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Response of Cabbage (*Brassica oleracea var capitata* L.) to Organic and Inorganic Fertilizer

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Authors' contributions

This work was carried out in collaboration among all authors. Author PYD designed the study and carried out the experiment, author CAD reviewed each chapter, wrote the protocol and wrote the first draft of the manuscript. Author FN managed the analyses of the study and reviewed the work. Author PFR managed the literature searches. Author EAO performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The experiment was conducted in the Kintampo North Municipality during the 2017 cropping season from August to November to evaluate the response of cabbage to different soil amendments.
Methods: It was a single factor experiment laid out in a Randomized Complete Block design with three replications. The five treatments which includes NPK 15-15-15, poultry manure, cow dung and goat manure and a control.
Results: Parameters measured were plant height, number of leaves, leave length, canopy diameter, head diameter and head weight. Generally, all treatments performed better than the control used in the study.
Conclusions: Poultry manure performed similar to NPK 15-15-15, and were superior to all other treatments in all parameters measured. Cow dung and goat manure performed fairly well in the parameters measured.

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Recommendation: The study therefore recommends the application of poultry manure for improved growth, yield maximization and sustainable cabbage production. Application of cow dung and goat manure can also be adopted for appreciable yields of cabbage.

Keywords: Poultry manure; cow dung; goat manure; NPK.

1. INTRODUCTION

Cabbage (*Brassica oleracea var capitata* L.) is a temperate vegetable crop cultivated worldwide including African countries and has become very popular in tropical Africa [1]. Cabbage has traditionally been used for medical purposes as well as for cooking. It has been accepted for the nutritional and Non-nutritive bioactive ingredients [2]. The ancient Greeks used fresh white cabbage juice to treat sore and infected eyes and juice from the cabbage stem is a good remedy for ulcers. Traditionally, the Romans and Egyptians drink cabbage juice before big dinners to prevent intoxication. [3], reported that, cabbage seeds are used to prevent hangovers.

Nutritionally, cabbage is a good source of beta-carotene, vitamins C and fiber. It is a cruciferous vegetable and has been shown to reduce the risk of some cancers, especially those in the colorectal group. This is possibly due to the glucosinolates found in Cole group, which serve as metabolic detoxicants or due to the sulphoraphane content, also responsible for metabolic anti-carcinogenic activities. Purple cabbage also contains anthocyanins, which in other vegetables have been proven to have anti-carcinogenic properties [4]. It is also a good source of calcium; 250 ml of raw cabbage contains 21 kilocalories and when cooked it contains 58 kilocalories [5]. Along with other Cole crops, cabbage is a source of indole-3-carbinol, a chemical that boosts DNA repair in cells and appears to block the growth of cancer cells [6]. Cabbage cultivation provides income to the rural, peri-urban farmers and market women in Ghana.

As in many other sub-Sahara African countries, majority of urban dwellers in Ghana still remain poor. This group lives in sub-standard areas especially slums, have less access to protein and other nutritious food and face huge economic hardship [7]. They are normally referred to as the urban poor who have sought alternative remedial measures to the improvement of their economic wellbeing through the adoption and embarking on intensive sustainable peri-urban agricultural activities. Vegetable production and marketing are mostly undertaken in large scale since the capital requirement is lower and more affordable compared to livestock and poultry. Such activities of peri-urban agriculture have in recent times assisted in improving livelihood earnings of farmers and has further empowered them in meeting other non-food household commitments such as paying of school fees for their children, meeting costs of medication and house rents. Moreover, the economy has also benefited from revenue generated from the production and marketing of vegetables in Ghana. For instance, Ghana generated revenue of US$ 11.5 million and US$ 75.64 million from exportation of organic fruits and vegetables respectively within 1995 to 2006 [8].

Cabbage requires a fertile soil for proper growth and development; therefore, it need to provide some form of nutrients. Inorganic fertilizers used by farmers in the country are expensive and sometimes difficult to obtain at the appropriate time. Inorganic fertilizers can also have adverse effects on the soil, if not used properly. Repeated application of nitrogenous fertilizers such as ammonium nitrate and sulphate of ammonia tend to acidify the soil [9]. Organic manures such as animal manure is important for cabbage production. Problems of animal manure disposal such as Air pollution resulting from the odour and pollution of water bodies through leaching are difficult to cope with, under conditions of a concentrated animal feeding system. The challenge is to use this waste effectively for crop production to increase yields while at the sometime minimizing its potential adverse effect on environmental quality.

