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Response differences of two maize hybrid varieties to the application of bioagent-ameliorant and chicken manure in fertile soil

Abstract. To ensure adequate nutrition for the growth of maize (*Zea mays* L.) in sustainable agriculture, it is necessary to apply bio-agent soil conditioner and manure. This study aims to determine the effect of doses of bioagent-ameliorant and chicken manure on growth and yield components. The research was conducted in highland with an altitude 800 m above sea level. This study used an experimental method with two sets of experiments, namely experiments using one and two-cobs maize cultivars. The experiment used a randomized block design (RBD) with two treatment factors and three replications. The first treatment factor was the dose of bioagent ameliorant, which consisted of 3 levels, namely 0, 7.5, and 15 kg/ha, while the second factor was the dose of chicken manure, which consisted of 3 levels, namely 0.5 and 10 tons/ha. The observed growth components were plant height and number of leaves, while the yield components observed were cob length, cob diameter, cob weight per plant, and cob weight per plot. In research on two-cob maize experiment, there was no interaction effect between doses of soil conditioner and chicken manure, while the interaction effect on plant height occurred in one-cob maize experiment. The single effect of ameliorant doses could not increase all components of growth and yield, both in one and two-cob maize cultivars. The single effect of doses of chicken manure increased number of leaves, cob length, cob weight per plant, and cob weight per plot in one-cob maize cultivar, while increased plant height in two-cob maize cultivar.

Keywords: Fertilizer efficiency · Maize · Soil quality · Sustainable agriculture

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Introduction

Maize or corn (*Zea mays* L.) is one of the staple food crop in Indonesia. Consumption of corn kernels in Indonesia was 14.37 million tons in 2021, most of which are used for the food and feed industry, while production was 15.79 million tons (Catriana, 2021) to supply this corn consumption. However, sustainable corn production must be carried to supply further consumption (Suwarto & Prihantoro, 2020).

To guarantee sustainable maize production, plants must absorb sufficient nutrients from the soil through the application of fertilizers. Synthetic fertilizers are often used by farmers which decrease soil quality (Tale & Ingole, 2015). A way to restore soil quality is to provide ameliorant with biological agents, including compost, biochar, dolomite, and humic acid, which are added with the biological agent *Bacillus* sp. and *Pseudomonas* sp. (Li et al., 2020; Chaudhary et al., 2022; Wei et al., 2020).

Compost has been known through previous studies to improve soil structure and increase the availability of nutrients in the soil (Scotti et al., 2016). Biochar can increase cation exchange capacity (CEC) and soil moisture, thereby increasing fertilization efficiency (Agegnehu et al., 2017). Dolomite is a soil enhancer to increases soil pH, while humic acid can increase CEC and stimulate the activity of microorganisms that produce plant growth hormones (Shaaban et al., 2015; Ampong et al., 2022). Biological agent *Bacillus* sp. make nitrogen fixation from the air to other forms of nitrogen so it can be absorbed by plants (Yousuf et al., 2017). On the other hand, *Pseudomonas* sp. can convert phosphorus into an available form that can be absorbed by plants (Liu et al., 2019).

The effectiveness of existing biological agents in soil ameliorant can be increased through the application of manure, such as chicken manure. Manure is known to increase the organic matter content needed for the growth and development of beneficial microbes in ameliorant (Liu et al., 2013; Singh et al., 2020). In addition, manure can also increase soil fertility, increase CEC and improve soil structure (Singh et al., 2020).

Research on the application of bioagent-ameliorant and chicken manure needs to be carried out to maintain or increase maize production in a sustainable agriculture. Research needs to be conducted on two hybrid corn cultivars that are widely cultivated in Indonesia, namely one and two-cob corn cultivars (Subagio & Aqil, 2013).

Materials and Methods

The research was conducted in Margahurip Village, Banjaran District, Bandung Regency, West Java Province. The altitude of the study site is ±800 m above sea level, the average rainfall is 2,598.4 mm/year and it is included in the C3 agro-climatological zone based on the Oldeman climate classification. The research site has soil with a pH of 6.8 (neutral), 2.07% C-organic content (moderate), 0.18% N (moderate), C/N ratio 11 (low), available P_2O_5 53.2 ppm (very high), Ca 11.23 me/100 g (high), Mg 2.59 me/100 g (high), K 0.33 me/100 g (moderate), Na 0.23 me/100 g (low), CEC 18.02 me/100 g (moderate) and base saturation (BS) 80% (high). The experiment was carried out from August to November 2022.

The materials used in this study were one-cob maize cultivar (cv. NK 7328 Sumo), two-cob maize cultivar (cv. Bisi-2), ameliorant (consisted of 40% compost, 20% biochar, 20% dolomite, 5% humic acid, 3% bacteria *Bacillus* sp. and *Pseudomonas* sp. and 12% other ingredients), chicken manure (contains C-organic 17.56%, C/N ratio 13.6, N 1.29%, P_2O_5 1 .27%, K2O 3.99% and moisture 6.41%), urea fertilizer, NPK 15:15:15 fertilizer, emamectin benzoate and Iufenuron insecticides, Dimetomorphic fungicides, Difenoconazole fungicides, and atrazine and mesotrion herbicides. The tools used are tape measure, calipers, digital scales, and cultivation equipment.

