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Effect of Poultry Manure Compost on Soil Fertility and Productivity Within a Protected Cultivation Environment in Polyhouse Condition

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ABSTRACT

Background: The effects of poultry manure compost (PMC) on soil fertility parameters under polyhouse conditions were monitored and investigated to study the soil nutrient availability and its improvement in soil fertility and productivity at FEEDS group of Institution, College of Agricultural Sciences, Hengbung, Manipur. PMC application improves the soil fertility and productivity and its efficiency increases with increase doses of PMC.

Methods: Poultry manure is collected from poultry farming shed, FEEDS, Hengbung for preparation of PMC. Randomized block design having six treatments (T) is applied using 2% PMC @T1, 4% PMC @T2, 6% PMC @T3, 8% PMC @T4, 10% PMC @T5 and 12% PMC @T6 with four replications in a polyhouse environment. Soil chemical analysis is done to evaluate the effect of PMC on soil nutrient availability. The yield of cabbage is taken to further study the soil productivity along with its fertility on application of PMC.

Result: The soil nutrient availability significantly increases with the incorporation of PMC doses in the order as follows, 12%>10%>8%>6%>4>2%. The applications of PMC in the soil under polyhouse condition significantly increases pH contents of soils when compare to control (c), as the pH of the poultry manure is 7.4 and makes the soil less acidic. The highest cabbage yield (79.8 t/ha) was obtained with T6 having 12 % of PMC. Incorporation of PMC into the soil in polyhouse improved soil quality and yield of cabbage.

Key words: Cabbage, Polyhouse, Poultry manure compost, Soil fertility, Soil heath.

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*) originates from northern European countries (Karaağaç *et al.*, 2016) and is widely used in gastrointestinal problems (Cavender, 2006). It is rich in fibers and vitamins. The whole fiber content in green cabbage is 2.53-4.32 g (Lonèarić *et al.*, 2020), vitamin C is 32.6-90.8 mg (Lonèarić *et al.*, 2020), vitamin K is 7.14-127 µg (Lee *et al.*, 2020) and vitamin A is 15.25-50 µg (Lee *et al.*, 2020). A polyhouse is a protected environmental condition where the entire area is covered with plastic material permitting the proper passage of sunlight where the crops can be grown throughout the year by maintaining the environmental condition. To maintain a suitable climate control conditions for crops, farmers should utilize protected cultivation like polyhouse or greenhouse (Gopi *et al.*, 2019). PMC is known for its capacity to improve the fertility of the soil by enhancing the availability of soil nutrients and increasing the crop yield through nutrient uptake by plants (Gunes *et al.*, 2014). The utilization of PMC as a source of soil nutrient in northeast India have a positive impact on the cultivation of crops as it supports the growth and yield by protecting soil health and fertility. PMC can be used as an ecological and economical approach due to its low cost and environmental benefits. It is used as a primary source of nutrients over conventional fertilizers among farmers in developing countries and the utilization of PMC in agriculture is very popular due to its lower costs, improve in soil health and crop yield (Hoover *et al.*, 2019., Mpanga *et al.*, 2021). Composting turns manure into fertilizer in an economical way with manure

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management (Bernal *et al.*, 2009; Khater, 2015 and Huang *et al.*, 2017). Poultry manure can also be added along with biochar to further improve soil nutrient availability and it have been used in potato cultivation in previous study by Stacey *et al.* (2024). Biofertilizers is widely used in Hengbung region for soil nutrient availability (Donbiaksiam *et al.*, 2025a). Co-composting poultry manure with biofertilizers will further improve the efficiency of the compost. The utilization of PMC compost has been increasing in Manipur by small scale farmers due to its availability, environmental and economic benefits. PMC provide economic benefit as a bio-fertilizer (Ojha *et al.*, 2020 and Żołnowski *et al.*, 2022), environmental benefits by releasing lesser greenhouse gas (Seidavi *et al.*, 2019), lesser carbon emission (De Priall *et al.*, 2022), lesser smoke emission (Abraham *et al.*, 2015), efficient CO_2 absorption (Lazzari *et al.*, 2022) during composting and social benefits by reducing infectious diseases (Irfan *et al.*, 2020., Mozhiarasi and Nataranjan, 2025), improving air quality (Ma *et al.*, 2019) and the creating more job opportunities in poultry waste industries. The study aims to analyze the utilization and benefits of PMC in enhancing soil health and the effect of PMC in soil nutrient and its availability in acidic soil under polyhouse environment.

