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Organic-mineral Fertilizer Based on Chicken Manure and Phosphorite from Central Kyzylkum

U. Sh. Temirov[1], S. Sh. Namazov[1], N. H. Usanbaev[1], B. E. Sultonov[2*] and A. M. Reymov[2]

[1]Institute of General and Inorganic Chemistry of Uzbek Academy of Sciences, Uzbekistan.
[2]Kara Kalpak State University, Uzbekistan.

Authors' contributions

This work was carried out in collaboration between all authors. Author UST did all the laboratory experiments. Author SSN checked and corrected the main article. Author NHU wrote the article. Author AMR helped process the experimental dates. Author BES helped to find literature dates. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Background: Kyzylkum phosphorite combine wastes in form of off-balanced ore (13-15% P_2O_5) and phosphorite sludge (10-12% P_2O_5) generated during the benefication of high calcareous Central Kyzylkum phosphorite in recent years. Total volume of produced phosphorite has already reached 13 billion tonnes. One of actual and rational way for processing low-grade phosphorites is their usage during the preparation of composts based on chicken manure. Mechanism of activation is phosphorus transfer from low-grade phosphorite into acceptable plant form during composition with chicken manure and transformation of manure organic matter into humic substance consider as nitrogen and organic matter losses in atmosphere.
Purpose: Research on the effect of organic-mineral fertilizer obtained from chicken manure and mineralized mass from Central Kyzylkum phosphorite by composting.
Methodology: Compost was made by mixing chicken manure with mineralized mass of Central Kyzylkum phosphorite in wide range of weight ratio. The composition of resulting composts by world famous methods depending on time process has been studied.

**Corresponding author: E-mail: bse-chemist-68@mail.ru;*

Originality: There have been explored the rate and kinetics of transition of manure organic part in humic substances and transfer of P_2O_5 into acceptable for plant form for the first time. It was established that decrease of organic matter and nitrogen emission into atmosphere during the composting manure by mineralized mass from Central Kyzylkum phosphorite. In addition, some chemical equations processing during the composting manure by phosphate were described.
Findings: Preparation of composts has been done based on manure and mineralized mass from Central Kyzylkum phosphorite when weight ratios of Dung: phosphorite (from 100:2 to 100: 25). In prepared mixing some water was added based on calculation to reach humidity till 70%. There have been determined the kinetics and rate of transformation of manure organic parts in humic substances and unacceptable form of phosphorus into acceptable form for plant in mineralized mass. The level releasing organic matter and nitrogen into gas phase has been determined during the composting manure with mineralized mass from Central Kyzylkum phosphorite. It was shown that with increasing duration of composting all ratios formation of humic substances and mobile phosphorus are grown while with increasing amount of mineralized mass in the compost organic matter and nitrogen losses are reduced, as well as the transformation rate of manure organic parts in humic substances. It has been found that when weight ratio of Dung: phosphorite = 100:2 during the composting losses of organic matter and nitrogen are 20.36% and 25.42 % respectively, as relative $P_2O_{5(acceptable)}$ by EDTA and 2 % solution of citric acid make up 69.44 % and 61.11%, while at 100 : 25 the losses of organic matter and nitrogen are 8.75 and 13.26 %, as relative $P_2O_{5(acceptable)}$ by EDTA and 2 % solution of citric acid constitute 43.81 and 42.38 %, respectively.

Keywords: Chicken manure; mineralized mass; composting; phosphorus; organic-mineral fertilizer.

1. INTRODUCTION

Fertility of soil mainly depends on the composition of organic matter. They played important role in soil formation processes and improvement of soil physicochemical properties, supply of plants by nutritional and biological active substances. The soil is exhausted rapidly without organic fertilizers especially under intensive agriculture. Mineral fertilizers cannot replace organic matter as nutrient source. Research shows that application of the same mineral fertilizer negatively effects to soil properties i.e. humus content is reduced. The direction of chemical and biological reaction is changed; as a result, the fertility of the soil has been reduced. When there is a high content of the humus and due to more favourable agrophysical properties, the return from fertilizer increases in 1.5-2 times [1].