Furthermore, recycling of animal manure for vegetable production will not only reduce the need for additional inorganic fertilizer elements but simultaneously provide organic matter and soil cover that are essential for sustainable agriculture. This farm yard manure (FYM) are abundant among small holder farmers who practices mixed farmer. Therefore, this study aimed to determine the effect of using organic and inorganic fertilizers on the growth and yield of cabbage production in the Kintampo North Municipality. The objectives of this study were to determine the fertility status of the soil, and the

effects of organic and inorganic fertilizers on the growth and yield of cabbage.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out in the Kintampo North Municipality of the Brong Ahafo region of Ghana. The area is located between latitude $8^0$45`N and $7^0$45`N and longitude $1^0$20` W and $2^0$1` E. The mean monthly temperature ranges from 25^0C to 30^0C with the mean annual temperature between 26.5 ^{0}C and 27.2 ^{0}C. The mean annual rainfall is between 1,400mm-1,800mm and occurs in two seasons; from May to June (major) and from September to October (minor) [10]. The type of soil found in the area is loamy fine sand.

2.2 Experimental Design and Treatment

The study was a single factor experiment laid out in a Randomized Complete Block Design with three replications. A total of five treatments were made up of three organic amendments (poultry manure, cow dung and goat dropping), inorganic fertilizer (NPK 15-15-15) and a control as indicated in Table 1.

2.3 Nursing of Seeds

The variety used for the study was “Fortune” a cabbage variety used by vegetable farmers. 0.1 kg of seeds were sown on a nursery bed by drilling 10 cm apart. The bed was then covered with palm fronds and watered periodically. Palm fronds were removed after emergence and shade was erected for the young seedlings. Malformed and week seedlings were thinned out. Seedlings were transplanted three weeks after the nursing of seeds.

2.4 Land Preparation

The land was cleared and tilled manually by hoeing. The land was lined and pegged, and demarcated into experimental units measuring 3m x 4m with an alley of 1m and 2m between plots and replications respectively. Respective experimental units were labeled for treatment application.

2.5 Soil Sampling and Analysis

Five soil cores were sample along each of the diagonals of the experimental area with a core sampler. The samples were thoroughly mixed, air-dried and sieved. Approximately 200g of the soil sample was taken for laboratory analysis. The sample was analyzed for pH, N, P and K.

2.5.1 Determination of soil pH

A 10-g air- dried soil sample was weighed into a 100-ml beaker and 25 ml distilled water added. The HT 9017 pH meter was used to read the pH value and the values recorded.

2.5.2 Total Nitrogen (N)

The Kjeldahl procedure modified was used to determine total N to include the mineral nitrates in the soil by the use of salicylic acid to convert all the nitrates into ammonium salts [11].

2.5.3 Available Phosphorus (P)

The Bray 1 extraction solution procedure [12] was used for available P. Phosphorus was analyzed by Pye-Unicam spectrophotometer at a wavelength of 660 nm with blue ammonium molybdate as reducing agent.

Table 1. Treatments, composition and application rate

Treatments	Composition	Application rate (kg/ha)
T1	Control	0 kg/plot
T2	Poultry manure	12 kg/plot
T3	Cow dung	12 kg/plot
T4	Goat manure	12 kg/plot
T5	NPK 15-15-15	0.3 kg/plot

The potassium content of the filtered extract is then determined using a Jenway PFP7 Flame Photometer [13].

2.6 Preparation and Analysis of Organic Amendments

The poultry, cow and goat droppings were decomposed. Approximately 200g each were sampled for laboratory analysis. They were analyzed for the following parameters; pH, N, P and K.

2.7 Application of Treatments

Organic amendments were decomposed before to application. Organic amendments were applied to plots 2 weeks before transplanting, and were incorporated into the soil with a hoe. NPK 15-15-15 was applied a week after transplanting.

