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RESEARCH PAPER

Addition of urea fertilizer to Crocober Plus Liquid Organic Fertilizer improves growth and yield of corn plants (*Zea mays* L.)

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Key Message: This study indicates that combining urea with CP LOF significantly improved corn growth parameters, such as plant height, total leaf area, and grain weight, with the highest yield observed at 10 g urea/L CP LOF and 50 ml/L CP LOF, achieving a dry grain yield of 6.33 tons/ha.

Abstract

This study aims to determine the effect of adding urea to Crocober Plus liquid organic fertilizer (CP LOF) on the growth and yield of corn. The research was conducted from March to July 2024 on dry land in Aia Pacah, Koto Tangah District, Padang City. The study employed a factorial completely randomized design (CRD). The first factor involved the addition of urea at doses of 0 g/L CP LOF, 5 g/L CP LOF, and 10 g/L CP LOF. The second factor was the concentration of CP LOF at 0 ml/L water, 25 ml/L water, and 50 ml/L water, with three replications. Data were analyzed using analysis of variance (ANOVA) at a 5% significance level, followed by Duncan's New Multiple Range Test (DNMRT) at the same level. The results showed that the combination of urea fertilizer and CP LOF significantly affected parameters such as plant height, total leaf area, 75% tasseling age, grain weight per sample plant, and 100-grain weight. The addition of 10 g urea/L CP LOF resulted in better growth and yield of corn compared to lower urea doses. The application of 50 ml/L CP LOF increased dry grain yield, reaching 6.33 tons/ha. Further research is needed to explore higher doses of CP LOF to achieve optimal corn yields.

Keywords: Corn, Crocober plus liquid organic fertilizer, Dry land, Optimization, Urea

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Introduction

Agricultural products such as corn play a strategic role in enhancing food supply and economic growth (Zia et al., 2023). Corn serves as a vital source of carbohydrates and protein, often used as a substitute for rice (Ahmad & Ahmad, 2018; Rubab et al., 2020; Mehmood et al., 2022). In various regions of Indonesia, particularly in Madura and Nusa Tenggara, corn is also a primary source of carbohydrates and protein. According to the Central Statistics Agency (2024), the production of dry shelled corn with 14% moisture content is projected to reach 14.46 million tons in 2023, a decrease of 2.07 million tons (12.50%) compared to 16.53 million tons in 2022. Enhancing soil fertility is one approach to addressing the decline in corn productivity.

Corn holds a strategic position not only in food supply but also in economic terms. To increase production, corn is an essential raw material benefiting industries such as animal feed, food processing, and biofuels (Irsyad & Kastono, 2019; Azam et al., 2023). Jamilah et al. (2016) demonstrated that the yield of Kabir 07 rice variety can be increased by applying 50 ml L^{-1} Crocober Plus Liquid Organic Fertilizer (CP LOF) and liquid organic fertilizer every two weeks from seedling to grain filling. This method resulted in a dry grain yield of 6.34 t ha^{-1}, with a harvest index of 0.53, despite CP LOF having only 0.03% nitrogen (N). Similarly, (Jamilah et al., 2017) found that black rice yields improved when CP LOF was applied as a foliar fertilizer, although this needed to be complemented by NPK fertilizers applied to the roots.

Given these findings, it is necessary to innovate and increase the nitrogen content in CP LOF by adding urea. To minimize the hygroscopic effects of urea on leaves, it is essential to test its application at low doses. Determining the optimal urea dose is crucial to achieving the best possible growth and development of corn. Urea is a synthetic fertilizer containing 46% nitrogen (N), making it highly beneficial during the vegetative growth phase of plants (Ahmad & Aslam, 2018; Shehzad et al., 2023). It plays a key role in promoting plant growth and development (Yousaf et al., 2018; Abbas & Shafique, 2019; Supandji & Saptorini, 2019). Plants require nitrogen-based fertilizers as they supply an essential macronutrient. Nitrogen regulates plant metabolism, particularly photosynthesis. Thus, the availability of N is critical for the survival and growth of all plants, including corn (Putra & Hanum, 2018; Iqbal et al., 2022).

