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Chicken Manure and KCL Effect on Growth and Yield of Sweet Corn in Ultisol

Hasanudin[1], Nanik Setyowati[2], Artita Pestaria Manurung[3], Zainal Muktamar[4]
[1,3,4] Department of Soil Science, Faculty of Agriculture, University of Bengkulu, Indonesia
[2]Department of Crop Production, Faculty of Agriculture, University of Bengkulu, Indonesia

ABSTRACT: Cultivation of sweet corn in Ultisols faces problems due to the poor quality of the soil. As a result, it is necessary to improve soil fertility through fertilization. Chicken manure can improve the fertility of Ultisol. However, it is a prolonged-release fertilizer, so it should be applied in conjunction with readily available fertilizers to plants, such as KCl. This study aimed to determine the effect of the dose of chicken manure and KCl on the growth and yield of sweet corn. The study was carried out between April and June 2019 in Medan Baru, Kandang Limun Village, Bengkulu, Indonesia. The experiment was arranged in a Randomized Complete Block Design (RCBD) with two factors. The first factor was the dose of chicken manure (20% moisture content), consisting of 3 levels, namely 0, 10, and 20 tons/ha. The second factor was the dose of KCl, which consists of 3 levels, namely 100, 150, and 200 kg/ha. The result indicated no interaction effect of chicken manure and KCl on sweet corn growth and yield. Likewise, sweet corn growth was affected by chicken manure. At a 10 t/ha dose, chicken manure increased plant height, shoot fresh and shoot dry weight. A 150 kg/ha of KCl resulted in higher plant height, shoot fresh weight, and unhusked cob weight than a 100 kg/ha.

KEYWORDS: Chicken Manure, KCL, Sweet Corn, Ultisol.

INTRODUCTION

The agricultural extension program in Indonesia is one of the efforts to increase sweet corn production. However, due to the scarcity of productive agricultural land, the agricultural expansion program needs to use the sub-optimal land area to meet sweet corn demands. The sub-optimal land available for the development of sweet corn cultivation is the land dominated by Ultisols. Even though Ultisols land is available for sweet corn cultivation, the soil has substantial obstacles. The problem with Ultisols are the low nutrient content and soil organic matter content (0.67-1.57 %), acidic to very acidic (pH 3.1 – 5.5), and high aluminum saturation (37-60%) [1] [2].

Improving soil fertility can be accomplished by applying a balanced fertilizer containing organic and synthetic fertilizers [3]. Organic matter addition aims to improve the physical, chemical, and biological properties of the soil and can provide macronutrients. Synthetic fertilizers are those made by industry or factories, whereas organic fertilizers are made from natural materials, such as plant or animal waste [4].

Chicken manure is one of the organic materials capable of improving Ultisols' properties and increasing sweet corn growth and yield. Manure treatment can raise soil pH, stimulate microorganism activity, and release organic compounds such as malic, citric, tartaric acids, and humic acid, which bind Al to form Al-organo complex [5]. According to [6], applying 15 tons/ha of chicken manure raised soil pH (H_2O and KCl), available P, and soil organic C while lowering exchangeable-Al. In addition, [7] reported that the application of chicken manure could increase plant height, cob diameter, tasseling, ear emergence, husked cob weight, unhusked cob weight, and shoot dry weight. Applying different dosages of chicken manure to acid soils could increase soil fertility and improve the soil's physical, chemical, and biological properties. A combination of manure and synthetic fertilizers such as urea, TSP, KCl, and other nutrients can meet plant growth and yield requirements.

Potassium is essential in photosynthesis and has a direct effect on plant growth. Furthermore, potassium can improve carbon dioxide (CO_2) intake [8]. The deficiency of K in plants brought about low formation of sweet corn cob [9]. Potassium is necessary for the production of carbohydrates and enzyme activity, therefore increasing the size and weight of seeds [10] [11]. According to [12], applying KCl fertilizer at a 150 kg/ha rate resulted in the highest sweet corn plant height, root dry weight, and shoot dry weight compared to other treatments.