Therefore, it is important when use of the fertilizers includes reserves of humus in the soil. Maintenance of the humus and reserve it in arable soil can be exercised by regular application of organic and organ mineral fertilizer. Compost was prepared based on waste from chicken farm amuses important place in the system of organic and organ mineral fertilizers. It was in a chicken farm; an important place in the system of organic and organ mineral organic fertilizers.

The compost of organic wastes has already become sector processing composts into fertilizers having farm managements and scientific production associations in many countries. In Uzbekistan, there is no single science-based approach to the preparation of composts based on wastes from stock farms. The humus formation from organic substances in the composts is an exclusive complex process by microorganisms. Meanwhile, the most available humus in the composts made from stock farms during the oxidation and regular moistening that is optimal conditions for active vital functions of microorganisms. Wastes mineral fertilizers, phosphorite powder, lime carbonate and other matter are added by farmers to create optimal condition during the composting stock. These substances are necessary to support pH as well as nutrient for vital activities of microorganisms. These obtained product as additives are acceptable for plants form [2]. Chicken manure composting with addition of phosphorite powder is effective approach. During composting of chicken manure with phosphorite flour, humus formation's rate of organic chicken manure is increased. Additionally, nitrogen loss reduced, therefore, phosphorus in phosphorite powder transfers into acceptable form due to interaction it with humus acid. The reaction among the humus acid and phosphates can be presented the following way:

$2R\ COOH + Ca_3(PO_4)_2 \rightarrow (R\ COO)_2Ca + 2CaHPO_4$

$2R\ COOH + 2CaHPO_4 \rightarrow (R\ COO)_2\ Ca + Ca\ (H_2PO_4)_2$

$2R\ COOH + Ca(H_2PO_4)_2 \rightarrow (R\ COO)_2Ca + 2H_3PO_4$

This production is novel type as organic-mineral fertilizer with higher environment friendly value and effectivity based on waste of livestock farm which is actual issue. As a result, application of such kind of fertilizers allows to reduce considerably dose mineral fertilizer applying in the balances ratio of nutrition, and reduces engineering expenditures for usage and storage [3].

All over the world processing livestock farm waste in organic or organic-mineral fertilizers is implemented either by composting or waste is piled up and introduced under soil in fresh form.

In [4] shows that when composting chicken manure large amount of nutrient is lost, especially nitrogen due to wrong storage. On a basis of the All-Union research institute on fertilizer and agrology data was found that the losses of total nitrogen constitute 20-25%, organic matter 25-30% for 3 months of composting. In that case, nitrogen and organic matter losses take place because of decomposition of urea, hippuric acid, urinary acid and other low-molecular organic matter in the liquid of chicken manure. Urea is decomposed quickly according to the following equation:

$CO(NH_2)_2 + H_2O \rightarrow (NH_4)_2CO_3$

$(NH_4)_2CO_3 \rightarrow NH_4HCO_3 + NH_3\uparrow$

Further, hippuric acid is decomposed into benzoic and amine-acetic acids. Amine-acetic is decomposed either into oxy-acetic or acetic acids and ammonia which is describing in below:

$C_6H_5\text{-}CO\text{-}NH\text{-}CH_2\text{-}COOH + H_2O \rightarrow C_6H_5\text{-}COOH + CH_2NH_2\text{-}COOH,$

$CH_2NH_2\text{-}COOH + H_2O \rightarrow CH_2OH\text{-}COOH + NH_3\uparrow$

Uric acid is decomposed much slowly, which first converts to allantoin. Then it decomposed with generation glyoxylic acid and urea which are presenting as below:

$C_5H_4N_4O_3 + O + H_2O \rightarrow C_4H_6N_4O_3 + CO_2\uparrow,$

$C_4H_6N_4O_3 + 2H_2O \rightarrow COH\text{-}COOH + 2CO(NH_2)_2.$

Hence, all nitrogen containing substances are decomposed till ammonia, which is total form of nitrogen during the storage of chicken manure. At once, nitrogen-free compounds namely sugar, starch, pectin and other organic matter are decomposed, as well. It is necessary to note that nitrogen-free generate carbon dioxide and water in aerobic condition. For instance, cellulose is converted substances below:

$(C_6H_{10}O_5)_n + nH_2O + 6nO_2 \rightarrow n(6CO_2\uparrow + 6H_2O);$

$(C_6H_{10}O_5)_n + nH_2O \rightarrow n(3CO_2\uparrow + 3CH_4\uparrow).$

During the decomposition process such gases as ammonia, carbon dioxide and other organic matter released. Thus, enormous amount of nitrogen and organic matter are lost gradually which is leading to a reduction of nutrient in chicken manure during the storage.