Nitrate ions (NO_3^-) and ammonium ions (NH_4^+) are primary nitrogen sources for plants (Akram & Iqbal, 2019). Nitrogen is vital for producing essential components like chlorophyll, nucleic acids, and enzymes. As a result, overall plant growth, especially vegetative development, depends heavily on nitrogen availability. Conversely, nitrogen deficiency leads to pale yellow leaves, stunted growth, and, in severe cases, wilting of leaves from the bottom to the top of the plant (Balatif et al., 2022). Liquid fertilizers can reduce the use of synthetic fertilizers by up to 25% (Jamilah et al., 2015; Jamilah et al., 2020). The application of CP LOF (Crocober Plus

Liquid Organic Fertilizer) has been tested under various conditions over the long term. This fertilizer is derived from *Chromolaena odorata*, a wild-growing shrub that thrives in marginal lands. The plant is known to contain relatively high levels of nitrogen (N) and potassium (K) (Jamilah et al., 2016).

The successful application of CP LOF has been demonstrated in rice varieties such as Pandan Wangi and Cisokan (Jamilah & Helmawati, 2015; Jamilah et al., 2015; Jamilah et al., 2017). Additionally, Munir (2016); Munir et al. (2019) compared CP LOF with other commercial liquid fertilizers and found that rice and corn treated with CP LOF exhibited better growth and yield than those treated with other liquid fertilizers. The objective of this study was to evaluate the effect of adding urea to CP LOF on enhancing the productivity of corn (*Zea mays* L.). The application of CP LOF to several crops has not yet been tested with the addition of urea, which could increase the nitrogen content of the fertilizer. Therefore, it is essential to investigate this to determine whether the combined application of urea and CP LOF can improve crop yields by providing a more balanced nutrient profile, ultimately enhancing corn productivity.

Materials and Methods

The study was conducted on dry land in Air Pacah, Koto Tangah District, Padang City, West Sumatra, at an altitude of approximately 10 meters above sea level as alluvial soils. It started in March and ended in July 2024. Alluvial soils in Koto Tangah are rich in weather-resistant minerals such as feldspar, quartz, orthoclase, and sanidine, contributing to their mineral diversity (Henly et al., 2022). However, the nutrient content is often low due to the presence of acidic materials, necessitating the addition of organic matter such as compost and manure to enhance soil fertility. Sediments derived from medium to basic volcanic materials are considered excellent nutrient sources, although acidity remains a limiting factor (Anda et al., 2015). Spatial variability of soil characteristics is significantly influenced by parent material and topography. Topography also affects particle size distribution, with fine sand and silt + clay contents showing different spatial patterns (Ito et al., 2022). The materials used included Pioneer 27 corn seeds, urea fertilizer, NPK fertilizer, and Crocober Plus Liquid Organic Fertilizer (CP LOF). The tools used were hoes, knives, sprayers, pots, buckets, digital scales, measuring sticks, scissors, markers, adhesive tape, rulers, writing tools, plastic cups, raffia strings, and a camera.

The experiment was designed using a two-factor completely randomized design (CRD). The first factor was urea doses at three levels: 0 g/L CP LOF, 5 g/L CP LOF, and 10 g/L CP LOF. The second factor was CP LOF concentrations at three levels: 0 ml/L water, 25 ml/L water, and 50 ml/L water. To achieve a total of 27 experimental units, each treatment combination was repeated three times. The total plot size was 3 × 2.4 meters, with a spacing of 75 cm between plant rows. Planting was done using the dibbling method at a depth of 3 cm. Each hole was filled with 2 maize seeds and then covered with soil. The planting distance used was 75 × 30 cm, resulting in 32 plants per plot.

Corn seeds were planted in pairs, with two seeds sown per hole at a depth of three centimeters, then covered with soil. The first fertilization was carried out at one week after planting (WAP) using 126 g/plot of NPK Phonska and 90 g/plot of urea, as per the recommended dosage. The CP LOF treatments were applied by spraying onto the entire plant using a hand sprayer, starting at two WAP and continuing until the cob formation stage. The treatments were applied every two weeks in the morning, according to the specified treatment levels.

