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To cite this article: R Darmawan *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **543** 012099

IOP Conf. Series: Materials Science and Engineering **543** (2019) 012099 doi:10.1088/1757-899X/543/1/012099

Liquid Organic Fertilizer from Waste of Coconut Porridge Manufacturer and Molasses using Various Microorganisms

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Abstract. Excessive use of inorganic fertilizers can aggravate soil conditions. The development of organic fertilizer is urgently required. The fertilizers are used to supply organic materials to improve the physical, chemical, and biological properties of the soil. Meanwhile, many potential waste from coconut porridge household industry in Ponorogo Distric of Indonesia have not been utilized properly yet. The aim of this research are to improve the quality of liquid organic fertilizers by using various microorganisms with addition of liquid materials such as coconut water waste, water of immersed coconut fiber and molasses; and to observe the growth of chilies, tomatoes, and eggplants which were treated using the organic fertilizer. Liquid organic fertilizer was made by mixing the liquid materials using various microorganisms, such as Aspergillus niger, Pseudomonas putida, Bacillus muchilaginosis, Azotobacter chrococum and bioactivator EM4. The liquid fertilizer was carried out with a mixed batch reactor equipped of aeration 4 L/ min for 10 days. From this research was conducted observations on the development of height and fruit on the assesed plants using the produced fertilizer.

1. Introduction

Coconut/ *Cocos nucifera* is a strategic commodity that has a social, cultural and economic role in the Indonesian people lives. Indonesia belongs one of the countries that has the largest coconut plantations in the world with an area of 3.54 million hectares and producing coconut 2.87 million tons [1]. Ponorogo is one of regency in East Java Province, Indonesia. According to the BPS of Ponorogo Regency in 2015 [2], the number of coconuts that can be produced is 6.170,09 tons. The benefits of coconut plants are not only in the flesh of the fruit, but all parts of the coconut plant have great benefits, starting from tree trunks, husks, shells to coconut water. Ponorogo district has a potential product from coconut especially coconut porridge in household industrial scale. There are some coconut porridge manufacturers to make the traditional food. The manufacturer release coconut water for coconut porridge production which is not utilized properly. The use of waste of coconut water is considered as a good chance to generate useful thing to the community. This effort is also one of promising ways by producing an organic liquid fertilizer from waste water of coconut. The fertilizer based on organic can be used to nourish plants and supply organic materials to improve nutrients and water uptake, growth and tolerance of plant to abiotic and biotic factors. Furthermore, the bio-fertilizers have been as eco-friendly and cost effective inputs for the farmers and have a key play role for production and improving the sustainability physical, chemical, and biological properties of the soil [3]. On the other hand, the existence of molasses as an

IOP Conf. Series: Materials Science and Engineering **543** (2019) 012099 doi:10.1088/1757-899X/543/1/012099

abundance side product from sugar factory is also limited using in Indonesia. Furthermore, the existence of Lapindo mud in Sidoarjo – Indonesia as a result of the spurt of material in the earth to the surface which has been determined as a national disaster has not been handled well and still leaves many problems, besides the potential possessed of the potential content of microorganisms, this experiment was conducted. This study has aims to utilize the waste of coconut water and molase to produce the organic liquid fertilizer by supplementing various microorganisms.

2. Materials and Methods

2.1 Microorganisms

There are five microorganisms and the mixed culture used in this study. Four types were ordered from the Microbiology Laboratory of Chemical Engineering Department, Faculty of Industrial Technology, Institut Teknologi Sepuluh Nopember (ITS) - Indonesia, namely Aspergillus niger, Azetobacter chrococum, Pseudomonas putida and Bacillus mucilagenosus. Effective Microorganism 4 (EM4) [4] was as bioactivators also added to the process. Meanwhile, the mixed cultured was isolated from Lapindo mud, Sidoarjo - Indonesia by applying enrichment culture for three weeks.

2.2. Medium

Minimum medium was prepared by adding some chemical such as 1 gram of $NHNO_3$, 1 gram of KH_2PO_4, 1.3 gram of $K_2HPO_4.3H_2O$, 0.1 gram of $MgSO_4.7H_2O$, 0.1 gram of $FeCl_3.6H_2O$, 0.008 grams of $CaCl_2$ which were are dissolved in 1000 ml of sterile distilled water for making solution in enrichment culture stage [5]. NB (nutrient broth) of 8 grams was dissolved within 1 liter and sterilized as a bacterial medium.