MATERIALS AND METHODS

The current study was conducted in a polyhouse environment at FEEDS group of Institution, College of Agricultural Sciences, Hengbung, Manipur in 2022. Poultry manure compost was prepared under aerobic conditions inside the polyhouse using traditional composting method for a period of 6 months and once the compost is properly decomposed, the PMC is left for curing for another 2 months to reduce pathogen contamination. The poultry manure was collected from poultry farming shed under Animal Husbandry Department, FEEDS, Hengbung. The manure was collected along with bedding material (Fig 1) to increase the carbon (C) portion of the PMC as poultry manure usually contains higher nitrogen(N) and after the complete composting the PMC became darker with crumbly texture (Fig 2). The nutrient content like N, phosphorus(P) and potassium (K) for both fresh poultry manure (FPM) and PMC were analyzed at Soil Chemical Laboratory, FEEDS, Hengbung, which is given in Table 1. There were six treatment applied with 2% PMC @T1, 4% PMC @T2, 6% PMC @T3, 8% PMC @T4, 10% PMC @T5 and 12% PMC @T6. The treatments were applied to the soil at 30 cm depth. The cabbage variety "Rare Ball F1" were cultivated following randomized block design with four replications. Each plot size was 1.5 m $\times$ 2 m. Twenty-one cabbage seedlings were planted in the plots with a spacing of 30cm within the row between each cabbage plants and the rows were maintained at 60 cm spacing (Fig 3). Soil samples were collected from each plots of the field before sowing for initial reading and at 30 and 100 days after sowing (DAS) for analysis of soil nutrient. The collected soil samples were allowed to dry for a week and samples were passed through a sieve (2 mm). Soil analysis is done for soil reaction (pH) using pH meter; electrical conductivity (EC) is recorded at 25°C using EC meter (Smith and Doran, 1996) and macronutrient is analyzed using Wet oxidation method for organic carbon (OC) as given by Walkley and Black, 1935. Alkaline permanganate method is used for determining the available N by Subbiah and Asija, 1956, P by Bray and Kurtz-1 extractants (Bray and Kurtz, 1945) and K, Calcium (Ca) and Magnesium (Mg) are analyzed using neutral ammonium acetate method (Chapman, 1965) and soil micronutrient availability due to addition of PMC is analyzed for micronutrients like Copper (Cu), Iron(Fe), Zinc (Zn) and Manganese (Mn) by using DTPA (Diethylene Triamine Pentaacetic Acid) method (Lindsay and Norvell, 1978). The PMC generally contains both macronutrients (N, P, K, Ca, Mg) and micronutrients (Zn, Cu, Fe and Mn) and therefore the soil nutrient content were analyzed to see the effect of addition of PMC in the plots with different doses as treatments. The yield of cabbage measured in tonnes/ hectare (t/ha). The statistical analysis is done with the software IBM SPSS Statistics (Version 27) to obtain the Analysis of Variance (ANOVA) and the critical difference are found to be statistically significant at 5%.

RESULTS AND DISCUSSION

The chemical soil analysis results in increase in soil nutrients with the increase in PMC doses from 2% to 12% and the sequence is as follows T6>T5>T4>T3>T2>T1>c for all the macro and micronutrient analyzed (Table 2). The value of pH of the soils increases with doses of PMC applied. The pH of the PMC is 7.4 and contributes to lesser acidic soil, the initial soil pH is 4.8 and addition of PMC resulted in pH ranging from 5.0 to 6.1 (Table 2). This increase in pH by PMC application improves soil nutrient availability and cabbage yield. The EC of the soil after PMC application

Fig 1: Poultry manure mixed with bedding material.

Table 1: Composition of poultry manure.

Poultry manurecomposition	N%	P%	K%
FPM	5.55	2.56	2.12
PMC	5.0	3.75	2.29

Table 2: Soil chemical analysis for soil nutrient.