The evaluation criteria included the following parameters: plant height, time to tassel and silk emergence, total leaf area, cob weight with husk, cob weight without husk, cob diameter without husk, cob length without husk, grain weight per plant, 100-grain weight, grain weight per plot, and yield per hectare. The data obtained from observations were analyzed using an F-test at significance levels of 5% and 1%. If the F-calculated value exceeded the F-table value, Duncan's New Multiple Range Test (DNMRT) was applied to further analyze the results at either the 5% or 1% level. The soil was analyzed prior to the experiment by collecting 10 g samples from 20 random points at the experimental site. The soil pH was determined using a pH electrode, with an average pH of 6.06. The dilution ratio used was 1: 2.5 (soil to distilled water).

Results and Discussion

Plant height (cm)

The analysis of variance for corn plant height with the addition of urea to CP LOF showed a highly significant interaction between the two factors. Both factors individually also had a highly significant effect (Table 1). Increasing the urea dose combined with multiple applications of CP LOF significantly influenced the height of corn plants. The tallest plants, reaching 198.33 cm, were achieved with the application of 10 g urea/L CP LOF combined with a concentration of 50 ml/L CP LOF. Corn plants responded well to increased doses of urea and CP LOF, as the higher nitrogen content in CP LOF significantly promoted plant growth rates. According to (Jamilah et al., 2017), applying CP LOF at a concentration of 50 ml/L improved rice plant height. Although the comparison was made with dissimilar plants, the focus was more on the effect of LOF on plant metabolism. This concentration is considered the optimal method for enhancing plant height. Increasing the concentration beyond this level did not result in a significant difference in plant height. Similarly, Yusnaweti and Akbar (2018) highlighted that organic fertilizers, derived from fermented plant materials, release nutrients that are readily absorbed by plant tissues. The integration of urea into liquid fertilizers is crucial for improving nitrogen use efficiency and minimizing nitrogen losses in agricultural practices. Liquid urea fertilizers offer several advantages over traditional granular forms such as improved distribution and reduced volatilization. According to Motasim et al. (2022), liquid urea can undergo hydrolysis before soil application, making ammonium (NH_4^+) immediately available to plants, unlike granular urea, which requires soil moisture for hydrolysis. Furthermore, the presence of multiple nitrogen forms, including nitrate, Ammonium, and amide, in liquid fertilizers enhances overall nitrogen availability (Milyutkin et al., 2021). Split applications of liquid urea can lower soil $NH4^+$ concentrations, reducing ammonia volatilization and nitrate leaching losses (Motasim et al., 2022). Synergistic liquid fertilizer formulations improve nitrogen retention in the soil, thereby prolonging its availability to crops (Klimczyk et al., 2021).

Table 1 Corn plant height (cm) with the addition of urea to CP LOF at 8 week after planting (WAP)

Urea (g)	PC LOF (ml/L)		
	0	25	50
0	93.17 Aa	113.83 Aa	104.72 Ab
5	119.72 Ba	109.11 Ba	174.89 Aa
10	105.61 Ba	127.99 Ba	198.33 Aa
CV (%)	12.41		

Numbers in the same row followed by the same capital letters and numbers in the same column followed by the same lowercase letters are not significantly different according to the 5% DNMRT test

Age of male flower emergence (DAP)

The analysis of variance for male flowering age in corn with the addition of urea to CP LOF showed a highly significant interaction between the two factors. Each factor individually also had a highly significant effect (Table 2). Increasing the urea dose combined with various concentrations of CP LOF significantly influenced the time of male flowering in corn. The earliest male flowering was observed with the application of 5 g urea/L CP LOF at a concentration of 25 ml/L CP LOF. The addition of urea to CP LOF significantly enhanced the response of corn plants accelerating the emergence of male flowers. The flowering period of corn is influenced by fertilization and nutrient availability in the soil (Syamsuwirman et al., 2023). The increased availability of nutrients due to the incorporation of urea into CP LOF promotes the emergence of corn flowers. The timing of male and female flower emergence is crucial for successful pollination in corn. This transition marks the shift from the vegetative to the reproductive stage, indicated by the appearance of male flowers. This process is not only affected by environmental factors but also by the nutritional status of the plant (Agustina et al., 2024).

