	-0.24	-0.41									
MFA	-0.14	-0.28	-0.43	0.98								
FFA	-0.33	-0.14	0.05	-0.02	-0.07							
CH	0.39	0.36	0.19	-0.64	-0.65	-0.06						
CD	0.26	0.36	0.55	-0.72	-0.78	0	0.71					
CL	0.36	0.25	0.33	-0.02	-0.1	0.28	0.3	0.4				
NSR	0.41	0.47	0.36	-0.07	-0.13	-0.19	0.04	0.23	-0.14			
CW	-0.01	-0.36	-0.07	-0.16	-0.09	0.31	0.35	-0.07	0.05	-0.5		
YP	-0.01	0.18	0.35	-0.57	-0.58	-0.3	0.51	0.7	0.08	0.12	-0.18	
Yield	**0.47** **	0.36*	0.40*	-0.14	-0.17	-0.07	0.20	0.22	-0.15	0.89**	-0.07	0.01

Notes: ***: significant at α = 1%, *: significant at α = 5%, the bold value means very significant in correlation analysis, PH: plant height, NL: number of leaves, SD: stem diameter, MFA: male flowering age, FFA: female flowering age, CH: cob height, CW: cob weight, CD: cob diameter, CL: cob length, NSR: number of seeds per row, YP: yield percentage, 1000-GW: 1000 grain weight.*

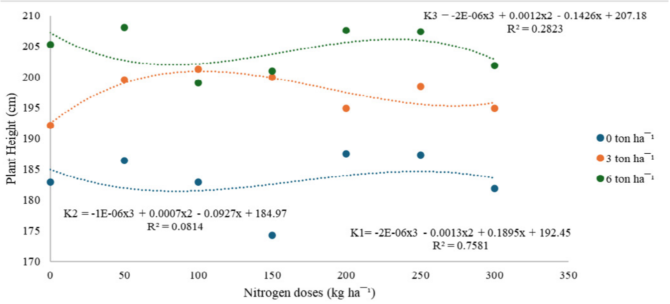

Figure 1: *Interaction of tricho compost dose and nitrogen fertilizer dose on plant height of Sinhas 1 maize variety ($K1 = 0\ t\ ha^{-1}$, $K2 = 3\ t\ ha^{-1}$, $K3 = 6\ t\ ha^{-1}$).*

correlation results showed that plant height and cob weight can be evaluation criteria representing vegetative and generative characters. Vegetative characters are represented by three characters, namely plant height, stem diameter, and number of leaves. However, when looking at the relationship between each other, the three characters are connected (Anshori *et al*., 2019; Fikri *et al*., 2023; Yunandra *et al*., 2023). This indicates that the three characters can be represented by one character only so that the plant height character can represent vegetative characters in evaluating the interaction of compost and nitrogen fertilizer application. Plant height character as an essential evaluation in maize was also reported by (Bhati *et al*., 2015; Amas *et al*., 2021). Meanwhile, generative characters can be represented singly by cob weight. In general, cob weight is a vital yield component for maize crops. This character also represents various other components such as seed weight, number of seeds per row, and number of rows. However, this character needs to be corrected with yield. However, the cob does not align with yield when looking at the correlation results. This indicates that the cob weights in this study were relatively similar between each treatment combination. This phenomenon was also reported by (Hafsah *et al*., 2020; Anwar *et al*., 2022; Abebe *et al*., 2023). Based on this, plant height and cob weight can be used to evaluate maize and yield.

Based on Figure 1, applying compost fertilizer mostly increases the potential height of maize plants. This can be seen from the graphs of 3 t ha^{-1} and 6 t ha^{-1} above the compost dose of 0 t ha^{-1} with a precise distance. The graphs for 3 t ha^{-1} and 6 t ha^{-1} showed a gap. However, the difference is not significant, even though the 6t ha^{-1} compost graph is slightly higher than the 3t ha^{-1} graph. As for the interaction pattern with nitrogen dose, the 3-ton ha^{-1} dose showed a clear pattern in describing the interaction between Trichoderma and nitrogen fertilizer. This indicates that 0-ton ha^{-1} and 6-ton ha^{-1} compost fertilizers do not have a specific interaction pattern or are random in explaining the height of Sinhas 1 maize plants, especially when interacting with nitrogen fertilizer.

Based on Figures 2 and 3, the application of tricho compost fertilizer at a dose of 6 t ha^{-1} has a graph of weight per cob and yield, which is always above compared to other doses of tricho-compost. However, when analyzing the interaction pattern with nitrogen fertilizer, tricho compost fertilizer at a dose of 3 t ha^{-1} has a more substantial model than other doses of tricho compost fertilizer on both characters. A dose of 3 t ha-1 has a determination value of more than 0.75 from both graphs, so the model of compost fertilizer at a dose of 3 t ha^{-1} can be analyzed further. Based on further analysis, the optimal point of nitrogen dose in supporting the weight per cob and the yield in the 3-ton ha^{-1} tricho compost fertilizer model is 150 kg ha^{-1}.

