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RESEARCH ARTICLE

Effect of mudpress as organic fertilizer on selected soil properties and yield of cowpea (*Vigna unguiculata* (L.) Walp.)

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Abstract

This study aimed to evaluate the nutrient composition of an organic fertilizer derived from sugarcane sludge (mudpress), its impact on selected soil properties and efficacy in improving cowpea yield. The study was conducted at the College of Agriculture, Isabela State University, San Mariano campus, from February to April 2017. The organic fertilizer was a mixture of mudpress, poultry manure and carbonized rice hull in a 6:3:1 ratio. The efficacy of this fertilizer on cowpea was evaluated through treatments: 20-40-45 kg nitrogen-phosphorus-potassium (NPK) ha^{-1} as per the recommended rate, 20 bags of organic fertilizer ha^{-1} and combinations of organic fertilizer with full and half rates of inorganic fertilizer, with the untreated plants that served as the control. The organic fertilizer contained substantial amounts of NPK, which significantly impacted soil pH, organic matter content and microbial count. The combination of organic fertilizer with full and half rates of inorganic fertilizer resulted in the highest cowpea yields, ranging from 5.80 to 5.86 t ha^{-1}. These results demonstrate the effectiveness of organic fertilizer in improving soil quality and enhancing crop yield, highlighting the potential for agricultural waste to be transformed into productive resources. The findings promote efficient management and utilization of agricultural wastes, providing a sustainable solution to environmental concerns while enhancing agricultural productivity. The technology and data generated can support organic agriculture initiatives (RA 10068) and solid waste management (RA 9003), benefiting researchers, organic advocates and farmers in the Philippines.

Keywords: cowpea yield; organic fertilizer; sugarcane sludge; sustainable agriculture

Introduction

Organic amendments, including biosolids, compost, vermicompost and animal manure, play a crucial role in enhancing soil fertility and improving soil physical and chemical properties. Biosolids, derived from sewage sludge, have been reported to significantly enhance soil quality by improving nutrient availability and soil structure (1, 2). However, concerns about potential heavy metal contamination and its impact on microbial activity have also been raised (3, 4).

The application of organic waste materials such as cocoa pod husk, poultry manure and pressmud has been shown to enhance soil nutrient content and crop yield (5-7). Pressmud, a byproduct of sugar processing, improves soil physico-chemical characteristics, leading to better crop performance (8, 9). Similarly, animal manure contributes to increased nitrogen (N), phosphorus (P) and potassium (K) availability in the soil, thereby enhancing soil fertility and productivity (10, 11).

The incorporation of vermicompost into soil has been shown to improve soil structure, aeration and water-holding capacity, which are essential for sustainable crop production (12, 13). The microbial population in the soil also benefits from organic amendments, as evidenced by increased enzymatic activities and microbial biomass (14, 15). Organic waste applications can alter soil physical properties, including bulk density and porosity, thereby enhancing root penetration and plant growth (16, 17).

Despite the benefits, excessive application of organic amendments, particularly sewage sludge, may lead to soil contamination with heavy metals, affecting soil biological functions and plant uptake (18, 19). Long-term studies suggest that integrating organic and inorganic fertilizers in a balanced manner can optimize nutrient availability while minimizing environmental risks (20, 21). The need for proper waste management strategies is emphasized by studies highlighting the potential of composting and biowaste recycling for sustainable agricultural production (22, 23). Organic amendments provide multiple agronomic and environmental advantages by enhancing soil fertility, improving soil structure and stimulating microbial activity. However, careful management is necessary to mitigate potential risks associated with heavy metal accumulation and nutrient imbalances (24, 25). A balanced approach integrating organic and inorganic amendments can ensure sustainable soil fertility management for long-term agricultural productivity (25, 26).

In this context, the selection of legumes as the test crop is particularly important. Legumes not only benefit directly from improved soil fertility but also contribute to sustainable soil management through biological N fixation, reducing dependence on chemical fertilizers. Their symbiotic association with rhizobia enhances soil microbial activity, while their relatively high protein content and adaptability make them valuable for both soil health restoration and food security. Thus, legumes serve as an appropriate model crop to assess the effects of organic amendments on soil fertility and long-term productivity.

