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Application of Chicken Manure Tea to Reduce NPK Fertilizer Doses Without Reduction of Growth and Yield of Small Chili in Dryland

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ABSTRACT

This study examined the effects of chicken manure tea (CMT) application and reduced NPK fertilizer dose on the growth and yield of small chili grown on dryland. The experiment was conducted from March to June 2025 in Gumantar Village, North Lombok Regency, Indonesia, using a randomized complete block design with three replications and four treatments: T1 (no CMT + 100% NPK fertilizer), T2 (no CMT + 60% NPK fertilizer), T3 (CMT application + 100% NPK fertilizer), and T4 (CMT application + 60% NPK fertilizer). Data were analyzed using analysis of variance (ANOVA) and Tukey's HSD test at the 5% significance level with CoStat for Windows. The results showed that the highest growth and yield were obtained in T3 (CMT + 100% NPK) and T4 (CMT + 60% NPK), with no significant differences between T3 and T4 except for number of branches. Therefore, CMT application allows the NPK fertilizer dose to be reduced to only 60%, producing a fruit yield of 277.87 g/plant compared with 200.87 g/plant under the without CMT + 100% NPK treatment, supported by the highest leaf number in T4, which was positively correlated with fruit weight per plant (R^2 = 35.2%, p-value = 0.04). Further research is needed to examine how much inorganic fertilizer use can be reduced by application of chicken manure tea (CMT) in chili production under different types of soil conditions in an effort to improve the sustainability of crop production in dryland areas.

KEYWORDS: small chili; chicken manure tea; dryland; NPK; reduced fertilizer doses

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1. INTRODUCTION

Small chili (*Capsicum frutescens* L.) is one of the most important vegetable crops because it is widely used in culinary applications to enhance flavor, aroma, and color in dishes [1]. In Indonesia, small chili is used as a primary spice in daily cooking as well as in most traditional Indonesian dishes. In addition, the food industry in Indonesia uses small chili extensively as a raw material, leading to high demand for this commodity in the country. Based on data from the Center for Agricultural Data and Information Systems, the average per capita consumption of small chili in Indonesia increased from 1.769 kg/capita/year in 2020 to 1.955 kg/capita/year in 2021, 2.073 kg/capita/year in 2022, and 2.192 kg/capita/year in 2023 [2]. Furthermore, projections of per capita chili demand indicate that chili consumption will continue to increase from 2023 through 2027 [3].

Small chili production in Indonesia must be increased to meet the rising annual demand. However, efforts to expand and intensify small chili cultivation face constraints related to the availability of sufficient land [4]. This is due to the continued decline in fertile land area in Indonesia caused by land-use conversion from agricultural land to industrial and residential areas. Between 2005 and 2015, the rate of paddy field conversion reached 54,716 ha/year across nine major national production centers, namely West Java, East Java, Bali, West Nusa Tenggara, South Sulawesi, South Kalimantan, South Sumatra, North Sumatra, and Gorontalo [5]. Consequently, one strategy to increase small chili production is to cultivate the crop on dryland.

One of the provinces in Indonesia with a large potential dryland area is West Nusa Tenggara (NTB) provinve. The dryland area in NTB covers 15,908.66 km22, or 92.7% of the provincial land area, and approximately 88.8% (14,130.38 km^2) of this dryland is located in lowland regions dominated by dry-climate dryland but it is highly suitable for agricultural development [6]. However, several constraints can affect agricultural productivity on dryland, including land degradation caused by destructive human activities and natural processes exacerbated by climate change, water scarcity due to declining groundwater and surface water availability, and frequent droughts resulting from low rainfall [7]. These conditions can cause plant stress and impair crop stability, making appropriate mitigation measures necessary.

One approach to overcoming constraints associated with land degradation is to reduce the use of inorganic fertilizers and increase the use of organic fertilizers. Intensive use of inorganic fertilizers can pollute soil, water, and air, and pose risks to human health [8]. Excessive and continuous application of inorganic fertilizers may also have negative effects, such as soil degradation, nutrient imbalance, soil structural damage, and increased bulk density due to salt accumulation [9]. On dryland that is less prone to leaching, inorganic fertilizers tend to accumulate more readily in the soil, further aggravating soil salinity, nutrient imbalance, and degradation [10]. Therefore, the use of inorganic fertilizers should be minimized by applying organic fertilizers to crops.