Fertilizer should be applied at the appropriate dosage for optimal crop production. Therefore, potassium fertilizer should be applied at the proper dose to achieve productivity. Excessive potassium fertilizer application will harm plant growth. According to [13], KCl fertilizer comprises 60-63 % K_2O and provides Cl as a micronutrient. However, a concentration of Cl greater than 0.1 % will poison the plant, while more than 0.1% can harm plants, causing them to wither and deceased.

As a source of food, feed, and industrial raw materials, sweet corn has become one of Indonesia's most important food crops. Extending the harvest area is a way of increasing sweet corn production. Ultisols are one of Indonesia's dominant soil orders, approximately 25% of the Indonesian mainland. This expansive area is the potential for increased sweet corn production, but the low fertility of such soil is the main obstacle to sweet corn production, so fertilization is necessary. The application of chicken manure has the potential to improve Ultisol's fertility. However, due to its slow release of plant nutrients, the combination with synthetic fertilizers such as KCl is required to assure good productivity of sweet corn. A proper dose of fertilizer is significant for the cultivation; otherwise, it will lower productivity. This study aimed to determine the best dose of chicken manure and KCl for the growth and yield of sweet corn.

MATERIALS AND METHODS

Experimental Site and Design

The study was conducted in Ultisols, located in Medan Baru, Kandang Limun District, Bengkulu, Indonesia, from April to June 2019. The experiment was arranged in a Completely Randomized Block Design (RCBD) with two factors. The first factor was the dose of chicken manure (20% moisture content) which consists of 3 levels, namely 0 (control), 10, and 20 tons/ha. The second factor was the KCl fertilizer dose, consisting of three levels: 100, 150, and 200 kg/ha. Furthermore, 9 treatment combinations were obtained from these two factors, and each was repeated three times.

Soil Analyses

The soil sample was collected using the zigzag method at five different positions to represent the overall condition of the land. The soil was sample at a depth of 0-20 cm. The sample from each position was then placed in a bucket and homogeneously mixed. 0.5 kg of well-mixed soil was air-dried, sieved with a 0.5 mm screen and analyzed for soil pH, CEC, total-N, P, K, and organic-C.

Land Preparation

The land was clean, plowed to the depth of 20 cm and divided into 27 plots with 2.8 m x 3.2 m (l x w). The plot size was 70 cm x 40 cm (l x w). The experimental plots were treated with chicken manure and KCl based on the treatment dose. Chicken manure was evenly mixed at 0-10 cm a week before planting. KCl was applied at planting according to the treatments. The basal fertilizer was urea at a 300 kg/ha rate, SP-36 at 200 kg/ha [14]. The fertilizer was applied 10 cm away from the plant using the planting hole method. Urea was applied twice, 1/3 portion applied at planting, and 2/3 portion applied 30 days after planting, whereas P fertilizer was applied at planting [15].

Plant Cultivation

Two sweet corn seeds were sown in each planting hole with a 3-5 cm depth. Each planting hole was treated with carbofuran to prevent pest attack. The sweet corn variety used in this experiment was Bonanza. Five plants were randomly selected in the middle row, without any plant samples from the border row.

The plant was watered regularly to keep the soil moist during the study. Weeding was performed weekly until for weeks after planting. Thinning was conducted two weeks after planting, leaving the healthier plant. At 4 WAP, the soil was hoarded to control weeds and ensure the plants from falling. Sweet corn was harvested seventy days after planting, indicated by the cob's dark brown and dry hairs.

Variables observed in this study included plant height (cm), stem diameter (cm), leaf number, length of unhusked cob (cm), the diameter of unhusked cob (cm), unhusked cob weight g), and shoot fresh weight (g) and shoot dry weight (g). Initial characteristics of soil included N (%), P (ppm), K (me/100g), organic-C (%), and pH, while chicken manure was analyzed for N (%), P (%), K (%), and organic-C (%). Climate data included rainfall (mm), air temperature (°C), and humidity (%).

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Data Analysis

The data were analyzed using analysis of variance at the 5% level. Treatment means were separated using DMRT at a 5% level.