Statement of the problem

Farmers today are burdened with the spiralling prices of farm inputs for their agricultural production. The heavy use of commercial chemical fertilizer has not only trimmed down the income of farmers but also resulted in the degradation of the environment, soil and surface waters. In the soil, the most significant effect is the decline in microbial diversity, which is responsible for the decomposition of plant residues and the release of nutrients for plant uptake. Inorganic fertilizers make soils acidic, rendering some nutrients unavailable to crops. High application rates of inorganic N fertilizers to maximize crop yields, combined with the high solubility of these materials, lead to increased runoff into surface water as well as leaching into groundwater. Methane emissions from crop fields are increased by the application of ammonium-based fertilizers which contribute greatly to global climate change as methane, a potent greenhouse gas. The high cost of chemical fertilizers, the growing awareness of consumers on the effect of synthetic chemical fertilizers on health and environment and the current global shift toward organic farming have led to an increase in the demand for organic-based fertilizers. This study seeks to answer the following problems:

1. What are the nutrient characteristics of the organic fertilizer derived from mudpress?
2. What is the impact of using the organic fertilizer on selected soil properties (chemical, physical and microbial)?
3. How is cowpea (*Vigna unguiculata* (L.) Walp.) performing when applied with organic fertilizer derived from mudpress?

Objectives of the study

Generally, the study aimed to develop an organic fertilizer utilizing locally available mudpress as a major substrate. Specifically, it aimed to:

- Analyze the nutrient content of the developed organic fertilizer derived from the mudpress.
- Assess the impact of the organic fertilizer on selected soil properties (chemical, physical and microbial).
- Evaluate the efficacy of the organic fertilizer on the growth and yield of cowpea.

Significance of the study

Results of research studies revealed that continuous use of organic fertilizers results in increased soil organic matter, reduced erosion, better water infiltration and aeration, higher soil biological activity and increased crop yields after the year of application due to residual effects. Organic fertilizers have been known to improve the biodiversity and long-term productivity of soil and may prove a large depository for excess carbon dioxide. Organic nutrients increase the abundance of soil organisms by providing organic matter and micronutrients for organisms such as fungal mycorrhiza. The advantages of using organic fertilizers, the availability of raw materials within the locality and the rising costs of chemical fertilizers highlight the need to produce quality organic fertilizers.

Time and place of the study

The study was conducted from January to April 2017 at the Agricultural Research Area, Isabela State University – San Mariano Campus, Sta. Filomena, San Mariano, Isabela.

Scope and delimitation of the study

The study utilized the available mudpress as the base component in the formulation and development of organic fertilizer and evaluated the efficacy on cowpea. The parameters gathered were plant height, nodule count (effective and non-effective), number of marketable pods, weight of pods per plant per sampling area and yield per hectare. The impact of organic fertilizer on soil properties is limited to nutrient composition, microbial count of bacteria and fungi.

Materials and Methods

Production of organic fertilizer using mudpress

The major substrate used in the production of organic fertilizer was mudpress, a waste product from sugarcane processing, which was obtained from Green Future Innovations, Inc., a private company located in Sta. Felomena, San Mariano, Isabela, whose products and by-products are derived from sugarcane. The formulated organic fertilizer consisted of 60 % mudpress and 30 % cow manure. Carbonized rice hull (CRH) was incorporated as a filler, making up about 10 % of the product. Effective microorganisms (EM), diluted at a ratio of 1:1000 with water, were drenched into the mixture and served as inoculants to accelerate the decomposition process. To further enrich the nutrient composition, leguminous crop residues such as *Leucaena* and *Gliricidia* leaves were added to enhance N content, while banana bracts were incorporated to improve K levels. The organic fertilizer was assessed in terms of the following:

Rate of decomposition

After having been thoroughly mixed all substrates, the pre decomposed substrates were piled in a concrete pen, drenched with diluted effective microorganism to enhance decomposition. The initial weight of the organic fertilizer was 100 kg and was allowed to further decompose for 2 weeks. The final weight after harvest was 83.50 kg. The rate of decomposition was 5.96 kg day^{-1}.

Percent (%) recovery

Substrates weighed 100 kg with an estimated initial moisture content of 60 %. Two weeks of decomposition took place and substrates were harvested with a weight of 83.50 kg % recovery was 83.5 %.

Nutrient and organic matter content

A composite sample of the developed organic fertilizer was submitted to the Department of Agriculture–Cagayan Valley Integrated Agricultural Laboratory (DA-CVIAL), subjected to laboratory analysis. Nutrients analyzed include such (a) N 0.70 % (b) P 0.72 % (c) K 1.14 % (d) zinc (Zn) 0.05 ppm, (e) copper (Cu) 0.02 ppm, (f) manganese (Mn) 0.17 ppm, (g) iron (Fe) 1.56 ppm.