Organic fertilizers can be derived from animal manure or plant residues that have undergone fermentation [11]. Thus, organic fertilizers not only provide nutrient recycling but also help reduce waste [12]. The addition of organic fertilizers has been shown to reduce the need for inorganic fertilizers while improving their efficiency [13]. Reduced dependence of the agricultural sector on inorganic fertilizers has positive impacts on preventing soil degradation [14]. Organic fertilizers can increase the diversity, biomass, and activity of soil microorganisms because they supply various carbon compounds with different chemical compositions that can be utilized by soil microbes to increase their biomass and growth rate [15]. Organic fertilizers also enhance carbon sequestration in agricultural ecosystems and improve soil quality [16].

One type of organic fertilizers that can serve as an alternative for improving nutrient availability is chicken manure tea (CMT). CMT is a liquid extract of chicken manure produced by fermenting the manure in water for a certain period to obtain a nutrient-rich solution. CMT contains 1.81% N, 0.67% P, 1.03% K, 443 ppm Fe, 152 ppm Zn, and 46 ppm Mn [17]. Its relatively high nutrient content makes CMT a potential organic fertilizer. Previous studies have also shown that plants treated with CMT exhibit higher growth and yield than plants receiving only inorganic fertilizers [18].

Therefore, the objective of this study was to evaluate the effects of CMT application and reduced NPK fertilizer dose on the growth and yield of small chili grown on dryland.

II. MATERIALS AND METHODS

The experiment was conducted from March to June 2025 in Gumantar Village, Kayangan district, North Lombok Regency, West Nusa Tenggara Province, Indonesia. Treatments included: T1 (no CMT + 100% NPK fertilizer), T2 (no CMT + 60% NPK fertilizer), T3 (CMT application + 100% NPK fertilizer), and T4 (CMT application + 60% NPK fertilizer). Each treatment was arranged in three replications (blocks) using a randomized complete block design (RCBD), resulting in 12 experimental units.

The experiment began with the production of seedlings of the small chili variety 'Dewata 43 F1' in a nursery for 28 days. The nursery medium consisted of a mixture of friable soil, farmyard manure, and rice husk in a 1:1:1 ratio. Initially, seeds were sown in nursery trays. After 10 days after seeding (DAS) the seedlings were then transplanted into 12 × 6 cm polybags filled with approximately 70 g of the growing medium and grown for an additional 18 days. Subsequently, land preparation and bed formation were carried out. The experimental field was first cleared of weeds and crop residues and then loosened using a hoe. Beds measuring 5.4 m in length and 1 m in width were constructed, with a height of 30 cm and 40 cm spacing between beds.

After bed formation, basal fertilization was carried out using NPK 'Pak Tani' (16–16–16) at the recommended basal dose of 700 kg/ha, applied according to the treatments: 378 g/bed for the 100% NPK treatments and 226.8 g/bed for the 60% NPK treatments. Basal fertilizer was broadcast on the unlevelled beds and covered with soil during bed leveling. Silver-black plastic mulch was then placed on the beds, and 18 planting holes (9 rows per bed) were made with a spacing of 60 × 50 cm. When seedlings were 28 days old, they were transplanted onto the beds in the late afternoon. Sample plants were then selected using random sampling, with three sample plants per bed. Crop management included irrigation (every 7 days by flooding the furrows to a depth of 5 cm for 30 minutes), pruning (removal of shoots below the first branch) at 2 and 4 weeks after transplanting, pest and disease control, and topdressing with CMT and NPK fertilizer.

Before topdressing, CMT was prepared by moistening 1.62 kg of chicken manure with 6.48 ml of EM-4 diluted in 648 ml of water, covering the mixture with a tarp, and fermenting it for three weeks. The fermented manure was then air-dried for two days and mixed into 6.48 L of water that had been supplemented with 64.8 ml molasses and 324 ml rice-washing water. After thorough mixing, the solution was fermented again for three days and then filtered to remove suspended particles, leaving a clear solution referred to as CMT. An additional 64.8 ml molasses and 324 ml rice-washing water were added to the CMT, followed by a further seven-day incubation. The CMT was then aerated for two hours to remove ammonia gas, after which it was ready for use [19].