2.8 Cultural Practices

Hoeing of weeds commenced two weeks after transplanting and was done thrice at two weeks interval. Field insect pests were controlled using K-optima (Lambda-cyhalothrin 15g/l, Acetamiprid 20g/l, EC). The application of the pesticide commenced two weeks after transplanting and was done at two weeks interval for four times.

2.9 Data Collection

Five plants were tagged in each plot for data collection. Data were collected on the following parameters:

2.9.1 Plant Height

Plant height was taken from the soil surface to the apex of the head with a meter rule. Means were computed and recorded in centimeters.

2.9.2 Number of leaves

The number of leaves on the tagged plants was countered. Averages were computed and recorded accordingly.

2.9.3 Leaf length

One leaf each was sampled from the bottom, middle and upper portion of each tagged plant, their lengths were measured. Averages were calculated and recorded in centimeters.

2.9.4 Canopy diameter

Diameter of leaf canopy was measured from two directions perpendicular using a ruler. Averages were computed and recorded in centimeters.

2.9.5 Head diameter

One head each was sampled from the bottom, middle and upper portion of each tagged plant, their lengths and breaths were measured and multiplied to obtain the heads area. Averages were calculated and recorded in square centimeters.

2.9.6 Head weight

Heads were weighed after harvest and recorded in kilograms. Yields were standardized by converting to kg/ha.

2.10 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using Genstat Statistical Package edition 12th. Means were separated using LSD at 5% level of significance.

3. RESULTS

Result of the soil analysis indicated that the soil was loamy fine sand, slightly acidic, low in total nitrogen, low in available phosphorus and potassium (Table 2). All the animal manure was slightly basic, poultry manure had relatively higher amounts of total nitrogen, available phosphorus and potassium, compared to cow dung and goat manure (Table 2).

Table 2. Soil and animal manure analysis

Sample	Parameter				
	pH	N (%)	P (%)	K (%)	Texture
Soil	6.54	0.10	9.33	12.00	Loamy sand
Poultry Manure	8.05	2.63	2.54	1.45	-
Cow Dung	9.32	1.10	0.22	0.64	-
Goat Manure	9.13	1.92	0.47	1.25	-

3.1 Plant Height

Plant height was significantly (P < 0.05) affected by the soil amendments at 15, 30 and 45 DAT (Days After Transplanting). Response in height of the plants was increasing trend within treatments at 15, 30 and 45 DAT for control, cow dung, goat manure, poultry and NKP respectively. Plants treated with NPK recorded the highest height (Fig. 1). It was followed by poultry manure, goat manure and cow dung, which recorded decreasing heights. The least plant height was recorded by plants from the control plots (Fig. 1).

3.2 Number of Leaves

The soil amendments significantly (P<0.05) affected number of leaves at 30 and 45 DAT. At these periods, application of NPK and poultry manure recorded the highest number of leaves (Fig. 2). It was followed by application of goat manure and cow dung, with the control plot recording the least number of leaves (Fig. 2). The highest number of leaves were recorded under poultry treatment (15 counts at 45 and 9 counts at 30 days after transplanting) and the least recorded under control (11 counts at 45 and 7 counts at 30 days after transplanting).

3.3 Leaf Length

Leaf length was significantly (P<0.05) affected by the soil amendments at 15DAT. Application of NPK was outstanding, recording the largest leaf length (9.0cm) among the treatments (Fig. 3). Is followed by performance by application of cow dung (6.0 cm), poultry manure (7.0 cm) and goat manure (7.5 cm). The least leaf length was recorded by the control plot (Fig. 3).