Table 2 Age of male flower emergence in corn with the addition of urea to CP LOF (DAP)

Urea (g)	PC LOF (ml/L)		
	0	25	50
0	51.67 Aa	49.33 Ab	51.67 Ac
5	55.33 Bb	45.67 Aa	45.67 Aa
10	52.33 Ba	49.67 Ab	48.33 Ab
CV (%)	2.00		

Numbers in the same row followed by the same capital letters and numbers in the same column followed by the same lowercase letters are not significantly different according to the 5% DNMRT test

Total leaf area of corn (cm^2) and weight of corn cob with husk (g)

The analysis of variance for total leaf area in corn with the addition of urea to CP LOF showed a highly significant interaction between the two factors and each factor individually had a highly significant effect (Table 3). Increasing the urea dose combined with various concentrations of CP LOF significantly influenced the total leaf area of corn. The largest total leaf area was observed with the application of 10 g urea/L CP LOF at a concentration of 50 ml/L CP LOF. This response is likely due to the addition of urea, which the corn plants responded to significantly, resulting in an increase in leaf area and subsequently enhancing photosynthesis.

Although organic fertilizers generally have low nutrient content and limited nutrients, they still provide all the essential nutrients needed by plants (Abbas, 2022). The addition of urea to CP LOF enhances the availability of nitrogen for corn plants leading to an increase in the total leaf area. The use of organic fertilizers improves the effectiveness and efficiency of fertilization because they release nutrients in a more stable and readily available form (Kresnatita et al., 2012). However, the total leaf area in this study was still lower compared to the report by Jamilah et al. (2009), which showed that corn treated with 3 Mg/ha Guano as an organic fertilizer produced 4608 m² of leaf area. Therefore, there is a tendency that increasing the urea dose could further improve leaf area. A larger leaf area in corn has the potential to produce more photosynthates, which will ultimately enhance the dry kernel yield.

The analysis of variance for cob weight with husk in corn, following the addition of urea to CP LOF, revealed no significant interaction. Additionally, the urea addition alone did not have a significant effect. However, the application of CP LOF alone had a significant effect on the cob weight with husk (Table 4). The addition of urea did not significantly affect the cob weight with husk whereas different concentrations of CP LOF did have a significant effect. The average cob weight with husk for the urea treatments ranged from 152.31 g to 188.03 g. The highest cob weight with husk was achieved with the application of 50 ml/L CP LOF which resulted in a weight of 237.83 g.

Chasanah et al. (2018) demonstrated that the concentration of liquid organic fertilizer significantly affects both the cob weight with husk and the cob weight without husk. The application of liquid organic fertilizer ensures the balance of both macro and micronutrients, optimizing the resulting cob weight of corn. If your plants do not receive the proper nutrients you will not achieve optimal yields. Rantong (2021) stated that when plants receive all the necessary nutrients, their metabolism produces proteins, enzymes, hormones and carbohydrates, which accelerate growth elongation and cell division.

100-grain weight (g)

The variance analysis of 100-grain weight in corn with the addition of urea to CP LOF shows a very significant interaction and both individual factors of the treatments have a very significant effect (Table 5). The addition of urea at different concentrations of CP LOF significantly influenced the weight of 100 grains of corn. The addition of 10 g urea/L CP LOF with a concentration of 50 ml/L CP LOF resulted in the highest 100-grain weight of 34.83 g. This is likely due to the corn plants' strong response to the addition of urea in CP LOF. The nutritional composition of corn kernels significantly influences their weight particularly the 100-kernel weight which varies based on factors such as protein and starch contents. Research has shown that the 100-kernel weight can range from 9.14 to 36.11 g with a notable negative correlation between protein content and kernel weight (Langyan et al., 2021). Jamilah et al. (2009) demonstrated that the 100-grain weight of corn reached 34.2 g when 3 tons/ha of guano compost was applied which is still lower than the results of this study. The application of 10 g urea/L CP LOF significantly enhanced the protein content in corn, as reported by Langyan et al. (2021). They found that higher protein content (from 8.83% to 15.54%) correlates with a reduction in both kernel weight and starch content (from 75.31% to 67.43%), with increased starch content typically contributing to higher kernel weight. The application of 10 g urea/L CP LOF significantly increased the protein content in corn, as reported by Langyan et al. (2021). They found that protein content rose from 8.83% to 15.54%, which was accompanied by a decrease in kernel weight and starch content (from 75.31% to 67.43%). This inverse relationship suggests that higher starch content contributes to greater kernel weight, highlighting the complex trade-offs between protein accumulation and other kernel traits.