Formation of humus from organic matter in the compost is exceptional complex process conducted, as a result of activity of microorganisms, as well as physical and chemical processes. The most valuable humus in the compost from livestock farms is generated at neutral pH under ambient temperature under medium wetting and creation of optimal condition. For obtaining composts with high quality some mineral fertilizer, phosphorite powder, limestone and so on usually are added in chicken manure. These substances it is necessary to support pH medium and as nutrient elements for various microorganisms [5-6].

Composting chicken manure with an addition of phosphorite powder is the most effective way. During the decomposition of chicken manure with phosphorite powder, it [7] was presented that fair quantity of organic acids piled up by forming ammonium, potassium salts and other component in the compost. These salts interact with phosphorite powder by generating insoluble organic compounds of calcium and more movable compounds of phosphorus with ammonium and potassium.

It is necessary to mention that in 2016 JSC “Uzkimyosanoat” produced 153.8 thousand tonnes of phosphoric fertilizers (based on 100% of P_2O_5). As regards, necessity of agricultural manure of Uzbekistan is 691.7 thousand tonnes of P_2O_5. These figures indicate that provision for phosphoric fertilizer in agriculture is insufficient.

Nowadays, production of waste in form of off-balanced ore (13-15% P_2O_5) and phosphorite sludge (10-12% P_2O_5) were processed during the benefication process of Central Kyzylkum phosphorite at Kyzylkum phosphorite combined. Total amount of produced waste of phosphorite has already been reached 13 billion tonnes. One of the most rational approaches of low-grade phosphorite processing is usage of compost technology based on chicken manure.

Early we [8-10] carried out research on obtaining organic-mineral fertilizers from manure of chicken, avian litter with the addition of slime phosphorite of the Central Kyzylkum. It was shown that the formation of humus substances and mobile forms of phosphorus increases in all ratios with the increment of composting time.

The purpose of the present research is transfer of unassimilable P_2O_5 in mineralized mass of Central Kyzylkum phosphorite into assimilate form for plat, as well as investigation of losses of nitrogen and organic matter into atmosphere from compost. Goal attainment allows to increase amount of phosphorus containing humus fertilizers which is less in huge amount in Uzbekistan's soils. The amount of humus acids in our soil ranges from 0.3 to1.5 % [8].

2. METHODS AND MATERIALS

In laboratory as an object mineralized mass containing (weight. %): P_2O_5 – 14.33; P_2O_5 acceptable by EDTA - 16.57; CaO – 43.02; Al_2O_3 – 1.18; Fe_2O_3 – 1.38; MgO – 1.19; CO_2 – 14.7; F – 1.85 was used. Whereas dispersion (granular composition0 is as follow:

(-0.315+0.2 mm) – 0.4%; (-0.2+0.16 mm) – 43.8%; (-0.16+0.1 mm) – 41.6%; (-0.1+0.05 mm) – 9.4%; (-0.05 mm) – 4.8%. Chicken manure (weight. %): moisture – 64.74; ash – 11.19; organic matter – 23.97; humic acid – 1.24; fulvic acids – 5.27; water soluble organic substances – 1.19; P_2O_5 – 1.21; N – 1.02; CaO – 1.58.

Composts were prepared under weight ratio of Dung: Phosphorite equal to100 : 2; 100 : 4; 100 : 5; 100 : 8; 100 : 10; 100 : 12; 100 : 16; 100 : 21 и 100 : 25. In prepared mixing it was poured water based on calculation to reach till 70%. Obtained mix was placed in vessel with 0.5 l then from above thin layer earth was poured. Subsequently, vessels were placed and incubated in thermostat at 25°C. Each 15 days some samples were selected to determine for composition then required quantity of water was poured subsequent stirring and setting in the thermostat more.