RESULTS AND DISCUSSION

The initial characteristics of the soil showed that soil contained 0.34 % total-N (moderate), 5.50 ppm available P (low), 0.210 me/100 g exchangeable K (low), 3.48 % organic-C (high), and pH H_2O of 5.02 (acid). Meanwhile, chicken manure had 1.47% N, 0.71% P, 0.63% K, 9.98% organic-C, pH of 7.84. These characteristics indicated that the soil had rather low fertility.

Analysis of Variance

The data were analyzed using Analysis of Variance (ANOVA at the 5% level. The effect of chicken manure and KCl on observed variables and their interactions are presented in Table 1.

Table 1. Summary of variance analysis.

Variables	F-calculated			CV
	Chicken manure	KCl	Interaction	(%)
Plant height	15.03*	10.67*	0.13 ^{ns}	2.86
Stem diameter	1.71 ^{ns}	2.78 ^{ns}	2.24 ^{ns}	3.54
Leaf number	0.12 ^{ns}	0.21 ^{ns}	1.03 ^{ns}	2.78
Shoot fresh weight	3.85*	5.25*	2.36 ^{ns}	4.51
Shoot dry weight	4.37*	2.15 ^{ns}	0.85 ^{ns}	8.07
Unhusked cob weight	2.93 ^{ns}	5.64*	1.45 ^{ns}	6.37
Unhusked cob length	2.74 ^{ns}	2.09 ^{ns}	2.89 ^{ns}	5.93
Unhusked cob diameter	0.67 ^{ns}	3.15 ^{ns}	1.43 ^{ns}	3.41

Note: *=significantly different, ^{ns}=non significantly different, CV = Coefficient Variation

The variance analysis shows that chicken manure significantly affected plant height, fresh plant weight, and shoot dry weight. In contrast, KCl fertilizer significantly affected plant height, shoot fresh weight, and unhusked cob weight. There was no interaction between chicken manure and KCl on all observed variables (Table 1).

Effect of Chicken Manure on Sweet Corn Growth and Yield

The application of chicken manure significantly affected plant height, fresh weight, and dry weight but did not affect stem diameter and the number of leaves (Table 1). Chicken manure yielded stem diameter and leaf number greater than the control treatment.

The effect of chicken manure on sweet corn growth is presented in Table 2

Table 2. Effect of chicken manure on sweet corn growth

Chicken manure dose (t/ha)	PH (cm)	SD (cm)	LN	SFW (g)	SDW (g)
0	156.99 b	1.75	10.47	415.27 b	225.42 b
10	168.06 a	1.79	10.53	451.76 a	252.13 a
20	166.85 a	1.80	10.49	440.20 a	241.92 a

Note: the numbers followed by the same letter in the same column are not significantly different at the 5% level DMRT test, PH= plant height, SD= stem diameter, LN= leaf number, SFW= shoot fresh weight, SDW= shoot dry weight.

Plant height

The application of chicken manure significantly increased plant height. At 10 and 20 t/ha doses, the plant height was higher than the control (Table 1). This result might have been associated with that chicken manure provides nutrients for the growth of

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sweet corn. According to [16], adequate nutrient content in the soil leads to good vegetative growth of sweet corn. Nutrient-deficient plants grow slowly and have low yields [17]. Also, [18] reported that an excess of one nutrient could influence the availability of other nutrients. According to [19] the inappropriate application of chicken manure is ineffective because it restricts plants from absorbing the applied nutrients. The findings of this study are similar to the results of [20], who reported that applying goat manure can increase the height of sweet corn plants.

Chicken manure can improve soil's physical qualities such as permeability, porosity, structure, and water holding capacity. Another study indicated that chicken manure could improve soil structure and cation exchange capacity, leading to better root growth. Chicken manure contains nutrients supporting growth.

Shoot fresh weight

Similar fashion to plant height, application of chicken manure increaseed shoot fresh weight (Table 1). The application of chicken manure enhances nutrient absorption, improving plant growth; as a result, an increase in plant weight. The chicken manure contained 0.34% N and, upon decomposition, will release nitrogen into the soil. The plant will absorb released N. Higher nutrient uptake by plants will increase fresh plant weight. [21] reported that chicken manure could improve soil fertility because it decomposed and released complete nutrients (macro and micro). The decomposition of manure by soil microbes improved soil structure, allowing nutrients in the soil to be available and easily absorbed by plants. In addition, [22] stated that chicken manure could improve soil structure and strengthen plant roots. According to [23], organic matter in chicken manure can serve as a nutrient supply to the soil while also increasing water retention as soil water content increases. Organic acids are formed during organic matter decomposition. Anions from organic acids can shift the phosphate bound by Fe and Al, freeing the phosphate and making it available to plants.