2.3. Liquid Material

Waste of coconut water and molasses were purchased from coconut porridge manufacturer in Ponorogo and a sugar factory from Mojokerto – Indonesia, respectively.

2.4. Enrichment culture

Medium was prepared first by making minimum medium. K_2HPO_4 50 ppm and UREA 50 ppm were added into medium. Then it was sterilized using autoclave for 15 minutes. The medium including mud was incubated for three weeks where every week, 1 ml of liquid culture transferred into new enrichment medium.

2.5. Process treatment

Liquid fertilizer of organic was made by mixing 3 l of coconut water waste, 6 ml of molasses waste and microorganisms into the bioreactor (Figure 1).

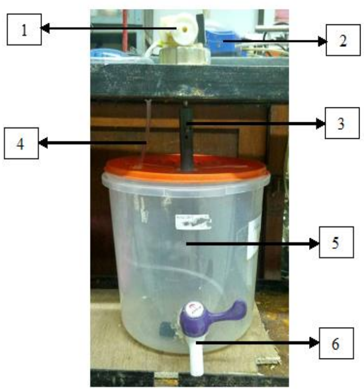

Figure 1. Reactor for biological process; with explanation no 1, 2, 3, 4, 5 and 6 are dynamo agitator, aerator, agitator air hose, reactor, and output valve, respectively

Various microorganisms such as Aspergillus niger, Azetobacter chrococum, Pseudomonas putida, Bacillus mucilagenosus, Effective Microorganism 4 (EM4) bioactivators, and mixed culture of Lapindo mud were added by considering the log phases of every microbe. The number of microorganisms was calculated using counting chamber method [6]. There were seven variables, they were 5 microbes (10^8 cells /mL), 4 microbes without EM4 (10^8 cells /ml), 5 microbes added mixed culture (10^8 cell /ml), 4 microbes without EM4 added mixed culture and only mixed culture (10^8 cell /ml). The bio-fertilizer was conducted in the mixed batch reactor with air aeration for 10 days. The result of fertilizer was analyzed N, P, K and C-organic content at t = 0 days, t = 5 days, and t = 10 days, then tested by manuring the bio-fertilizer to chili, tomato and eggplant.

3. Results and Discussion

There were five microorganism groups applied as variables for producing the organic liquid fertilizer. They were 5 Microbes (Aspergillus niger, Azetobacter chrococum, Pseudomonas putida, Bacillus mucilagenosus and EM4); 5 Microbes with Mixed Culture; 4 Microbes (Aspergillus niger, Azetobacter chrococum, Pseudomonas putida and Bacillus mucilagenosus); 4 Microbes with Mixed Culture and only Mixed Culture from Lapindo Mud. The resulting of the biofertilizer was analyzed by N, P, K and C-organic content at t = 0 days, t = 5 days, and t = 10 days, then tested on pepper, tomato and eggplant.

3.1 Effect of incubation process and microorganisms used on N, P, K and C elements

Many factors or parameters affected to the number of N, P, K and C elements on bio-fertilizer, such as the initial element and concentration material sources from coconut water and molasses, respectively, microbes used and duration of incubation. Based on the analysis of the bio-fertilizer product, it was found that the best result on N, P, K and C elements were obtained at t = 5 days with concentrations of 0.059%, 113.18 mg /l, 401.63 mg /l and 1.1%, respectively. Meanwhile, the percentage enhancing of macro elements were presented in the figures below. From Figure 2, 3, 4 and 5, it can be seen percentage enhancing of N, P, K and C elements, respectively during process incubation period.