Cost of production

Based on a hectare basis, the cost of production in producing a home-made organic fertilizer for 1 metric tonne was P2500 or P125 per bag.

Efficacy of organic fertilizer on cowpea

A field trial was established using cowpea as a test crop at the Isabela State University-San Mariano research experimental area to evaluate the efficacy of the formulated organic fertilizer. The area selected has 0-5 % slope provided with a ready source of irrigation water, accessible and secured to both humans and animals.

Soil sampling

A composite soil sample of 1 kg representing the whole experimental area was collected and submitted to the DA-CVIAL, Carig Sur, Tuguegarao City, for laboratory analysis before the experiment was conducted.

Land preparation

The experimental area was thoroughly prepared with a double pass harrowing by a 4-wheel tractor and manual labor in the construction of plots by treatment and replication.

Securing seeds

Cowpea seeds were secured at the Department of Agriculture-Cagayan Valley Research Center, San Felipe, Ilagan City.

Field layout, design and treatments

The experimental area was divided into 3 equal blocks, each further subdivided into 6 equal plots with dimensions of 3.0 m × 3.0 m. The treatments were randomly assigned following the randomization procedure for a randomized complete block design (RCBD). By arranging the experiment into 3 blocks, the minimum degree of freedom for error was achieved, as blocking helped account for field variability while still allowing sufficient replication to provide a reliable estimate of experimental error. The treatments were the following:

T1	Control
T2	20-40-45 kg NPK ha^{-1}
T3	10-20-22.5 kg NPK ha^{-1}
T4	10-20-22.5 kg NPK ha^{-1} + 20 bags OF ha^{-1}
T5	20-40-45 kg NPK ha^{-1} + 20 bags OF ha^{-1}
T6	20 bags OF ha^{-1}

T = treatments; OF = organic fertilizer.

Fertilizer application

The recommended rate of organic fertilizer was applied as basal in bands on a per-hectare basis. For treatments requiring a mixture, the organic fertilizer was combined with muriate of potash, following the recommendations derived from the soil laboratory analysis for cowpea.

Planting and replanting

Cowpea was planted 2 seeds per hill at a distance of 30 cm between hills and 50 cm between rows. Missing hills were immediately planted to maintain the desired plant population. Thinning was done 2 weeks after emergence by maintaining one plant per hill to avoid nutrient competition.

Plant care and management

Cultivation

Hilling-up was done using a grab hoe 3 weeks after emergence to suppress the growth of emerging weeds.

Water management

Irrigation water was applied through sprinkler during planting and every 3 days thereafter up to 3 weeks to maintain soil moisture needed by the plants for growth and development during reproductive and early pod formation.

Weed management

Emerging weeds were removed immediately through hand weeding to keep the experimental area clean and free of weeds.

Crop protection

Occurrence of pests and diseases was controlled by manual picking and uprooting of plants infected with diseases.

Harvesting

Pods were harvested as vegetables when seeds were fully developed inside the pods. Harvesting of pods was done per sample plant and per plot, weigh and record immediately.

Data gathered

Plant height

The plant height of 10 representative sample plants per treatment was measured at 20, 40 and 60 days after planting (DAP). The heights were measured from the base of the plant up to the tip of the highest pod stalk.

Number of marketable pods per plant

The number of harvested pods per 10 sample plants was counted up to the last priming. The total number of pods of the sample plants was divided by 10 to get the average number of marketable pods per plant.

Number of effective and non-effective nodules

Ten sample plants were considered per treatment. The number of effective nodules and non-effective nodules per sample plant was properly counted and recorded.

Fresh weight of pods per plant and per sampling area

The fresh pods harvested were weighed every priming and recorded up to the last priming, summed up and divided by the number of samples to obtain the average number of fresh pods per plant. Fresh weight of pods per sampling area was obtained by multiplying the fresh weight per plant by the plant population of the sampling area.

Computed yield per hectare

The computed yield was based on the average yield per plant x plant population per hectare (66666 plants ha^{-1}), expressed in kg.

Effect of organic fertilizer on selected soil properties

Simultaneously with the efficacy trials, an evaluation was conducted to determine the effects of the organic fertilizer on soil productivity and its various properties, including microbial diversity, as well as physical and chemical characteristics. To accomplish this, soil samples were randomly collected from each plot at a depth of 30 cm both before the application of treatments and after the completion of the experiment. The collected samples were then submitted to the DA-CVIAL in Carig Sur, Tuguegarao City, for comprehensive analysis. This procedure ensured that changes in soil quality parameters could be accurately assessed and attributed to the application of organic fertilizers.