Treatment	pH	EC	OC(%)	Macronutrient					Micronutrient			
		(dS/m)		N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	Ca (ppm)	Mg (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
C	5.0	0.11	0.60	398	29.12	165.76	301.12	35.57	7.4	690	9.03	6.97
T1	5.3	0.12	0.72	460	30.90	189.28	612.33	98.11	10.3	700	10.59	8.43
T2	5.5	0.15	0.78	478	31.24	203.84	657.74	187.93	11.29	790	10.60	10.22
T3	5.6	0.19	0.81	501	31.36	216.16	722.83	200.04	11.5	810	18.51	24.06
T4	5.7	0.28	1.16	531	33.15	239.68	757.23	211.16	11.57	1010	33.42	27.81
T5	6.0	0.36	1.89	560	33.60	263.2	831.87	229.65	16.61	1828	40.53	33.14
T6	6.1	0.4	2.10	560	35.80	297.92	912.52	301.43	20.71	2490	45.47	50.06
Mean	5.6	0.23	1.15	498.28	32.167	225.12	685.09	180.556	12.765	1188.285	24.02	22.956
Range	5.0- 6.1	0.11- 0.4	0.60- 2.10	398- 560	29.12- 35.80	165.76- 297.92	301.12- 912.52	35.57- 301.43	7.4- 20.71	690- 2490	9.03- 45.47	6.97- 50.06
CD (5% level of significance)	5.07	37.84	38.87	8.72	5.03	14.90	21.33	36.01	25.73	43.52	47.72	50.89
Standard deviation (SD)	0.383	0.117	0.604	58.636	2.184	45.283	197.219	87.759	4.434	698.083	15.473	15.768
Standard error of the mean(SEM)	0.284	0.087	0.448	43.439	1.618	33.546	192.02	65.013	3.285	517.147	11.463	11.682
Initial	4.8	0.1	0.56	356	26.64	122.08	267.8	34.49	6.78	300	8.06	6.08

shows increment with the increase in doses of the PMC ranging from 0.11-0.4 dS/m (Table 2). Soil pH and EC shows positive correlation with doses of PMC applied (Fig 4,5). The OC % ranges from 0.60 to 2.10 where c shows less OC content, T1 to T4 shows adequate OC% within 0.75-1.5%, T5 and T6 shows high OC% above 1.5% (Table 2). It is observed that adding PMC to the soils under polyhouse conditions have enhance soil properties. The available N, P, K increases with each treatment, available N ranges from 398-560 Kg/ha which is within the required value of available N, available P ranges from 29.12-35.80 Kg/ha which is high in value, addition of PMC to the plots have resulted in excess of available P, available K is also within the normal range with 165.76 Kg/ha as lowest at c and 297.92 Kg/ha as the highest at T6 (Table 2). The Ca content in the soil is less at 267.8 ppm as the soil is acidic but the application of PMC increased the Ca availability ranging from 612.33 ppm (T1)-912.52 ppm (T6) whereas c that didn't receive any PMC is as low as 301. 12 ppm (Table 2). Mg is also very low at 34.49 ppm due to acidity of the soil but treatment with PMC resulted in increase in Mg availability ranging from 98.11 ppm (T1) - 301.43 ppm (T6) and 35.57 ppm for c (Table 2). The micronutrient availability also shows similar increment. The micronutrient Fe, Mn, Cu are already present in the acidic soil within the optimal level but the addition of PMC increases its availability. Zn is deficient in the soil as Zn is more available in alkaline soil and application of PMC have made Zn available in the soil (Table 2). Both soil macronutrient (C, N, P, K, Ca, Mg) and micronutrient (Fe, Mn, Cu, Zn) shows positive correlation with higher doses of PMC (Fig 6-15). The yield of cabbage is found to be highest in T6 with 12% PMC with yield of 79.8 t/ha and lowest in c with no PMC application with 65.7 t/ha yield (Table 3). There is a positive correlation between the yield and doses of PMC applied from 2% to 12% for the 6 treatments (Fig 16).