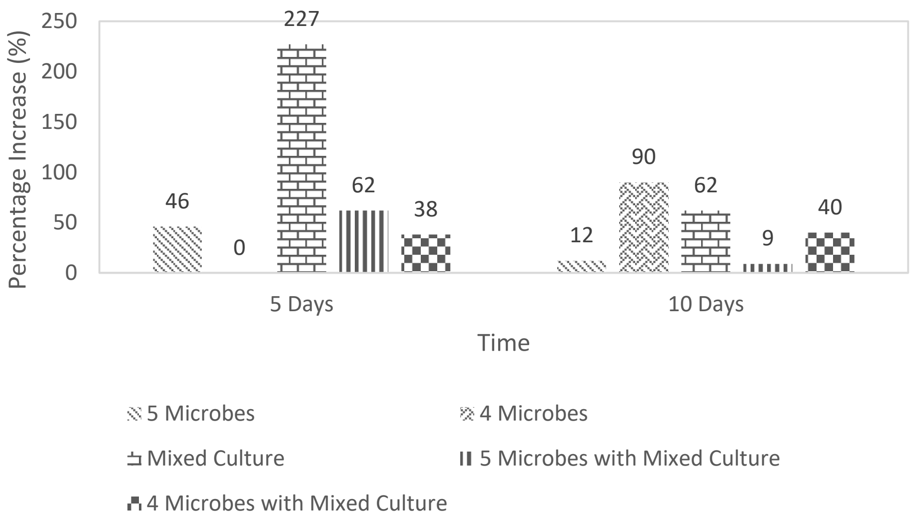

Figure 2. Percentage enhancing of N during process incubation period

Figure 2 shows the results of percentage increasing of N element for 10 days incubation period, where this figure indicates the highest enhance of N (227 %) was achieved by mixed culture at 5 days.

As shown in Fig. 2, the mixture culture isolated from Lapindo Mud reported that it had the highest increase of nitrogen compound. These culture from LapindoMud believed can upgrade and have a good role as the nitrogen contributors on the plants [7]. These microbes might be belonging to diazotroph bacteria where the isolates have a critical role to fix nitrogen. The capability of the isolates might be the existence a nitrogenase enzyme which have ability for combining nitrogen and hydrogen [8, 9].

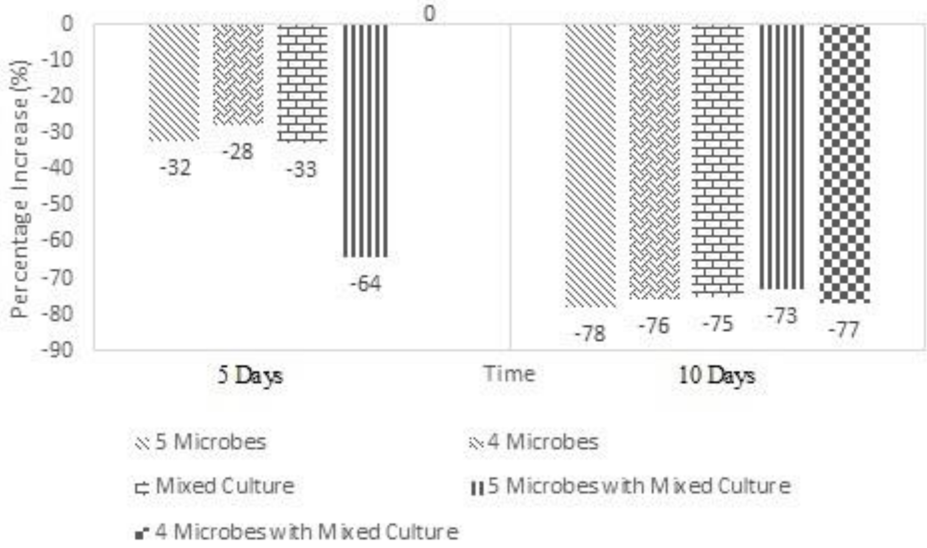

Figure 3. Percentage enhancing of P during process incubation period

Figure 3 shows the results of percentage decreasing of P during process incubation period. With increasing incubation period, the enhancing of phosphor elements were decreased. After 5 days incubation, the highest content can be achieved (-28 %) then the element composition was decreased (-73 %) for 10 days incubation period. The best result of P element enhancing was obtained by 4 microbes (-28 %) variable at 5 days incubation. From the result indicates that the combination of microbes (Aspergillus niger, Azetobacter chrococum, Pseudomonas putida and Bacillus mucilagenosus)
4 microbes) were not suitable to enhance element of phosphor [7].