This study used experimental method with two sets of experiments, namely experiments using one and two-cobs maize cultivars. The experiment used a randomized block design (RBD) with two treatment factors and three replications. The first treatment factor was the dose of bioagent-ameliorant, which consisted of 3 levels, namely 0, 7.5, and 15 kg/ha, while the second factor was the dose of chicken manure, which consisted of 3 levels, namely 0, 5, and 10 tons/ha.

The plot size was 160 cm x 500 cm and the number of plots was 27. Plants were planted with a spacing of 20 cm x 80 cm, so that there is a population of 50 plants for each plot. Samples used 8 plants for each plot. The distance

between plots was 30 cm and the distance between replications was 50 cm.

Observations were made on the growth and yield components. Growth components were plant height and number of leaves, while the yield components observed were cob length, cob diameter, cob weight per plant and cob weight per plot. Plant height was measured from the base of the stem to the tip of the leaf using a tape measure at 49 days after sowing (DAS). The number of leaves was counted at the age of 49 DAS. Cob length, cob diameter, cob weight per plant and cob weight per plot were measured after the cobs were dried. The length of the cob was measured using a tape measure, while the diameter of the cob was measured using a caliper. Cob weight per plant and cob weight per plot were measured using digital scale.

Statistical analysis was performed using ANOVA at 5% significance level to determine whether there were factors that made a difference. Furthermore, data analysis was performed using Duncan's multiple range test at 5% significance level to determine the difference between treatment levels (Gaspersz, 1995).

Land preparation begins with clearing the land using herbicides, then plowing. Chicken manure was given a week before planting, while bioagent-ameliorant was given 3 days before planting. Ameliorant was given according to the treatment dose, previously dissolved in 1 liter of water and stirred until it looks homogeneous. A maize seed was planted in a planting hole with a depth of 3-5 cm. Watering was done when there was no rain. Weeding and hilling were carried out at 15, 29, and 43 DAS. Urea fertilizer 200 kg/ha and NPK fertilizer 300 kg/ha were applied at 21 hst and 40 hst. Control of pests and diseases used insecticides and fungicides. Corn harvest was done at 105 DAS by hand picking, then removing the corn husks and silk and drying to 14% seed moisture content.

Results and Discussion

Results. In the study of two-cob maize cultivars, there was no interaction effect between the dose of soil conditioner and the dose of chicken manure, both on the growth and yield components of the plant. The single effect of soil ameliorant doses could not increase all growth and yield components, while the single effect of chicken manure doses increased plant height at doses of 5 and 10 tons/ha, but could not increase the number of leaves and all yield components (Table 1 and 2).

Table 1. The single effect of ameliorant and chicken manure doses on the growth components of two-cobs corn

Treatment	Plant Height (cm)	Number of Leaves
Ameliorant dose		
0 kg/Ha	155.58 a	12.06 a
7.5 kgs/Ha	154.53 a	12.08 a
15 kgs/Ha	156.75 a	12.22 a
Chicken manure dose		
0 Ton/Ha	150.81 a	12.31 a
5 Tons/Ha	155.78 b	12.06 a
10 Tons/Ha	160.28 c	12.00 a

Note: The average number marked with the same letter in the same column was not different according to Duncan's Multiple Range Test at 5% significance level.

Table 2. The single effect of ameliorant and chicken manure doses on the yield components of two-cobs corn

Treatment	L (cm)	D (cm)	W/p (g)	W/u (g)
Ameliorant dose				
0 kg/Ha	18.00 a	3.84 a	279.97 a	13.42 a
7.5 kgs/Ha	18.11 a	3.82 a	282.25 a	13.72 a
15 kgs/Ha	18.22 a	3.85 a	283.39 a	13.83 a
Chicken manure dose				
0 Ton/Ha	17.88 a	3.85 ab	290.42 a	13.37 a
5 Tons/Ha	18.13 a	3.77 a	277.31 a	13.56 a
10 Tons/Ha	18.33 a	3.88 b	277.89 a	14.06 a

Note: L was cob length, D was cob diameter, W/p was cob weight per plant, W/u was cob weight per plot. The average number marked with the same letter in the same column was not different according to Duncan's Multiple Range Test at 5% significance level.

In a study of one-cob maize cultivars, an interaction effect was found between the dose of ameliorant and the dose of chicken manure on plant height (Table 3). Increasing the dose of ameliorant up to 15 kg/ha without manure increased plant height, but increasing the dose of ameliorant on plots with manure of 5 and 10 tons/ha gave the same height. The single effect of ameliorant did not improve the number of leaves or all yield components. The single effect of chicken manure increased the number of leaves, cob length, cob weight per plant and cob

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weight per plot (Table 4 and 5). The best dose of chicken manure for number of leaves was 10 tons/ha, but not different from 5 tons/ha, while the best dose of chicken manure for cob length, cob weight per plant and cob weight per plot was 10 tons/ha.