Diverse content phosphorus such as P_2O_5 (total), P_2O_5 acceptable by EDTA and 2 % solution of citric acid were defined according to the procedure in [11]. Ash content according to State standard 26714-85, nitrogen by State standard 26715-85, humidity by State standard 26712-85, organic matter by State standard 27980-80. Water-soluble fraction content of organic matter recovered from product by water was determined by filtration and evaporation in water bath, drying solid residue to constant weight subsequent burning to calculate ash content. Humic acids were leached processing product by 0.1 N solution of alkali and acidification of obtained solution by mineral acid [12-13]. The solid phase after separating from it alkali soluble organic matter is residual organic matter. The latter was washed carefully by distiller water then dried to constant weight and determined outlet in towards to organic weight. Difference between amount of alkali soluble organic matter and humus acid gives us content of fulvic acids in the compost.

3. RESULTS AND DISCUSSION

Figs. 1-5 gives the data of acceptable form of P_2O_5 and humic substances changing depending on composting duration and weight Dung: Phosphorite. So, when weight ratios of Dung: Phosphorite equal to100: 2 for 90 days relative content of $P_2O_{5\ (acceptable)}$ by EDTA and 2 % solution of citric acid increase form initial 16.57 and 9.01 % to 71.43 and 63.03%, while at ratio of 100: 25 $P_2O_{5\ (acceptable)}$ by EDTA and 2 % solution of citric acid grow to 45.02 and 43.54 % respectively.

Whereas, in Figs. 3-5 the changing results of humic acids, fulvic acids and water-soluble organic matter are given.

As seen from figures that under ratio of Dung: Phosphorite = 100: 2 after 15 days the content of humic acids, fulvic acids, and water-soluble organic matter constitutes 0.88%, 4.16%, 0.98%, but after 90 days has already reached 2.67%, 6.27%, 2.07% respectively. With weight ratio of Dung: Phosphorite = 100: 25 after 15 days content above is 0.61 %, 2.99%, 0.7 %, and after 90 days is 2.03%, 5.34%, 1.68% respectively.

In Figs. 6 and 7, it was presented the changing total content of organic matter and nitrogen in the composts depending upon weight ratio of Dung: Phosphorite. Thus, when weight ratio of Dung:

Phosphorite 100: 2 for 90 days losses of organic matter and nitrogen into atmosphere is 26.57 and 21.75%, and at 100: 25 those of indicated substances make up 14.22 and 9.87%, that is with increase content of mineralized mass in the compost losses of the substances are reduced in gas phase.

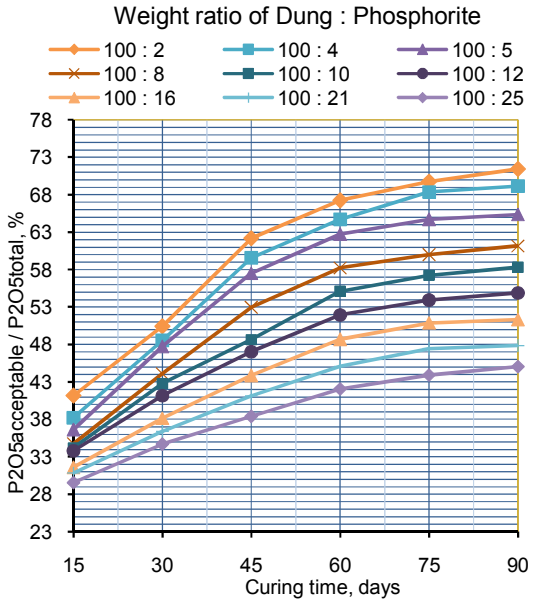

Fig. 1. Changing acceptable form of phosphorus by EDTA depending upon the curing time and weight ratio of Dung: Phosphorite

Furthermore, the results of the research showed that conversion phosphorus in mineralized mass were in acceptable form, decrease of emission ammonia and organic matter takes place due to interaction of organic acids with phosphates. In literature there are some information about decomposition of urea, hippuric acids and other organic acids to ammonia and more low-molecular acids, as well as till CO_2 and H_2O during the worsen packing. These substances possess all properties of carboxylic acid, which generate salts of complex ethers and amides. However, their anhydrides are unstable due to presence of NH_2-groups. In case of composting chicken manure with mineralized mass, the organic acids interact with phosphates and generate acceptable form of phosphorus such as monobasic calcium phosphate and water unsoluble compounds of calcium with organic acids. Due to interaction mono basic calcium phosphate with ammonia mono ammonium phosphate and acceptable form of phosphorus as dicalcium phosphate are generated.