The results of the current study emphasize on the significant impact of PMC application on soil nutrient availability using 6 treatments with different percentage (Table 2). The initial soil texture is clay loam and acidic with low pH and low EC. Hengbung soil is favourable for zero tillage over other tillage systems (Donbiaksiam *et al.*, 2025b) and therefore incorporation of compost over conventional fertilizers along with zero tillage will be an ecological and economical approach for farmers of the area. The initial chemical analysis showed optimal level of nutrients, except for OC, Mg and Zn and the addition of PMC were required to meet the deficiencies of soil nutrient. The nutrient composition of the PMC utilized for the experiment contains adequate macro and micronutrients (Table 1), thereby improving soil nutrient availability and fertility. Organic matter content increase with application of PMC in the soil and thereby improve the soil physical properties like soil structure, soil aeration, soil bulk density, soil water retention, soil infiltration (Agbede *et al.*, 2017). Soil nutrient availability is increased with application of PMC as it contains the essential macro and micronutrient

required in the soil for plants, similar effect of PMC on soil fertility is shown by Adekiya *et al.* (2019) in radish, Hoover *et al.* (2019) in corn and soyabean, Praveen *et al.* (2022) in Groundnut, Agbede, (2025) in maize.

The application of PMC with increase in doses shows positive correlations with soil chemical properties from 2% to 12% and similar findings were observed by Agbede, 2025. The PMC application rates at 2% to 12% increases soil nutrient present in the soil supporting the results from other research using poultry manure where significant improvement in soil fertility is observed (Adeyemo *et al.*, 2019, Hoover *et al.*, 2019 and Mpanga *et al.*, 2021). The presence of soil essential nutrients was recorded to be higher in treatments with higher percentage of PMC as poultry manure are proven to improve soil health, fertility and crop yield (Agbede and Oyewumi, 2022). The yield of the cabbage is higher with each treatments and is statistically significant at 5%. Similar findings were found in alkaline soil by Ashraf *et al*. (2021) which showed the role of organic manures in improving the crop quality. The increased yield of cabbage with treatments having higher doses of PMC, suggest the increase in quality and nutrient content of the cabbage. Previous study by Sahin (2014) have shown nutrient content improvement with PMC in pepper plant. Studies has found that the utilization of PMC made nutrient available in different type of soil, resulting in higher yield due to improve in soil nutrient availability, release of nutrient into the soil solution and improve soil microbiome by Inal *et al*. (2015) in beans and maize in calcareous soil, (Gunes *et al*., 2014) in lettuce plant in alkaline soil and supporting the present research done in an acidic soil.

There is consistent increase soil nutrient in the soil with addition of PMC (Table 2). These data suggest that PMC promotes nutrient cycling in the soil due to higher soil nutrient content in the soil after application of PMC and similar finding are also reported where poultry manure increases yield of plants (Boateng *et al.*, 2006; Adeyemo *et al.*, 2019

Fig 2: Poultry manure compost.

Fig 3: Cabbage plantation in polyhouse condition with PMC.

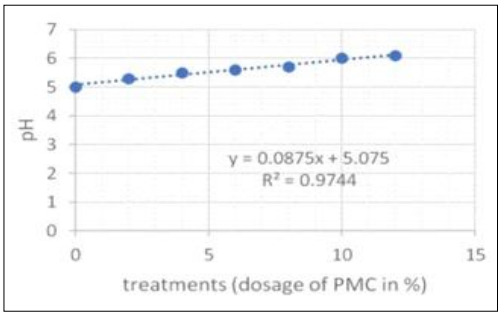

Fig 4: Correlation of pH with dosage of PMC.

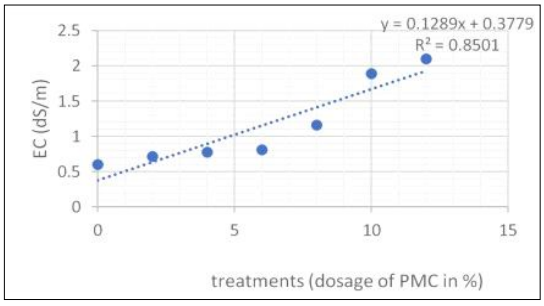

Fig 5: Correlation of EC with dosage of PMC.