Topdressing fertilizers consisted of NPK ‘Pak Tani’ (16–16–16) and CMT, applied alternately. CMT topdressing was applied five times, at 2, 4, 6, 8, and 10 weeks after transplanting (WAT). NPK ‘Pak Tani’ (16–16–16) was also applied five times, at 3, 5, 7, 9, and 11 WAT. The recommended topdressing rate of NPK fertilizer was 500 kg/ha, equivalent to 100 kg/ha per application. For the 100% NPK treatments, 54 g/bed was applied per topdressing, whereas 32.4 g/bed was applied in the 60% NPK treatments. Before application, NPK fertilizer was dissolved in 9 L water and applied by watering 500 ml solution per plant. For CMT application, 1 L CMT was diluted in 10 L water and applied at 300 ml/plant [18].

Measurements included plant height, stem diameter, number of branches, and number of leaves at 9 WAT (first harvest), as well as total leaf chlorophyll at 4 WAT (vegetative phase). Yield variables consisted of fruit number/plant, fruit weight/plant, and fruit weight/bed. The crop was harvested five times at 9, 10, 11, 12, and 13 WAT. Fruits were counted and weighed at each harvest, and totals were calculated after the final harvest. Additionally, plant nitrogen and phosphorus concentrations were analyzed at the end of the experiment (13 WAT). Data were analyzed with ANOVA and Tukey’s HSD test using CoStat for Windows.

III. RESULTS AND DISCUSSION

Overall, the data in Tables 1 and 2 show that the CMT + 100% NPK treatment and the CMT + 60% NPK treatment produced the highest mean values for most growth and yield variables. As shown in Table 1, the CMT + 100% NPK treatment resulted in the highest plant height and total leaf chlorophyll, although these values did not differ significantly from those obtained with CMT + 60% NPK. However, for number of branches, the CMT + 100% NPK treatment produced not only the highest value but also a value significantly higher than those of the other treatments. In contrast, the highest stem diameter was obtained with CMT + 60% NPK, but it did not differ significantly from that of the CMT + 100% NPK and no CMT + 100% NPK treatments. For number of leaves, the CMT + 60% NPK treatment also produced the highest value, although it was not significantly different from the other treatments.

Table 1. The effects of CMT application and reduced NPK doses on growth of small chili in dryland

Treatments	Plant height (cm)		Stem diameter (mm)		Branch number per plant		Leaf number per plant		Total chlorophyll of leaves (mg/L)	
T1: No CMT + 100% NPK	50.50	b	7.80	ab	51.33	c	183.33	a	8.90	b
T2: No CMT + 60% NPK	45.00	b	7.17	b	45.11	c	180.67	a	7.88	b
T3: With CMT + 100% NPK	63.37	a	8.20	a	70.44	a	197.00	a	13.98	a
T4: With CMT + 60% NPK	61.53	a	8.30	a	61.11	b	198.67	a	13.18	a
Tukey’s HSD 5%	10.72		0.80		6.96		110.07		2.12	

Remark: CMT = Chicken Manure Tea. Mean values in each column followed by the same lowercase letters are not significantly different between treatments based on Tukey’s HSD at 5% significance level

Table 2. The effects of CMT application and reduced NPK doses on yield of small chili in dryland

Treatments	Fruit number/plant		Fruit weight/plant (g)		Fruit weight/bed (g)	
T1: No CMT + 100% NPK	203.67	ab	200.87	b	815.13	a
T2: No CMT + 60% NPK	150.33	b	226.84	ab	784.49	a
T3: With CMT + 100% NPK	301.33	a	241.64	ab	804.31	a
T4: With CMT + 60% NPK	230.67	ab	277.87	a	874.64	a
Tukey’s HSD 5%	114.43		71.85		230.13	

Remark: CMT = Chicken Manure Tea. Mean values in each column followed by the same lowercase letters are not significantly different between treatments based on Tukey’s HSD at 5% significance level

Table 2 shows that application of CMT + 100% NPK resulted in the highest fruit number/plant, though this value did not differ significantly from those under CMT + 60% NPK and no CMT + 100% NPK. For fruit weight/plant, CMT + 60% NPK produced the highest value, but it did not differ significantly from those of CMT + 100% NPK and no CMT + 60% NPK. Moreover, the CMT + 60% NPK treatment also produced the highest fruit weight/bed, although not significantly different from the other treatments. In contrast, reducing the NPK dose from 100% to 60% without CMT led to reduced growth and yield, producing the lowest values for all growth and yield variables except fruit weight/plant. These all mean that NPK fertilizer dose can be reduced to only 60% of the recommended dose but only if NPK reduction is accompanied with application of CMT.