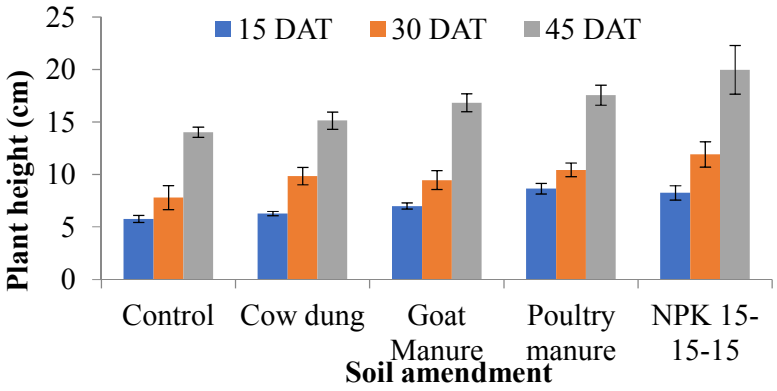

Fig. 1. Effect of soil amendment on plant height. Bars represent SEM

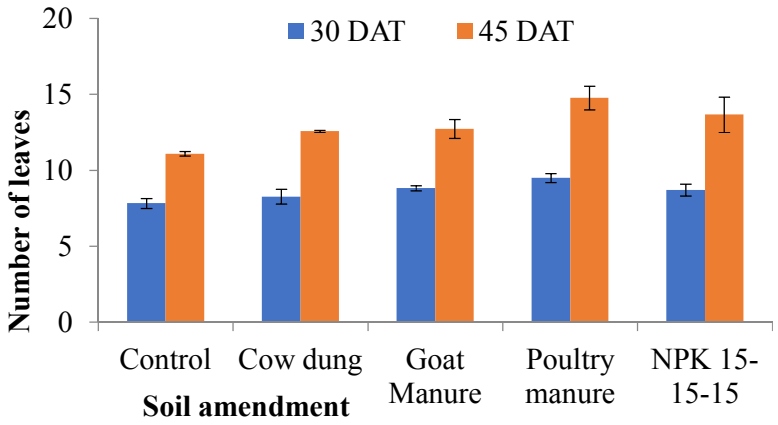

Fig. 2. Effect of soil amendment on number of leaves. Bars represent SEM

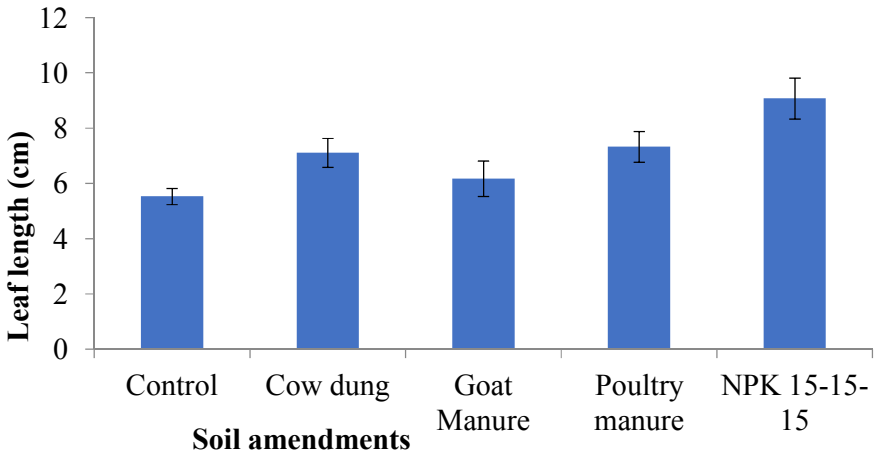

Fig. 3. Effect of soil amendment on leaf length. Bars represent SE (m)