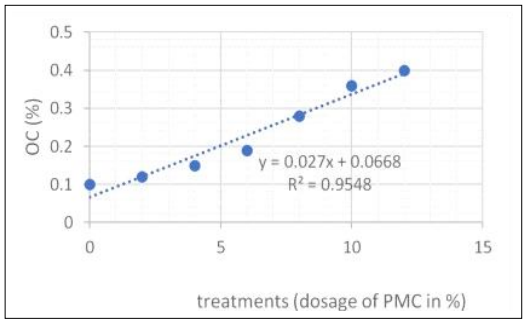

Fig 6: Correlation of OC with dosage of PMC.

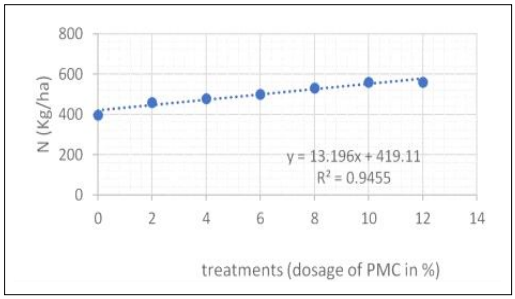

Fig 7: Correlation of Available N with dosage of PMC.

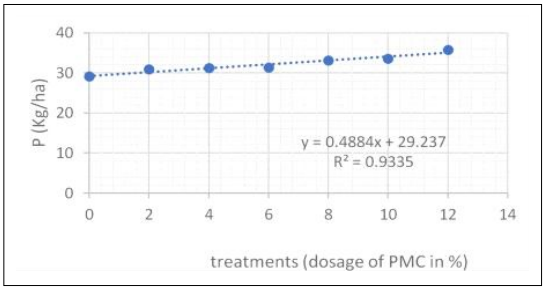

Fig 8: Correlation of Available P with dosage of PMC.

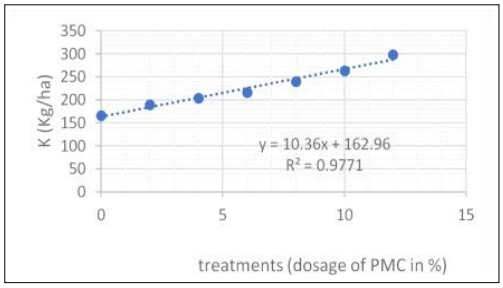

Fig 9: Correlation of Available K with dosage of PMC.

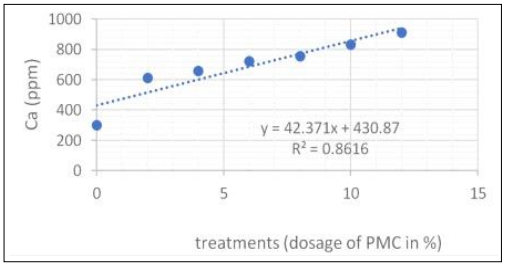

Fig 10: Correlation of Ca with dosage of PMC.

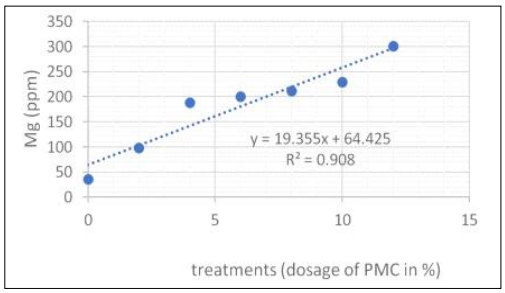

Fig 11: Correlation of Mg with dosage of PMC.

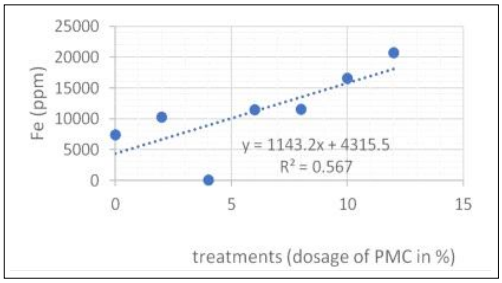

Fig 12: Correlation of Fe with dosage of PMC.