Statistical analysis

All the data gathered were recorded and analysed following the analysis of variance (ANOVA) for a RCBD. The Duncan's multiple range test (DMRT) was used for mean comparison.

Results

Site characterization

San Mariano, Isabela is located in the north-eastern part of Isabela Province at 16°59'0" North latitude and 122°0'58" East longitude. The soil in the study area is classified as Ilagan sandy clay loam, which is a residual soil derived from sandstones and gravels. These soils are moderately deep, well-drained and typically found on undulating to rolling low shale and sandstone hills.

Based on the initial soil analysis, the area has moderate natural fertility, with values of 1.10 % N, 0.51 ppm P, 20 ppm K and a soil pH of 4.8. The soil profile is characterized by the presence of partially and highly weathered rock fragments in the substratum. It is classified as fine, mixed, isohyperthermic Typic Haplustalfs. The dominant land use in the area is grassland with scattered mixed tree species. In level to rolling portions, the land is commonly planted with upland rice, root crops and pasture.

Stand and vigor of the plants

During the 1st month, all plants across the 6 treatments appeared healthy and vigorous. However, in the succeeding months, nutrient deficiency symptoms were observed in crops under Treatment 1, as indicated by pale green leaves, thinner stems and reduced plant height. In contrast, plants in the other five treatments exhibited green to deep green leaves, firm and robust stems and healthy branches emerging from the main stems. At 50 DAP, the plants were detopped to manage excessive growth and stimulate the emergence of more flowers.

Occurrence of insect pests and diseases

During the first 3 weeks after planting, no insect pests were observed on the plants. However, a few leaf folders appeared later, but these were easily managed through manual picking. During the pod development stage, pod borers were noted attacking the young pods. With regard to diseases, 2 types were observed: cowpea yellow mosaic virus and bacterial pustule (bacterial spot) caused by *Xanthomonas sp*. Only 2 hills were affected and the diseased plants were immediately removed and replaced with healthy plants from the border plots to maintain the desired plant population.

Days to first flowering

The first flowers appeared 37 DAP in treatments 1, 5 and 6, followed by treatments 2, 3 and 4 at 40 DAP.

Climatic data during the experiment

The climatic data during the conduct of the study were obtained from the DOST-PAGASA Station at ISU-Echague, Isabela. Weekly maximum temperatures ranged from 24.71 °C to 30.27 °C, while minimum temperatures varied from 19.37 °C to 22.84 °C. Relative humidity was high in the morning, ranging from 90.42 % to 96.71 % and slightly lower in the afternoon, ranging from 62.42 % to 85.42 %. Rainfall received by the crop, from early development up to the last pod priming, ranged between 0.04 mm and 17.27 mm.

Soil properties as influenced by organic fertilizer application

As gleaned from Table 1, the soil pH before organic fertilizer application was 4.8 and after harvest, it was 5.2. Bulk density decreased from 1.29 to 1.15 g cm^{-3}, which indicates improvement of soil porosity that influences the movement of air and water. The soil organic matter, N and K decreased, while the increase in P indicates improvement from 0.51 ppm (very low) it increased to 15 ppm (high).

Table 1. Soil properties as influenced by organic fertilizer application

	Soil properties	Before	After
1	pH	4.8	5.2
2	Bulk density (g cm^{-3})	1.29	1.15
3	Organic carbon (%)	12.76	10.91
4	Organic matter (%)	22.00	18.80
5	Nitrogen (%)	1.10	0.94
6	Phosphorus (ppm)	0.51	15.00
7	Potassium (ppm)	20.00	15.00
8	Bacteria (cfu mL^{-1})	2.9×10^4	5.9×10^5
9	Fungi (cfu mL^{-1})	3.2×10^3	4.4×10^4

The application of organic fertilizer was found to increase both bacterial and fungal populations in the soil. Organic matter introduced through organic fertilizers stimulates microbial growth and activity, thereby enriching soil biological processes. In general, the use of organic fertilizers and various composts led to higher populations of bacteria, fungi and actinomycetes compared to chemical fertilizers. However, the extent of this increase varied depending on factors such as the type of organic fertilizer used, the rate of application, the soil type and the timing of observation.