Shoot dry weight

The increase in fresh shoot weight was followed by the increase in shoot dry weight, mainly at sweet corn fertilized at doses of 10 and 20 tons/ha. Taller plants yielded greater fresh and dry weights (Table 1). The taller the sweet corn plant will have more leaves. The more leaves there are, the more active the photosynthesis process is, and thus the supply of nutrients increases. This study's findings are in accordance with those of [24], who reported that an increase in plant height was followed by an increasing number of leaves on sweet corn. As a result, the shoot dry weight also increases. The number of leaves substantially impacts the number of nutrients available to plants through photosynthesis [20]. Furthermore, the greater the ability of the roots to absorb nutrients, the more significant the amount of nutrients obtained by plants.

Plant fresh and dry weights were greater in chicken manure applications of 10 tons/ha and 20 tons/ha than in control plants. This result might be related to that chicken manure increased soil pH, organic C, and nutrients required by plants for growth, leading to increased shoot dry weight. This result is similar to that reported by [25]. Applying chicken manure resulted in a higher shoot dry weight than other organic materials because chicken manure decomposed more quickly, allowing it to release nutrients for plant growth more quickly.

Yield Components

There was no significant effect of chicken manure application on unhusked cob weight, length, and diameter (Table 1). The application of chicken manure, on the other hand, tended to increase the weight, length, and diameter of the unhusked cob. The higher dose of chicken manure tended to have the cob's greater weight and diameter. Table 3 shows the unhusked cob weight, length, and diameter.

Table 3. Effect of chicken manure on sweet corn yield

Chicken manure dosage (t/ha)	Unhusked cob weight (g)	Unhusked cob length (g)	Unhusked cob diameter (cm)
0	187.27	16.47	4.00
10	198.04	17.35	4.02
20	200.69	17.51	4.07

The potential of chicken manure to increase the weight and diameter of the cobs is related to both the providing of nutrients for plants and the improvement of the chemical, physical, and biological properties of the soil. Chicken manure contains both macro and micronutrients. The application of chicken manure improves soil fertility and serves as a substrate for soil microorganisms. As a result, microbial activity increases, and the decomposition process accelerates.

Although chicken manure increased plant height and weight, it did not lead to a considerable increase in cob weight and diameter. The manure analysis showed that the N content was 1.47%, P was 0.71%, and K was 0.63%. Nutrient release of the manure might not be sufficient for the entire stage of sweet corn growth, especially in the generative period and during the filling of the cobs. Thus, the manure application did not significantly increase the yield component. This yield falls short of the potential sweet corn yield. The results showed that the unhusked cob weight ranged between 187.27 and 200.69 g, the unhusked cob length ranged between 16.47 and 17.51 cm, and the unhusked cob diameter ranged between 4.00 and 4.07 cm, while those of its potential was 300 – 325 g, 20 – 22 cm, and 5.3 – 5.5 cm, respectively.

Effect of KCl on Sweet Corn Growth and Yield

Plant Growth Components

The application of KCl fertilizer had a significant effect only on plant height and shoot fresh weight (Table 1). This is because KCl fertilizers at doses of up to 200 kg/ha were inadequate to meet the plant's needs. Laboratory analysis revealed that the initial soil's K content was only 0.21 me/100 (low). However, the average results showed that the application of KCl fertilizer tended to increase stem diameter, number of leaves, and leaf dry weight. The increase in KCl dose was accompanied by an increase in stem diameter, leaf number, and shoot dry weight. Table 4 shows the study results on the effect of chicken manure on stem diameter and leaf number.