The above results indicate that plants subjected to reduced inorganic fertilizer doses exhibit lower growth and yield than those receiving the full 100% recommended NPK dose. This is consistent with previous studies showing that reducing inorganic fertilizer rates leads to decreased plant growth and yield [20]. However, when the reduction in inorganic fertilizer dose was accompanied by CMT application, plant growth and yield increased sharply and even surpassed those under 100% inorganic fertilizer without CMT

(Table 2). These findings agree with several previous studies reporting positive effects of CMT application on plant growth and yield [17, 18, 19, 21]. As an organic fertilizer, CMT can improve soil quality, including soil organic matter, soil carbon, soil microbial activity, soil enzyme activity, aggregate stability, bulk density, and water-holding capacity, and can help plants cope with abiotic stress, thereby enhancing growth and yield [22]. Therefore, the CMT + 60% NPK treatment is recommended in this study because it not only minimizes the use of inorganic fertilizers to prevent environmental pollution and soil degradation but also does not cause a significant reduction in the growth and yield of small chili.

Regarding plant nitrogen and phosphorus concentrations, the no CMT + 60% NPK treatment produced slightly higher values than the other treatments, but the differences were not statistically significant (Table 3). The lack of significant differences among treatments may be due to nutrient concentration measurements being taken at the end of the experiment (at fifth harvest), when nutrient uptake rates decline sharply as plants enter the fruiting stage [23]. During this period, plants no longer actively absorb nutrients from the soil but instead remobilize nutrients from vegetative to reproductive organs, so nutrient concentrations in plant tissues reflect residual rather than total absorbed nutrients, resulting in relatively uniform values across treatments. Previous studies also reported that nitrogen and phosphorus concentrations decrease as plant biomass increases [24].

Table 3. The effects of CMT application and reduced NPK doses on nitrogen and phosphorus concentration in shoots of small chili in dryland

Perlakuan	Konsentrasi Nitrogen Pada Tanaman (%)		Konsentrasi Fosfor Pada Tanaman (%)	
T1: Tanpa CMT + 100% NPK	1.98	a	0.37	a
T2: Tanpa CMT + 60% NPK	2.40	a	0.38	a
T3: Dengan CMT + 100% NPK	2.22	a	0.37	a
T4: Dengan CMT + 60% NPK	2.28	a	0.37	a
Tukey's HSD 5%	1.07		0.07	

Keterangan: CMT = Chicken Manure Tea. Nilai rata-rata yang diikuti oleh huruf yang sama pada kolom yang sama menunjukkan tidak ada perbedaan nyata antar perlakuan pada setiap faktor berdasarkan hasil uji BNJ taraf 5%.

Based on the mean values in Tables 1, 2, and 3, increases in one measurement variable are accompanied by increases in other variables, indicating relationships among the observed variables. This is supported by the correlation analysis results presented in Table 4, which show that total leaf chlorophyll is very strongly and significantly positively correlated with plant height ($r = 0.951$; $\rho < 0.001$), branch number ($r = 0.933$; $\rho < 0.001$), and stem diameter ($r = 0.807$; $\rho = 0.002$). This indicates that increases in total leaf chlorophyll are associated with increases in plant height, number of branches, and stem diameter, and vice versa. Leaf chlorophyll content can serve as an indicator of plant growth status because total leaf chlorophyll influences photosynthetic capacity, and the resulting photosynthates are allocated to support vegetative growth [25]. Plants with higher total chlorophyll tend to exhibit better vegetative growth [26].

There were also very strong and significantly positive correlations between plant height and branch number ($r = 0.882$; $\rho < 0.001$) and between branch number and stem diameter ($r = 0.802$; $\rho = 0.002$) (Table 4). Plant height is related to the availability of space for new shoot development; taller plants have greater potential to produce more branches. Previous findings have shown that increases in plant height are accompanied by increased branch number [27]. In general, as the number of branches increases, stem diameter also increases to provide sufficient mechanical support. This is consistent with previous research indicating that increased stem diameter reflects plant responses to the greater mechanical load associated with more branches [28].