In some instances, compost or farmyard manure did not significantly increase microbial density compared to mineral fertilizers, suggesting that the effect of organic amendments on microbial populations is not always consistent throughout the growing season. Nonetheless, bacterial and fungal counts were relatively more abundant in the organic fertilizer-treated plots during certain growth stages, indicating that organic fertilizers positively influenced the soil microbial community, particularly at specific periods of the cropping cycle.

Nutrient content of organic fertilizer derived from mudpress

Table 2 presents the nutrient composition of the organic fertilizer derived from the mudpress. The length of time needed for the decomposition of the substrates is 14 days, since the compost piles have similar quantities of sugarcane sludge and poultry manure. The more fibrous the plant materials, the longer the period needed for composting (25). Furthermore, % of recovery is 83.5 %. The compost showed high organic matter content with 14 %, while organic carbon content is also high at 5.12 %. The presence of large quantities of organic carbon in a compost helps improve the physical and chemical properties of soils. The most common changes due to continuous compost application are improved water holding capacity, increased soil aeration and increased soil pH. The composting period for sugarcane sludge was hastened by the poultry manures and other

Table 2. Characteristics of the formulated organic fertilizer

Parameters	Analysis	Philippine National Standard
Rate of decomposition (kg day^{-1})	5.96	-
Amount of initial substrates (kg)	100	-
Amount of product (kg)	83.50	-
Percent recovery (%)	83.50	-
Color	Black	Brown to black
Consistency	Friable	Friable
Odor	None	None
pH	7.1	6.5-7.5
Organic carbon (%)	8.12	-
OM content (%)	14.00	≥20
N (%)	0.70	-
P (%)	0.72	-
K (%)	1.14	-
Zn (ppm)	0.05	-
Co (ppm)	0.02	-
Mn (ppm)	0.17	-
Fe (ppm)	1.56	-
Bacteria (cfu mL^{-1})	3.2 × 106	-
Fungi (cfu mL^{-1})	3.7 × 105	-

organic wastes with a lower C: N ratio. Usually, sugarcane sludge has low N content but is rich in carbon, giving a high initial C:N ratio. The initial C:N ratio of the substrates used for composting plays a major role in determining the length of the composting period. If substrates have an initial C:N ratio of 25:1, the composting period can be shortened to only 3 weeks (26).

The NPK level is considerably low compared to chemical fertilizers, with mean values of 0.70 % N; 0.72 % phosphorus pentoxide (P_2O_5) and 1.14 % potassium oxide (K_2O). However, the compost contains a wide range of plant nutrients that are essential for crop growth which are not available in chemical fertilizers. Total NPK of the composts is 2.56 % which is lower than the 5 % required for a material to be considered organic. The compost contains Fe, Zn, Cu and Mn and probably contains several other micronutrients which were not included in the analysis. These micronutrients are not present in the ordinary formulations of inorganic fertilizer sold on the market. The produced composts have more bacteria than fungi. Microbial count is 3.2×10^6 cfu mL^{-1} for bacteria and 3.7×10^5 cfu mL^{-1} for fungi and no rhizobia detected.

Field evaluation of organic fertilizer on cowpea

Table 3 shows the height of cowpea plants at 20, 40 and 60 DAP as influenced by inorganic and decomposed organic fertilizers.

At 20 DAP, the tallest plants were observed in T5 (20-40-45 kg NPK ha^{-1} + 20 bags OF ha^{-1}) with a mean height of 14.17 cm (a), which was significantly higher than the control (T1, 10.93 cm, c). Treatments T3, T6, T4 and T2 produced comparable plant heights of 12.83, 12.67, 12.23 and 12.10 cm, respectively (b), indicating they were not significantly different from each other but significantly taller than the control.

At 40 DAP, significant differences were also observed with all treated plants producing taller plants than the control (T1, 46.60 cm, b), which was significantly shorter than the fertilized treatments (T2–T6, a).

By 60 DAP, T5, T4, T3, T2 and T6 produced the tallest plants with comparable mean heights of 64.83, 63.87, 63.73, 61.50 and 64.90 cm, respectively (a–b), while the control remained the shortest (55.43 cm, c). These differences in plant height could be attributed to the increased availability of N, P and other nutrients and the improvement in soil structure provided by organic matter.

Such differences in plant height could be attributed to the abundance of N, P and other nutrients and improvement in soil texture and structure by the presence of a high amount of organic matter in the organic fertilizer application. The application of organic fertilizer from mudpress to the crops has positively affected the plant growth parameters (27).