Table 3 Total leaf area of corn with the addition of urea to CP LOF (cm²)

Urea (g)	PC LOF (ml/L)		
	0	25	50
0	2316.10 Aa	2226.58 Aa	2328.26 Ac
5	2270.20 Ba	3213.25 Aa	3887.98 Ab
10	2342.96 Ba	3181.94 Ba	5523.09 Aa
CV (%)	23.26		

Numbers in the same row followed by the same capital letters and numbers in the same column followed by the same lowercase letters are not significantly different according to the 5% DNMRT test

Table 4 Weight of corn cob with husk with the addition of urea to CP LOF (g)

Urea (g)	PC LOF (ml/L)			Average
	0	25	50	
0	103.27	155.94	197.72	152.31a
5	132.99	139.89	254.05	175.64a
10	139.05	164.66	260.39	188.03a
Average	125.11 B	153.50 B	237.83 A	
CV (%)	18.52			

Numbers in the same row followed by the same capital letters and numbers in the same column followed by the same lowercase letters are not significantly different according to the 5% DNMRT test

Table 5 Weight of 100 corn kernels with the addition of urea to CP LOF (g)

Urea (g)	PC LOF (ml/L)		
	0	25	50
0	20.27 Cb	26.99 Ba	29.99 Ab
5	26.33 Ba	28.66 Ba	32.55 Aa
10	25.39 Ca	28.00 Ba	34.83 Aa
CV (%)	5.16		

Numbers in the same row followed by the same capital letters and numbers in the same column followed by the same lowercase letters are not significantly different according to the 5% DNMRT test

Yield of corn (Mg/hectare)

The analysis of variance of dry kernel weight in corn with the addition of urea to CP LOF showed no significant interaction nor did the addition of urea alone have a notable impact. However, the application of CP LOF alone significantly affected the dry kernel weight (Table 6). The addition of urea did not significantly impact the production per hectare. The highest production reached 6.33 tons per hectare when CP LOF was applied at a dose of 50 ml/L.

Further research is needed to increase the application dose of CP LOF in order to enhance corn yield. Based on the data the optimal dose of CP LOF was not yet achieved in this experiment. Edy et al. (2023) demonstrated that the use of liquid organic fertilizers can optimize corn plant growth. Similarly, Su'ud and Lestari (2018) showed that the application of liquid organic fertilizers significantly affects seed weight per plot, 100-seed weight and crop production per hectare. Fertilization requires careful consideration to achieve optimal results including the type of fertilizer used, timing of application, concentration or dose, application method and recommendations for its use. The use of the appropriate concentration of CP LOF along with the right method, can reduce the use of synthetic fertilizers by up to 25% while simultaneously improving crop yields (Jamilah et al., 2023).

Table 6 Corn yield with the addition of urea to PC LOF (Mg/hectare)

Urea (g)	PC LOF (ml/L)			Average
	0	25	50	
0	3.06	4.17	4.96	4.06a
5	4.22	3.75	7.08	5.02a
10	3.41	4.39	6.94	4.91a
Average	3.56 B	4.10 B	6.33 A	
CV (%)	18.42			

Numbers in the same row followed by the same capital letters and numbers in the same column followed by the same lowercase letters are not significantly different according to the 5% DNMRT test

Conclusion

The addition of 10 g urea/L CP LOF resulted in better growth and yield of corn compared to lower doses of urea. The application of 50 ml/L CP LOF increased the production of dry corn kernels to 6.33 tons/ha. Further research is needed to optimize the CP LOF dose to achieve optimal corn yields.

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