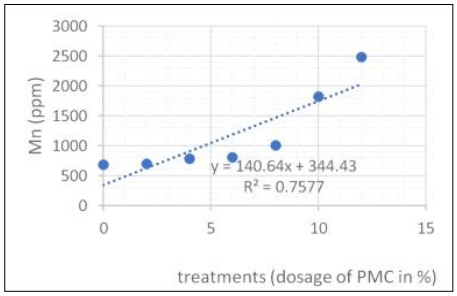

Fig 13: Correlation of Mn with dosage of PMC.

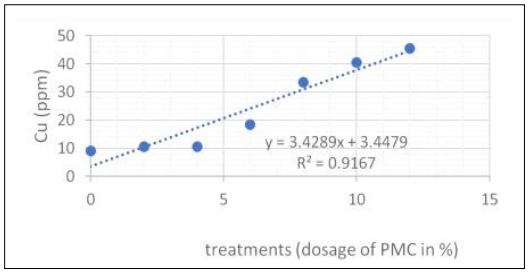

Fig 14: Correlation of Cu with dosage of PMC.

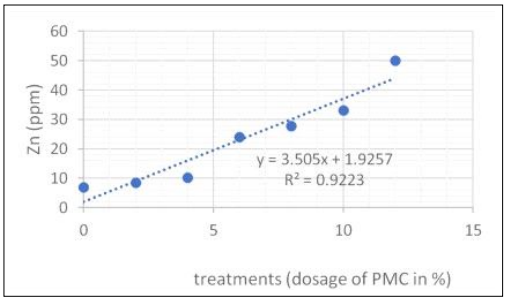

Fig 15: Correlation of Zn with dosage of PMC.

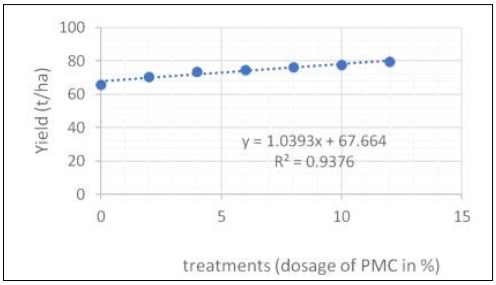

Fig 16: Correlation of yield with dosage of PMC.

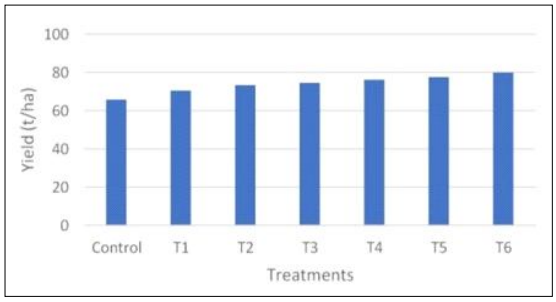

Fig 17: Effect of PMC on Cabbage yield (t/ha).

Table 3: Yield of cabbage.

Notations	Yield (t/ha)
C	65.7
T1	70.5
T2	73.4
T3	74.5
T4	76.2
T5	77.5
T6	79.8
Mean	73.94
SD	4.698
SEM	3.481
CD (5% level of significance)	4.71

and Mpangpa *et al*., 2021). The study supports the previous findings which observed PMC as a valuable organic amendment for enhancing soil nutrient availability and fertility. Previous findings have confirmed that soil fertility is improved with PMC in various soil types (Sipan, 2021). This study confirms the suitability of PMC in acidic type of soil. Among the different doses of PMC, T6@ 12% PMC shows highest improvement in soil nutrient availability and cabbage yield (Fig 17).

CONCLUSION

The applications of PMC showed an increase in soil nutrient availability and increased yield in cabbage under polyhouse environment. Cabbage yield were higher in treatments that have higher doses of PMC and lowest in control. The application of PMC also acts as an approach for sustainable soil management by improving soil properties and supports sustainable agricultural production. The conversion of harmful poultry manure to compost having no harmful pathogens resulted in healthy soil. This studies showed improvement in the efficiency of PMC with increase in doses without affecting the soil health. Further studies can be done on co-composting with other livestock manure for higher nutrient availability with lesser doses.

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Disclaimer

The experiment, views and results conveyed and shown in this article is an original work. The authors take full responsibility for the accuracy of the information provided, but will not be held responsible for losses that may result from the utilization of this work.

Conflict of interest

The author declares that there is no conflict of interest for the publication of the manuscript.

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