Strong and significantly positive correlations were also observed between fruit number/plant and stem diameter ($r = 0.699$; $\rho = 0.011$), and between fruit number/plant and branch number ($r = 0.738$; $\rho = 0.006$) (Table 4). Stem diameter influences fruit number/plant because it is positively related to branch number. Each branch of small chili plants bears nodes that serve as sites for fruit formation, so more branches create more potential sites for fruit development. Previous studies have demonstrated that fruit number/plant increases with increasing branch number [29]. In addition, a strong and significantly positive correlation was found between leaf number/plant and fruit weight/plant ($r = 0.593$; $\rho = 0.042$) (Table 4). In this relation, leaves are the primary photosynthetic organs and thus function as sources while fruits act as sinks that store and utilize the products of photosynthesis. Photosynthetic capacity increases with the number of leaves per plant, leading to greater photosynthate production and, consequently, higher fruit weight/plant [30]. Accordingly, previous research has reported a direct relationship between leaf number and fruit weight/plant [31].

Table 4 also shows a strong and significantly positive correlation between plant height and stem diameter ($r = 0.792$; $\rho = 0.002$), in agreement with empirical evidence of a positive relationship between these variables [32]. Taller plants require thicker stems to prevent lodging, and larger stem diameters also enable more efficient transport of water and nutrients from roots to canopy [33]. Furthermore, the correlation between nitrogen and phosphorus concentrations was moderately strong and significant ($r = 0.593$; $\rho = 0.042$). Several studies have indicated that nitrogen and phosphorus in plants are tightly balanced and synergistic, with increased nitrogen concentrations associated with higher phosphorus concentrations [34, 35].

Table 4. Coefficients and p-values of correlation between measurement variables

Variables	Plant height	Stem diameter	Branch number	Leaf number	Chloro-phyll	Fruit number per plant	Fruit weight per plant	Fruit weight per bed	N-concen-tration
Stem diameter	0.792								
p-value	**0.002**								
Branch number	0.882	0.802							
p-value	**0.000**	**0.002**							
Leaf number	-0.206	0.099	0.048						
p-value	0.521	0.760	0.882						
Chlorophyll	0.951	0.807	0.933	-0.074					
p-value	**0.000**	**0.002**	**0.000**	0.818					
Fruit number/plant	0.408	0.699	0.738	0.500	0.520				
p-value	0.188	**0.011**	**0.006**	0.098	0.083				
Fruit weight/plant	0.313	0.299	0.332	0.593	0.387	0.327			
p-value	0.322	0.346	0.292	**0.042**	0.214	0.299			
Fruit weight/bed	-0.137	0.343	0.102	0.531	0.037	0.502	0.406		
p-value	0.671	0.275	0.753	0.076	0.908	0.096	0.191		
N concentration	0.133	0.086	0.036	-0.168	0.175	-0.161	-0.009	0.069	
p-value	0.681	0.789	0.912	0.602	0.586	0.618	0.978	0.832	
P concentration	0.177	0.086	0.095	0.220	0.092	0.027	0.214	-0.074	0.593
p-value	0.581	0.789	0.770	0.491	0.775	0.933	0.505	0.820	**0.042**

Remark: p-values in blue color indicates significant correlation (p-value < 0.05)

IV. CONCLUSION

CMT application in combination with reduced inorganic (NPK) fertilizer dose by 40% still resulted in better growth and higher fruit yield of small chili when compared to fertilization using 100% inorganic fertilizer without CMT. This demonstrates that CMT can meet plant nutrient requirements when the inorganic fertilizer dose is reduced to only 60% of the recommended dose. Correlation analysis revealed both direct and indirect positive relationships between growth variables and fruit yield of small chili plants, with a positive correlation between leaf number and fruit weight/plant ($r = 0.593$ or $R^2 = 0.3516$; $\rho = 0.042$), indicating a 35.2% contribution of leaf number to fruit weight/plant. Further investigation needs to be done to examine how much fertilizer requirement can be met by application of CMT in chili production in different types of soil conditions.

V. DISCLOSURE

We do not have any conflicts of interest in this work.

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