Table 4 presents the number of marketable pods. The highest number of pods was produced by T5 and T4 (19.00 and 18.83, a), which were significantly higher than T3 (12.50, c) and the control (9.70, d). T6 (17.07, ab) and T2 (16.20, b) had intermediate values, showing that organic fertilizer alone or moderate NPK can also improve pod production. The ANOVA result indicates these differences are statistically significant at $p < 0.01$.

Table 4. Number of marketable pods of cowpea applied with inorganic and organic fertilizers

Treatments ($p < 0.05$)	Number of marketable pods
T_1 - Control	9.70^d
T_2 - 20-40-45 kg NPK ha^{-1}	16.20^b
T_3 - 10-20-22.5 kg NPK ha^{-1}	12.50^c
T_4 - 10-20-22.5 kg NPK + 20 bags OF ha^{-1}	18.83^a
T_5 - 20-40-45 kg NPK + 20 bags OF ha^{-1}	19.00^a
T_6 - 20 bags OF ha^{-1}	17.07^{ab}
ANOVA result	**
C.V. (%)	2.59

The effect of organic fertilizer from mudpress helped increase the number of pods per plant because of its positive effect on soil, nutrients' availability and organic matter contents along with pH, exchangeable calcium (Ca) and magnesium (Mg) in the soil as shown in Table 2. NPK and macronutrient content of the soil applied with 20 bags of organic fertilizer from the mudpress increased because the mudpress is rich in these nutrients. Other researchers have also found mudpress a good nutrient source (28). Increase in the organic matter content, total porosity of the soil and decrease in bulk density might have improved the nutrients availability, soil physical qualities, water holding capacity, water holding capacity and population of microbial organisms. These are extremely important changes because an increase in organic matter content of soil due to mudpress might have improved soil physical conditions, reducing bulk density and increasing porosity. The reduction in bulk density helps in better root development and proliferation. The reduction in bulk density helps in better root development. On the other hand, an increase in porosity helps in better soil aeration and water retention. These results are also in accordance with the findings of researchers who have reported an increase in macro and micronutrient contents of the soil after the mixture of sugarcane trash and mudpress (29).

Table 5 shows the number of branches. Fertilized treatments T2–T6 (5.43–5.63, a) produced significantly more branches than the control (T1, 4.37, b), as indicated by the letter superscripts. No significant differences were observed among fertilized treatments highlighting that fertilizer type had less influence on branching than on other growth parameters.

The mudpress or filter cake is one of the organic wastes capable of supplying a sufficient amount of plant nutrients to soil. Due to its favourable effects on the physical condition of the soil, the water holding capacity and aeration of the soil are improved. The high amount of NPK content has made it a valuable nutrient resource (9). Along with a luxurious amount of organic matter, important micronutrients like Zn, Cu, Fe and Mn are also abundant in mudpress, being deficient in calcareous soils (29). Therefore,

Table 3. Plant height (cm) of cowpea applied with inorganic and organic fertilizers

Treatments ($p < 0.05$)	Plant height (cm)		
	20 DAP	40 DAP	60 DAP
T_1 - Control	10.93^c	46.60^b	55.43^c
T_2 - 20-40-45 kg NPK ha^{-1}	12.10^b	55.60^a	61.50^b
T_3 - 10-20-22.5 kg NPK ha^{-1}	12.83^b	62.50^a	63.73^a
T_4 - 10-20-22.5 kg NPK + 20 bags OF ha^{-1}	12.23^b	57.53^a	63.87^a
T_5 - 20-40-45 kg NPK + 20 bags OF ha^{-1}	14.17^a	57.67^a	64.83^a
T_6 - 20 bags OF ha^{-1}	12.67^b	59.43^a	64.90^a
ANOVA result	*	**	**
C.V. (%)	6.79	6.23	2.47

Table 5. Number of branches of cowpea applied with inorganic and organic fertilizers

Treatments ($p < 0.05$)	Number of branches
T_1 - Control	4.37[b]
T_2 - 20-40-45 kg NPK ha^{-1}	5.47[a]
T_3 - 10-20-22.5 kg NPK ha^{-1}	5.43[a]
T_4 - 10-20-22.5 kg NPK + 20 bags OF ha^{-1}	5.53[a]
T_5 - 20-40-45 kg NPK + 20 bags OF ha^{-1}	5.63[a]
T_6 - 20 bags OF ha^{-1}	5.47[a]
ANOVA result	**
C.V. (%)	1.03

mudpress is more likely to improve the micronutrient distribution and enhance microbial activities.