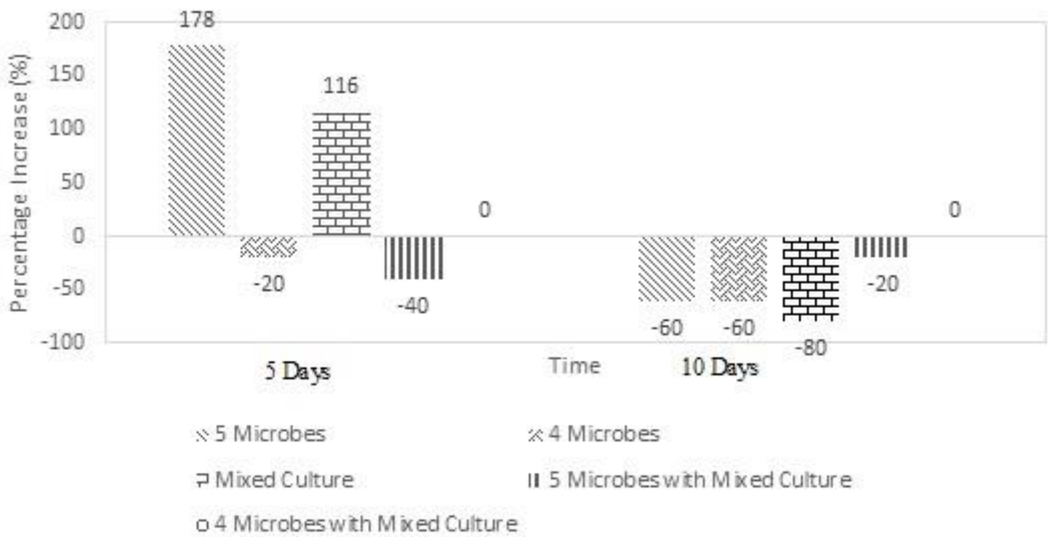

Figure 4. Percentage enhancing of K during process incubation period

Potassium element from several variables were increased along with the incubation experiment conducted after time 5 days then for all variables were decreased after 10th days period. From Figure 4, it can be seen that highest percentage enhancing of K during process incubation period was obtained by 5 microbes at 5 days. The enhancing of potassium component might be caused by the hydrolysis and proteolysis reactions so that it lead to release K^+ from the organic matter.

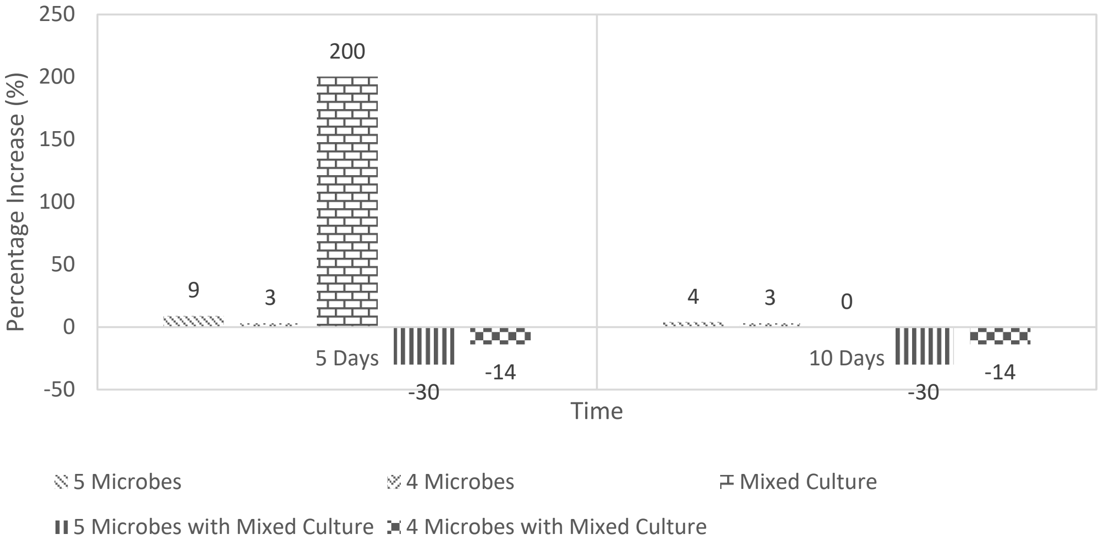

Figure 5. Percentage enhancing of C during process incubation period

Figure 5 exhibits that best percentage decreasing of C element during process incubation period was obtained by 5 microbes with mixed culture at 5 days. In the conducted experiment, the carbon elements from coconut water and molasses were degraded into a simpler compound with more stable. All variables represent the decreased with enhancing the incubation period. The condition occurs might be caused by absence of the added microorganisms that consume C-organic within coconut water and molasses as a carbon source to enhance the microorganisms metabolism.