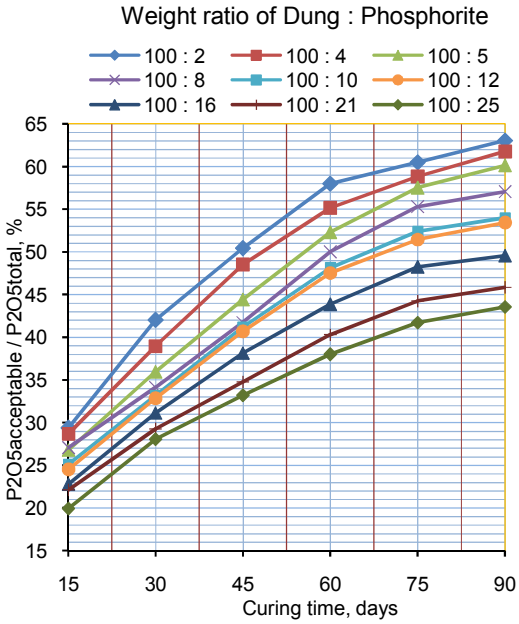

Fig. 2. Changing acceptable form of phosphorus by citric acid depending upon the curing time and weight ratio of Dung: Phosphorite

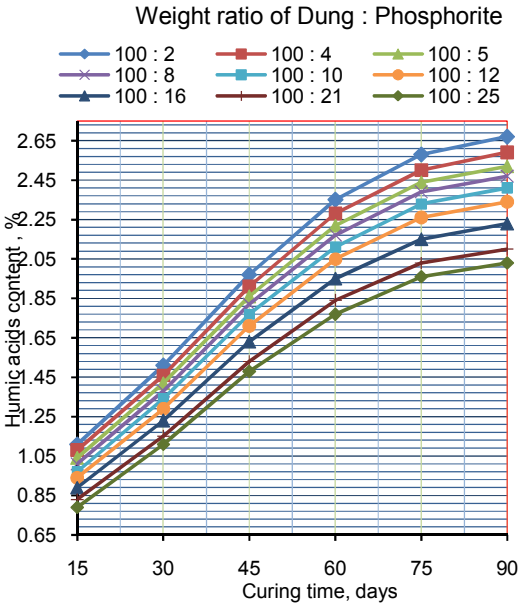

Fig. 3. Humic acids content in the composts depending upon curing time and weight ratio of Dung: Phosphorite

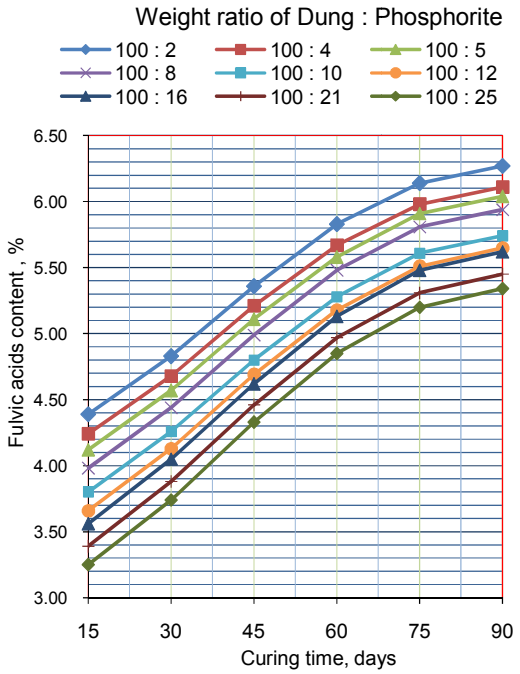

Fig. 4 Fulvic acids content in the composts depending upon curing time and weight ratio of Dung: Phosphorite