Table 6 shows the length of pods. T5, T4 and T6 produced the longest pods (18.20, 16.93 and 17.53 cm, a), which were significantly longer than T2 (14.52, b), T3 (13.52, b) and the control (12.70, b), as indicated by letter groupings. The ANOVA result confirms that fertilizer significantly influenced pod length. The differences in the pod length are attributed to the nutrient's availability after treatment of the soil with organic fertilizer from the mudpress. The result is also in agreement with the findings (30) that organic fertilizers from sugarcane sludge significantly increased the length of pods of cowpea.

Table 6. Length (cm) of pods of cowpea applied with inorganic and organic fertilizers

Treatments ($p < 0.05$)	Length of pods (cm)
T_1 - Control	12.70[b]
T_2 - 20-40-45 kg NPK ha^{-1}	14.52[b]
T_3 - 10-20-22.5 kg NPK ha^{-1}	13.52[b]
T_4 - 10-20-22.5 kg NPK + 20 bags OF ha^{-1}	16.93[a]
T_5 - 20-40-45 kg NPK + 20 bags OF ha^{-1}	18.20[a]
T_6 - 20 bags OF ha^{-1}	17.53[a]
ANOVA result	**
C.V. (%)	2.77

Table 7 presents the weight of pods per plant. The heaviest pods were recorded in T5 and T4 (79.80 and 79.10 g, a), significantly higher than T6 (71.92 g, b), T2 (68.13 g, c), T3 (51.25 g, d) and the control (38.80 g, e). The letters (a–e) indicate statistically significant differences at $p < 0.05$, while the ANOVA result confirms these differences are highly significant. The least weight of pods was attained by untreated plants (T1) with a mean of 38.80 g. These findings are analogous to the result of study (30) that significant increase in yield and other important yield parameters of the cowpea due to mudpress application in the form of organic fertilizer.

Table 7. Weight (g) of pods of cowpea applied with inorganic and organic fertilizers

Treatments ($p < 0.05$)	Weight of pods (g)
T_1 - Control	38.80[e]
T_2 - 20-40-45 kg NPK ha^{-1}	68.13[c]
T_3 - 10-20-22.5 kg NPK ha^{-1}	51.25[d]
T_4 - 10-20-22.5 kg NPK + 20 bags OF ha^{-1}	79.10[a]
T_5 - 20-40-45 kg NPK + 20 bags OF ha^{-1}	79.80[a]
T_6 - 20 bags OF ha^{-1}	71.92[b]
ANOVA result	**
C.V. (%)	2.59

Table 8 shows pod weight per sampling area. T5 and T4 (5.27 and 5.22 kg, a) produced the highest yields, which were significantly higher than T6 (4.75 kg, b), T2 (4.50 kg, b), T3 (3.38 kg, c) and T1 (2.56 kg, d). The ANOVA confirms these differences are highly significant, indicating combined fertilizers improve total pod yield per area.

Table 8. Weight (kg) of pods per sampling area

Treatments ($p < 0.05$)	Weight per sampling area (kg)
T_1 - Control	2.56[d]
T_2 - 20-40-45 kg NPK ha^{-1}	4.50[b]
T_3 - 10-20-22.5 kg NPK ha^{-1}	3.38[c]
T_4 - 10-20-22.5 kg NPK + 20 bags OF ha^{-1}	5.22[a]
T_5 - 20-40-45 kg NPK + 20 bags OF ha^{-1}	5.27[a]
T_6 - 20 bags OF ha^{-1}	4.75[b]
ANOVA result	**
C.V. (%)	2.60

Table 9 presents effective and ineffective root nodules. The highest number of effective nodules was observed in T3 (101.25, a), significantly higher than T1 (97.53, b) and T2 (79.76, c). Treatments with combined fertilizers (T4, T5) had significantly fewer effective nodules (25.33, e; 16.67, f), likely due to suppression of biological nitrogen fixation by high N availability. Ineffective nodules were highest in the control (17.57, a) and lowest in T6 (2.93, d), demonstrating that organic fertilizer can enhance root nodule efficiency. The ANOVA results confirm significant differences among treatments.