3.2 Observation of organic liquid fertilizer application to test plants

After bio-fertilizer was obtained, the observation of fertilizer application on the test plants for 45 days. There were three test plants, i.e. chili, tomato and eggplant. The growth observation was conducted including difference high of plants before and after of manuring, the average number of fruit and leaf. Each fertilizer experiment variable on the test plant used three plants each, so that for the height, fruit and number of leaves were calculated on average. Table 1, 2 and 3 show about observation of plant growth on tested plants such as chilies, tomatoes and eggplants. From these tables, it can be seen the highest growth on chilies, tomatoes and eggplants were achieved by 4 types of microbes with mixed culture, 4 types of microbes with mixed culture, and mixed culture variables after 45th day with high plants of 56.20, 141,23 and 62.67 cm, respectively.

Table 1. Observation data of plant growth on chilies

No	Variable	Δh (cm)			
		0 day	15 day	30 day	45 day
1	5 types of microbes	37.67	40.90	41.20	42.90
2	5 types of microbes with *mixed culture*	35.67	38.40	38.97	40.90

3	4 types of microbes without EM4	36.67	40.03	41.50	48.23
4	**4 types of microbes with *mixed culture***	42.00	50.20	51.90	**56.20**
5	*Mixed culture*	36.67	39.90	41.23	43.57
6	Only coconut water	40.67	44.23	44.87	46.27
7	Only water	39.67	37.57	38.23	39.57

Table 2. Observation data of plant growth on tomatoes

No	Variable	Δh (cm)			
		0 day	15 day	30 day	45 day
1	5 types of microbes	32.67	57.2	67.6	89.23
2	5 types of microbes with *mixed culture*	38.33	65.2	92.63	97.75
3	4 types of microbes without EM4	33.67	52.97	71.67	85
4	**4 types of microbes with *mixed culture***	40.67	71.67	101.6	**141.23**
5	*Mixed culture*	34.67	65.3	89.63	106.85
6	Only coconut water	40.67	70.9	81.97	97.23
7	Only water	39.33	75.53	82.57	86.35

Table 3. Observation data of plant growth on eggplants

No	Variable	Δh (cm)			
		0 day	15 day	30 day	45 day
1	5 types of microbes	30.33	34.93	35.93	38.73
2	5 types of microbes with *mixed culture*	26.67	31.27	32.6	36.3
3	4 types of microbes without EM4	34.33	43.9	46.6	51.7
4	4 types of microbes with *mixed culture*	31.67	41.83	47.23	56.3
5	***Mixed culture***	36	47.93	50.93	**62.67**
6	Only coconut water	30.33	34.53	35.97	38.83
7	Only water	30.67	33.63	35.87	38.03

Meanwhile, Table 4, 5 and 6 show about observation of the number of fruit on tested plants. From these tables, it can be seen the highest fruit number on chilies, tomatoes and eggplants were all variables achieved by 4 types of microbes with mixed culture, after 45th day with the average number of fruit of 1.67, 7.67 and 1.67, respectively.

Table 4. Data on observing the average number of fruit on chilies

No	Variable	Mean of fruit number			
		0 day	15 day	30 day	45 day
1	5 types of microbes	-	-	0.33	0.33
2	5 types of microbes with *mixed culture*	-	-	-	-
3	4 types of microbes without EM4	-	0.67	1.33	0.67
4	**4 types of microbes with *mixed culture***	-	-	0.67	**1.67**
5	*Mixed culture*	-	-	-	1.33

6	Only coconut water	-	-	-	1
7	Only water	-	-	-	-

Table 5. Data on observing the average number of fruit on tomatoes

No	Variable	Mean of fruit number			
		0 day	15 day	30 day	45 day
1	5 types of microbes	-	-	-	5
2	5 types of microbes with *mixed culture*	-	-	1	6
3	4 types of microbes without EM4	-	-	-	5.67
4	**4 types of microbes with *mixed culture***	-	-	0.67	**7.67**
5	*Mixed culture*	-	-	0.67	3.67
6	Only coconut water	-	-	-	3.67
7	Only water	-	-	0.67	4