Table 4. Effect of KCl fertilizer on sweet corn growth

KCl dosage (kg/ha)	PH (cm)	SD (cm)	LN	SFW (g)	SDW (g)
100	159.89 b	1.74	10.46	414.14 b	231.67
150	162.30 a	1.79	10.49	429.34 a	237.60
200	169.71 a	1.80	10.54	443.73 a	250.20

Note: the numbers followed by the same letter in the same column are not significantly different at the 5% level DMRT test, PH= plant height, SD= stem diameter, LN= leaf number, SFW= shoot fresh weight, SDW=shoot dry weight.

Plant height

The application of KCl fertilizer at a 200 kg/ha dose resulted in the highest plant height; however, it was not significantly different from a 150 kg/ha dose. The lowest plant height resulted from KCl treatment at a dose of 100 kg/ha. These results indicate that applying 200 kg/ha of KCl fertilizer will increase the supply of K to plants so that plant height increases. According to [12], the application of KCl was also able to increase the height of sweet corn.

Shoot fresh weight

Applying KCl at a 200 kg/ha dose also resulted in a higher shoot fresh weight. The lowest shoot fresh weight was obtained at 100 kg KCl/ha (414.14 g). As a result, increasing the dose of KCl will increase the supply of K to plants, allowing the fresh shoot weight to increase. Potassium (K) plays a role in plant growth, for example, by accelerating the translocation of carbohydrates from leaves to plant organs [13]

The high shoot fresh weight at 200 kg/ha KCl was partly attributed to the plants fertilized at that level having higher plants than the other treatments. The taller the plant and the number of leaves resulted, the faster the photosynthesis process and the higher shoot fresh weight. According to [20], the number of leaves correlates to plant nutrient availability through photosynthesis. The better the plant growth, the greater the ability of the roots to absorb nutrients, and so the amount of nutrients absorbed by the plant increases.

Yield Components

The use of KCl had a significant effect on fresh shoot weight and unhusked cob weight but did not affect dry shoot weight, unhusked cob length, and unhusked cob diameter (Table 1). Table 5 shows the effect of KCl on the weight of the unhusked cob, the length of the unhusked cob, and the diameter of the unhusked cob.

Table 5. Effect of KCl fertilizer on sweet corn yield

KCl dosage (kg/ha)	Unhusked cob weight (g)	Unhusked cob length (g)	Unhusked cob diameter (cm)
100	185.41 b	16.58	3.95
150	205.13 a	17.55	4.12
200	195.46 a	17.19	4.03

The weight of the unhusked cob fertilized with KCl at doses of 150 kg/ha and 200 kg KCl/ha was greater than the weight of the unhusked cob fertilized with 100 kg/ha, but there was no significant difference in unhusked cob length or diameter (Table 5).

Unhusked cob weight

The application of KCl at doses of 150 kg/ha and 200 kg/ha resulted in significantly different plant heights than the application of KCl fertilizer at 100 kg/ha. As a result, the higher the KCl dose, the greater the contribution to nutrient availability for plants. However, this yield is lower than the potential yield of Bonanza varieties. The study found that the weight of the unhusked cob was between 185.41 – 205.13 g, the length of the unhusked cob was between 16.58 – 17.55 cm, and the diameter of the unhusked cob was between 3.95 – 4.12 cm, while those of potential yields were 300 – 325 g, 20 – 22 cm, and 5.3 – 5.5 cm, respectively.

Potassium plays some roles, including starch formation, enzyme activation, nutrient absorption, strengthening drought resistance, and contributing to root development. Another role of element K in plants growth and development is to stimulate the activity of various enzymes, including acetic thiokinase, aldolase, pyruvate kinase, glutamylcysteine synthetase, formyl tetrahydrofolate synthetase, succinyl Co A synthetase, and ATPase. Potassium also promotes carbohydrate translocation from leaves to other plant organs, particularly carbohydrate storage plant organs such as fruit and seeds [4] [10].

CONCLUSIONS

The application of chicken manure significantly increased sweet corn growth but did not significantly affect the yield. At 10 t/ha dose, chicken manure increased plant height, fresh weight, and shoot dry weight. However, the yield was not significantly different among the treatments of chicken manure. A 150 kg/ha dose of KCl fertilizer resulted in higher plant height, fresh plant weight, and unhusked cob weight than a 100 kg/ha dose.

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