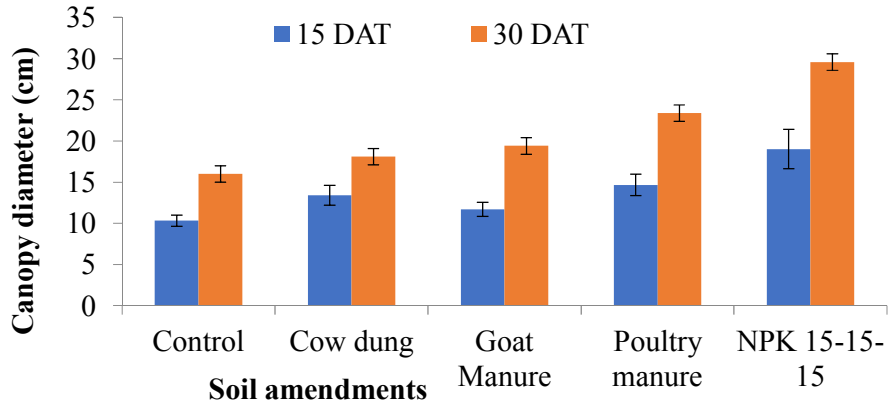

Fig. 4. Effect of soil amendment on canopy diameter. Bars represent SEM

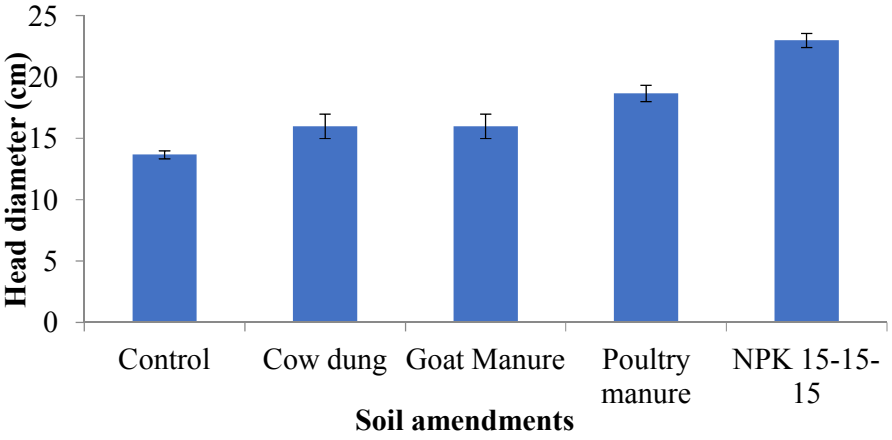

Fig. 5. Effect of soil amendment on head diameter. Bars represent SEM

3.4 Canopy Diameter

Soil amendment affected canopy diameter significantly (P<0.05) at 15 and 30 DAT. NPK recorded the widest canopy at 15 (20 cm) and 30 DAT (30 cm), and was followed by application of poultry manure (10 cm at 15 DAT and 15 cm at 30 DAT) as demonstrated in Fig. 4. These were followed by application of goat manure; whose performance was similar to application of cow dung. The smallest canopy diameter was recorded by the control plot (Fig. 4).

3.5 Head Diameter

Head diameter was significantly (P<0.05) affected by the soil amendments. NPK recorded the widest head diameter, and was followed by application of poultry manure (Fig. 5). These were followed by application of cow dung; whose performance was similar to application of goat manure. The smallest head diameter was recorded by the control plot (Fig. 5).

3.6 Head Weight

The soil amendments significantly (P<0.05) affected the head weight of cabbage. The highest head weight was recorded by application of NPK and poultry manure (Fig. 6). These were followed by cow dung and goat manure, with the control plot recording the least head weight (Fig. 6).

4. DISCUSSION

It was evident from the results obtained that the control (unfertilized) plot recorded the least performance in all parameters measured. This is because cabbage is a heavy feeder, requiring adequate and balanced amounts of essential nutrients for optimum growth and yield enhancement. This is confirmed by findings of [14] who reported that cabbage has high requirements for all nutrients, especially nitrogen, and cabbage demands for achieving high yields ranged from 130 to 310 kg N/ha. [15] also mentioned that adequate fertilization is required to increase the yield and improve the quality of cabbage.

Organic matter acts as a reservoir for plant nutrients and prevents leaching loss of nutrients which are vital for plant growth and also creates an environment that encourages beneficial soil organisms e.g. earthworms. Organic matter undergoes mineralization with the release of substantial quantities of nitrogen, phosphorus, sulphur and small number of micronutrients [16].

There is an assertion that poultry manure is among the most important animal manure that supplies adequate nutrients for plant growth [17]. The comparable performance of poultry manure shows that it is an efficient organic fertilizer and an important source of plant nutrients. He added that in addition to releasing nutrients, poultry manure also improves the physical properties of soil. [18] reported that 30 % of nitrogen from poultry litter is in urea or ammonium form and are therefore readily available. The average primary nutrient content of poultry is 3.03% N, 2.63% P_2O_5 and 1.4% K_2O. Application of 15 t/ha of poultry manure has also been recommended by [18] for higher yields of vegetables.