Table 6. Data on observing the average number of fruit on eggplants

No	Variable	Mean of fruit number			
		0 day	15 day	30 day	45 day
1	5 types of microbes	-	-	-	-
2	5 types of microbes with *mixed culture*	-	-	-	-
3	4 types of microbes without EM4	-	-	0.33	0.33
4	**4 types of microbes with *mixed culture***	-	-	0.67	**1.67**
5	*Mixed culture*	-	-	0.67	1
6	Only coconut water	-	-	-	-
7	Only water	-	-	-	-

Furthermore, Table 7, 8 and 9 show about observation of the number of leaves on tested plants. From these tables, it can be seen the highest leaves number on chilies, tomatoes and eggplants were all variables also achieved by 4 types of microbes with mixed culture, after 45th day with the average number of leaves of 48.33, 24.67 and 24.67, respectively.

Table 7. Data on observing the average number of leaves on chilies

No	Variable	Mean of leaf number			
		0 day	15 day	30 day	45 day
1	5 types of microbes	11.33	14.67	15	18.67
2	5 types of microbes with *mixed culture*	11	15	21	27
3	4 types of microbes without EM4	16	21.67	40.67	45.67
4	**4 types of microbes with *mixed culture***	12.33	23.33	37	**48.33**
5	*Mixed culture*	7.33	14.67	18	25
6	Only coconut water	12.33	14.67	18.67	19
7	Only water	10.33	13.67	18.67	18.33

Tabel 8. Data on observing the average number of leaves on tomatoes

No	Variable	Mean of leaf number			
		0 day	15 day	30 day	45 day
1	5 types of microbes	7.67	9	11.33	17.33
2	5 types of microbes with *mixed culture*	7.67	9.33	13.67	23.67
3	4 types of microbes without EM4	6.67	8.67	11.67	20.33
4	**4 types of microbes with *mixed culture***	7.33	10.33	15.67	**24.67**
5	*Mixed culture*	7.67	9	12	21.33
6	Only coconut water	8	9.67	11.67	17.33
7	Only water	7.33	8.67	11.33	17

Table 9. Data on observing the average number of leaves on eggplant

No	Variable	Mean of leaf number			
		0 day	15 day	30 day	45 day
1	5 types of microbes	9.33	8	11	12.67
2	5 types of microbes with *mixed culture*	6.33	7.67	9.67	13
3	4 types of microbes without EM4	6.67	9.67	12.67	16.67
4	**4 types of microbes with *mixed culture***	7.67	10.67	15.33	**24.67**
5	*Mixed culture*	7.67	12.67	19	19.67
6	Only coconut water	6	7	8.67	10.33
7	Only water	5	4.33	6	7.67

Based on three parameters observation results including the height, fruit and number of leaves show that variable of 4 types of microbes with mixed culture was the best combination of microorganism to give good effect of chilies, tomatoes and eggplants. This condition might be beside 4 microorganisms such as Aspergillus niger, Azetobacter chrococum, Pseudomonas putida and Bacillus mucilagenosus, the mixed culture isolated from Lapindo mud have a key play role on the plants. This occurs because the mixed culture of Lapindo mud may contain good microorganisms and can increase soil so that plants can thrive and bear fruit well. In the future, it is necessary to conduct bacterial community analysis in order to know the name of bacteria contained in Lapindo mud.

4. Conclusion

The coconut waste water supplemented by molasses can be used as the potential material sources for generating liquid biofertilizer. A combination between Aspergillus niger, Pseudomonas putida, Bacillus mucilagenosus, Azetobacter chrococum and mixed culture isolated from Lapindo Mud have been found as a promising combination cultures to make the organic liquid fertilizer for manuring to chilies, tomatoes and eggplants.

5. Acknowledgments

The authors would like to thank the Institut for Research and Community Services (LPPM) of Institut Teknologi Sepuluh Nopember (ITS) on the Program (*Pengabdian Kepada Masyarakat Berbasis Penelitian*) for financial supporting with agreement document No: 1474/PKS/ITS/2018.

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