Table 3. The single effect of ameliorant and chicken manure doses on the plant height of one-cob corn

Chicken manure dose	Ameliorant dose		
	0 kg/ha	7.5 kgs/ha	15 kgs/ha
0 ton/ha	106.67 a A	122.92 a B	122.08 a B
5 tons/ha	125.83 b A	122.50 a A	124.17 a A
10 tons/ha	128.75 b A	127.92 a A	129.58 a A

Note: The average number marked with the same capital letter (horizontal direction) or lowercase letter (vertical direction) was not different according to Duncan's Multiple Range Test at 5% significance level.

Table 4. The single effect of ameliorant and chicken manure doses on number of leaves of one-cob corn

Treatment	Number of Leaves
Ameliorant dose	
0 kg/Ha	12.83 a
7.5 kgs/Ha	13.03 a
15 kgs/Ha	13.22 a
Chicken manure dose	
0 Ton/Ha	12.53 a
5 Tons/Ha	13.11 b
10 Tons/Ha	13.44 b

Note: The average number marked with the same letter in the same column was not different according to Duncan's Multiple Range Test at 5% significance level.

Discussion. There was no interaction effect between bioagent-ameliorant and manure on most of the observations because the ameliorant could not increase growth or yield. This can also be seen in the single effect of ameliorant which did not make a difference in plant growth or yield. This situation was due to the fertile soil at the research site, where the criteria were neutral pH, moderate CEC, high BS, moderate organic-C content, moderate N content, very high available P content, moderate K content and high Ca and Mg content (Soil Research Institute, 2009).

Table 5. The single effect of ameliorant and chicken manure doses on the yield components of one-cob corn

Treatment	L (cm)	D (cm)	W/p (g)	W/u (g)
Ameliorant dose				
0 kg/Ha	19.36 a	5.01 a	285.78 a	13.94 a
7.5 kgs/Ha	19.22 a	5.08 a	291.53 a	14.12 a
15 kgs/Ha	19.53 a	5.05 a	286.31 a	14.28 a
Chicken manure dose				
0 Ton/Ha	19.11 a	4.98 a	278.67 a	13.79 a
5 Tons/Ha	19.22 a	5.05 a	285.19 ab	14.17 ab
10 Tons/Ha	19.69 b	5.11 a	299.75 b	14.39 b

Note: L was cob length, D was cob diameter, W/p was cob weight per plant, W/u was cob weight per plot. The average number marked with the same letter in the same column was not different according to Duncan's Multiple Range Test at 5% significance level.

Dolomite in ameliorant could not significantly increase soil pH which has neutral criteria (Rastija et al., 2014). Dolomite containing Ca and Mg also had no effect, because the soil contains high Ca and Mg, so it cannot play a role as it does where the content of Ca and Mg is low (Higgins et al., 2012; Soratto & Crusciol, 2008). Compost and biochar which function to increase CEC also have no effect on good soil CEC (Mautuka et al., 2022). Nitrogenase on *Bacillus* sp. did not make nitrogen fixation in quite high soil N content (Ayuni et al., 2015). Bacteria *Pseudomonas* sp. which functions to provide the available form of P did not work in very high available P content (Zabihi et al., 2011).

In contrast to most of the observations, there was an interaction effect that occurs between ameliorant and manure on plant height. Manure only enhanced plant growth when there was no application of ameliorant. This can happened because manure has same effects as bioagent-ameliorant, such as improving soil structure, increasing soil CEC, increasing soil fertility, and improving the environment for the growth of microorganisms (Singh et al., 2020).

Chicken manure could significantly increase several components of growth and yield of maize. This could occur due to improvements in soil structure, addition of soil CEC, increasing soil fertility, and additional nutrients for microorganism due to manure application (Bayu et al., 2005). On the other hand, the increase in growth and yield of maize due to the application of chicken manure occurred more in one-cob maize than with two-cobs. This situation is

interesting, but further studies are needed to discuss it. Unfortunately, the interaction that occurs between two treatments on plant height of one-cob maize may be revealed if it supported by data on nutrient uptake. Besides, this experiment proved that fertile soils does not need any treatment to maintain its quality.

Conclusion

In the two-cobs maize cultivar, there was no interaction effect between the dose of ameliorant and chicken manure on growth and yield components, while the interaction effect between the dose of ameliorant and chicken manure on plant height occurred in the one-cobs maize cultivar. The single effect of soil conditioner doses could not increase all growth components and yield components, both in research on two and one cob maize cultivars, except number of leaves in one-cob cultivar. The single effect of chicken manure dose increased plant height in two-cobs maize cultivar, while increasing the number of leaves, cob length, cob weight per plant and cob weight per plot in one-cob cultivar.

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