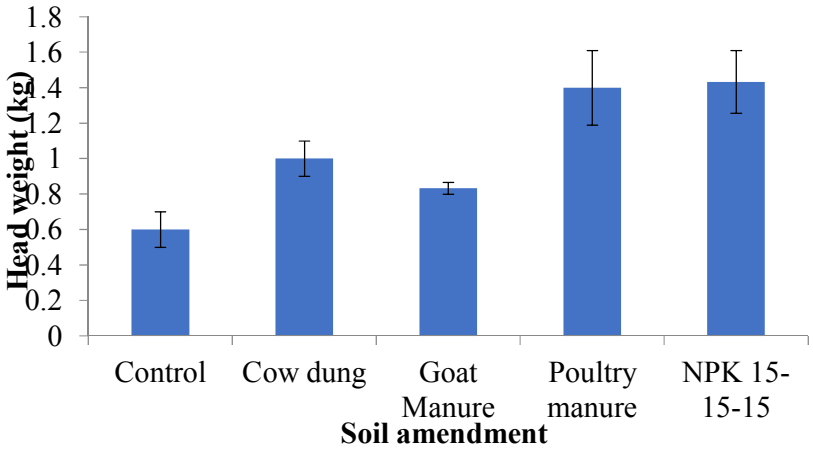

Fig. 6. Effect of soil amendment on head weight. Bars represent SEM

Table 3. ANOVA table of agronomic data taken for the experiment

Source of variation	d.f.	Plant Height			Number of leaves			Leaf length			Canopy diameter			Diameter	Weight
		15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT		
Rep stratum	2	0.6065**	11.3038**	10.129	0.2574	0.8722	1.309	4.1223	12.282	18.04	20.939	55.6	39.07	11.667	0.07267
Rep.*Units* stratum	4	4.5749**	6.7256**	15.845**	0.2991	1.1741**	5.572*	5.4433**	13.202	58.98	33.522**	86.54*	246.46	38.1**	0.391**
Treatment	8	0.5723	0.6894	3.381	0.1046	0.238	1.456	0.1936	3.968	18.06	2.291	17.27	69.4	5.5	0.061
Residual															
Total	14														

p< 0.05 significant difference at 5%, p<0.01 significant difference at 1%

The superiority of cow dung over the control and slightly over goat manure is because cow dung is known to be a rich source of different essential plant nutrients required for growth and development, especially for a crop like cabbage that has relatively high demand for nutrients. According to [19] cow dung is a rich source of different nutrients, providing 0.5 % N, 0.15 % P, 0.5 % K and moisture 60 ± 6 %. Similar result was obtained by [20] in kohlrabi.

Goat manure performed better than the control but was the least performing among the organic manure. It is believed that though the goat manure supplied nutrients to enhance growth, its nutrient supply potential was less than the amounts supplied by poultry and cow dung. This is supported by [21] who investigated the nutrient composition of different organic materials; buffalo, camel, cow, poultry and goat droppings, and found goat manure to be the least in terms of nutrient composition.

5. CONCLUSION AND RECOMMENDATION

It was evident from the result that application of 0rganic and inorganic fertilizer is improved field growth and yield enhancement in cabbage production, In general all treatments performed better than the control plot (plots without any fertilizer treatment) in all the parameters measured. Plots that received poultry manure performed similar to those that received NPK 15:15:15 treatment in all parameters measured. Plots that received cow-dung treatment performed the least among all the organic fertilizer treatments administered. While goat manure treatment performed better than the cow dung and the control plot.

Though inorganic NPK 15:15:15 was the best performing treatment, its performance was generally similar to poultry manure. Poultry manure was outstanding among the organic manure treatments, recording the best performance in growth and head weight. Cow-dung performed appreciably while goat manure was the least performing among the organic treatments. The study therefore recommends the application of poultry manure of 12 tons per hectare for improved growth, yield maximization and sustainable cabbage production. The study also recommends the application of cow dung and goat manure in the absence of poultry manure and NPK which is seen as expensive among small holder farmers for appreciable yields of cabbage.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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