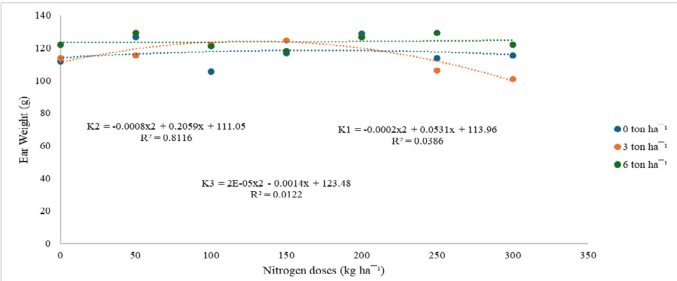

Figure 2: *Interaction of tricho compost dose and nitrogen fertilizer dose on cob weight of Sinhas 1 maize variety.*

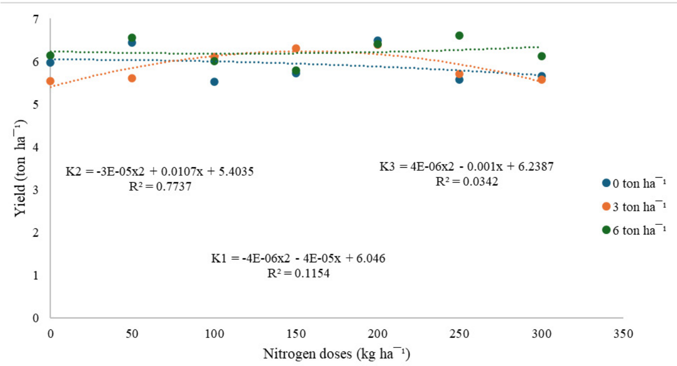

Figure 3: *Interaction analysis of tricho compost dose and nitrogen fertilizer dose on the Sinhas 1 maize variety yield.*

The effect of tricho compost dosage on plant height of the Sinhas 1 maize variety is closely related to its role in improving soil conditions and providing nutrients. Tricho compost is an organic fertilizer enriched with microorganisms that can increase the decomposition of organic matter and provide macro and micronutrients (Fadhli *et al*., 2020; García-Martínez *et al*., 2020a; Padjung *et al*., 2020; Ranjan *et al*., 2020). Tricho compost also improves soil structure, increases cation exchange capacity (CEC), and provides growth hormones such as auxins that support root system development. Nitrogen fertilizers play a key role in supporting plant vegetative growth. According to Kuswanto *et al*. (2013) and Yuan *et al*. (2016) as an essential element, nitrogen is required for chlorophyll synthesis and vital for photosynthesis. In addition to supporting optimal growth, this combination reduces dependence on non-organic nitrogen fertilizers, thus supporting sustainable agricultural practices.

The interaction analysis on plant height, cob weight, and yield showed that 3 t ha^{-1} of tricho compost was the best dose. This is reflected in all characters' high model determination values (Li *et al*., 2018; Lin *et al*., 2019; Mengesha *et al*., 2019; Alimuddin *et al*., 2020; Resmi, 2022). The high determination value reflects a model's accuracy, so the dose of tricho compost 3 t ha^{-1} is the most effective model for the growth and yield of Sinhas 1 maize. In addition, economically, the comparison gap is not too far. It also strengthens the allegation of the effectiveness of the dose of 3 t ha^{-1} as the optimal dose for Sinhas 1 maize cultivation. The interaction of the dose of 3 t ha^{-1} tricho compost with the dose of nitrogen, 150 kg ha^{-1}, is the best. According to García-Martínez *et al*. (2020a) and Jiang *et al*. (2022), this dose is determined following the general concept of fertilization, including nitrogen. The 3-ton ha^{-1} tricho compost fertilizer dose showed a quadratic polynomial graph of the character of cob weight and yield so that the optimum point of nitrogen dose can be determined for both characters. Moreover, both characters have a significant correlation between them, which means the optimum point of nitrogen dosage, especially for generative characters, is more easily determined (Amas *et al*., 2021; Fikri *et al*., 2023). As for vegetative characters, a tricho compost fertilizer dose of 3 t ha^{-1} is also considered to have good potential. However, this point is not the peak point of the character. Based on these results, a tricho compost fertilization dose of 3 t ha^{-1} and a nitrogen fertilizer dose of 300 kg ha^{-1} can be recommended to cultivate Sinhas 1 synthetic maize.

Conclusions and Recommendations

This study showed that plant height and cob weight could be used as evaluation criteria to assist with the yield. Based on tricho compost fertilizer, a dose of 3 t ha^{-1} is optimal for the growth and yield of Sinhas synthetic maize. Based on the tricho compost dose, the interaction with the nitrogen fertilizer dose of 150 kg ha^{-1} optimally induced the growth and yield of Sinhas 1 synthetic maize. However, this potential must be tested against several environments to see the potential for environmental interactions. However, combining a tricho compost fertilizer dose of 3ton ha^{-1} and a nitrogen fertilizer dose of 150 kg ha^{-1} can be recommended to cultivate Sinhas 1 synthetic maize.

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Novelty statement

This study provided new insights into the optimal interaction between tricho compost and nitrogen fertilizer in improving the growth and yield of Sinhas 1 synthetic maize. The results identified that the interaction of fertilizer dose of 3 t ha-^{1} tricho compost and 150 kg ha-^{1} nitrogen as the optimal combination forms a practical fertilization strategy, particularly for maize cultivation in Gowa District. These findings contribute to the advancement of sustainable maize production by integrating organic and inorganic nutrient management.

Author's contribution

Abd. Rahman Arinong: Conceptualization, formal analysis, methodology, investigation, data curation, writing—original draft preparation
Rusnadi Padjung: Conceptualization, validation, methodology, resources, funding acquisition, writing—review and editing, supervision
Muh. Farid: Conceptualization, formal analysis, methodology, resources, writing—review and editing, supervision
Burhanudin Rasyid: Conceptualization, validation, methodology, writing—review and editing, supervision
Nirwansyah Amier: Investigation, software, visualization
Muhammad Fuad Anshori: Formal analysis, validation, data curation, software, writing—review and editing

Conflict of interest
The authors declare there is no conflict of interest

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