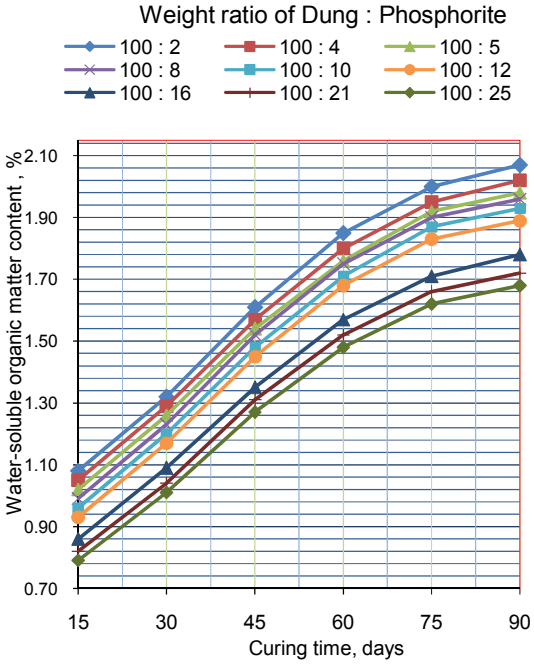

Fig. 5. Water-soluble organic matter content in the compost depending upon curing time and weight ratio of Dung: Phosphorite

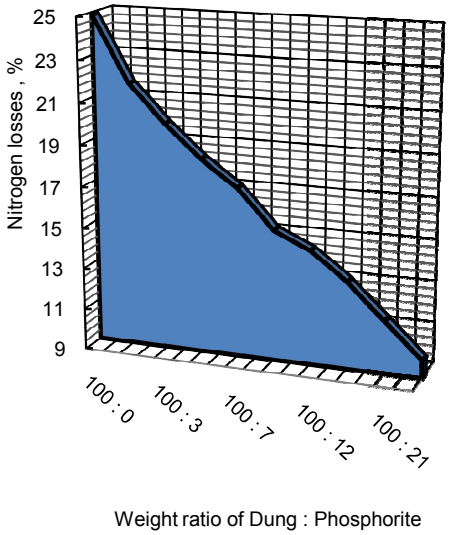

Fig. 6. Nitrogen losses in the composts based on mineralized mass from Central Kyzylkum phosphorite and chicken manure

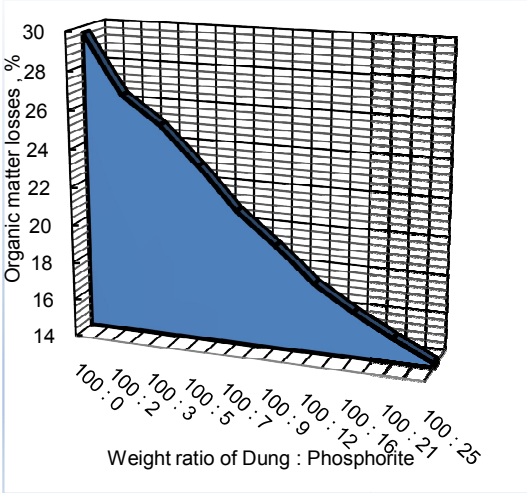

Fig. 7. Organic matter losses in the composts prepared based on mineralized mass from Central Kyzylkumphosphorite and chicken manure

4. CONCLUSION

Thus, investigation of composts prepared in a range of weight ratios of Dung: Phosphorite = 100: (2-25) has shown the compost of chicken manure with mineralized mass. Because of interaction of organic acids with phosphorite, movable phosphorus content increases while losses of organic matter and nitrogen reduced

considerably. Finally, it promotes growth of product outlet. In addition, it was established that increasing the curing time of composts lead to raise acceptable form of phosphorus, humic and fulvic acids, as well as water-soluble organic matter while increase mass fraction of phosphorite towards chicken manure. It promotes to grow conversion rate of organic matter into humic acids, fulvic acids and water-soluble organic matter. On the other hand, the limited ratio and composting time has found out. Accountable ratio of Dung: Phosphorite is 100: (8-12) which are organic-mineral fertilizers with maximal humus substances content in where acceptable P_2O_5 can be generated. Fertilizer obtained after drying from air-dry condition which is defined as following figures on quality (weight. %): P_2O_{5total} – 1.19-2.71; $P_2O_{5(acceptable)}$ by EDTA – 0.85-1.22; $P_2O_{5(acceptable)}$ 2 % solution of citric acid– 0.72-1.13; humic substances – 11.01-9.05.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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