These results in yield differences are in agreement with the work of other researchers who found a significant increase in cowpea yield due to organic amendments such as mudpress (13). Increase yield in cowpea in soil applied with mudpress has also been reported by some scientists (13). It is also evident from some other experiments that yield parameters in mungbean were also increased by application of organic amendments, including mudpress (15).

Table 10 shows computed yield per hectare. The highest yields were obtained in T5 (5855.56 kg ha^{-1}, 5.86 t ha^{-1}) and T4 (5800 kg ha^{-1}, 5.80 t ha^{-1}, a), which were significantly higher than T6 (5277.78 kg ha^{-1}, b), T2 (5000 kg ha^{-1}, b), T3 (3755.56 kg ha^{-1}, c) and T1 (2844.44 kg ha^{-1}, d). The ANOVA results indicate that the differences are statistically significant.

Application of 20 bags of organic fertilizer derived from mudpress significantly increased the yield of cowpea regardless of whether it is added with inorganic fertilizer at full and half rates. This is attributable to the nutrient content and organic matter derived from the amendment. NPK and macronutrient content of the soil applied with 20 bags of organic fertilizer from the mudpress increased because the mudpress is rich in these nutrients. Other researchers have also found mudpress a good nutrient source (27).

Table 9. Number of effective and ineffective root nodules

Treatments ($p < 0.05$)	Number of root nodules	
	Effective	Ineffective
T_1 - Control	97.53[b]	17.57[a]
T_2 - 20-40-45 kg NPK ha^{-1}	79.76[c]	11.70[b]
T_3 - 10-20-22.5 kg NPK ha^{-1}	101.25[a]	17.17[a]
T_4 - 10-20-22.5 kg NPK + 20 bags OF ha^{-1}	25.33[e]	5.77[c]
T_5 - 20-40-45 kg NPK + 20 bags OF ha^{-1}	16.67[f]	6.07[c]
T_6 - 20 bags OF ha^{-1}	42.13[d]	2.93[d]
ANOVA result	*	**
C.V. (%)	46.17	36.80

Table 10. Computed yield per hectare (yield ha^{-1})

Treatments ($p < 0.05$)	Pod yield per hectare	
	kg	t
T_1 - Control	2844.44	2.84
T_2 - 20-40-45 kg NPK ha^{-1}	5000.00	5.00
T_3 - 10-20-22.5 kg NPK ha^{-1}	3755.56	3.76
T_4 - 10-20-22.5 kg NPK + 20 bags OF ha^{-1}	5800.00	5.80
T_5 - 20-40-45 kg NPK + 20 bags OF ha^{-1}	5855.56	5.86
T_6 - 20 bags OF ha^{-1}	5277.78	5.28
ANOVA result	*	**
C.V. (%)	55.32	8.70

Increase in the organic matter content, total porosity of the soil and decrease in bulk density might have improved the nutrients availability, soil physical qualities, water holding capacity, water holding capacity and population of microbial organisms. These are extremely important changes because an increase in organic matter content of soil due to mudpress might have improved soil physical conditions, reduced bulk density and increased porosity. The reduction in bulk density helps in better root development and proliferation. On the other hand, an increase in porosity helps in better soil aeration and water retention. These results are also in accordance with the findings of researchers who have reported an increase in macro and micronutrient contents of the soil after the mixture of sugarcane trash and mudpress (29).

Conclusion & Recommendations

It could be concluded from the study that mudpress is rich in organic matter, NPK and micronutrients like Zn, Cu, Fe and Mn, which is more likely to cause improvement in the physico-chemical characteristics of the soil and influence the soil environment favourably. All the important growth and yield parameters of cowpea, like plant height, number of pods, pod weight per plant and per sampling area and yield were increased with the addition of 20 bags OF ha^{-1} derived from mudpress. The study showed that mudpress can be used as a substrate in the production of organic fertilizers. Likewise, the developed organic fertilizer is effective in enhancing the growth and yield performance of cowpea under wet season planting if applied along with inorganic fertilizer (full or half rate). The study proved that the organic fertilizer produced from mudpress, chicken manure and CRH mixture at a 6:3:1 ratio is effective as a substitute for at least half of the recommended rate of NPK, which could reduce production cost in cowpea production.

Based on the result of the study, mudpress/sugarcane sludge can be used as substrate for organic fertilizer production and can be used to lessen the use of inorganic fertilizer to at least 50 %. It could be inferred from the study that mudpress transformed into organic fertilizer at 20 bags or 1 t ha^{-1} could be recommended as the most suitable rate for cowpea production in the soils of ISU San Mariano campus.

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