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# 1 Improving nitrogen fertilizer efficiency with the addition of compost extracts to kailan (*Brassica oleracea* L.) plants with wick hydroponic cultivation

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## ABSTRACT

The goal of this research was to observe the impact of the application of the forms of compost extract and urea fertilizer on the development of kailan plants in the hydroponic wick method. The experiment consisted of 15 was arranged in a completely randomized factorial design with the first element reflecting the compost type: no compost extract, cow manure compost extract, rice straw compost extract, and vermicompost extract. The second element was the use of 0, 100 and 200 kg ha<sup>-1</sup> nitrogen fertilizers. The usage of vermicompost extract shows the maximum growth (59.27 cm), amount of leaves (23.00), overall plant weight (93.92 g plant<sup>-1</sup>), canopy weight (61.37 g plant<sup>-1</sup>), dried foliage weight (7.17 g plant<sup>-1</sup>), fresh root weight (33.40 g plant<sup>-1</sup>), leaf greenness (183.80 SPAD) and nutrient uptake (6.32 g plant<sup>-1</sup>). The optimal nitrogen fertilizer application was found to be 200 kg ha<sup>-1</sup>, which culminated in the maximum plant height (42.18 cm), number of leaves (17.75), overall plant weight (60.42 g plant<sup>-1</sup>), leaf greenness (166.23 SPAD) and N uptake (3.75 g plant<sup>-1</sup>). With the addition of 100 kg of urea ha<sup>-1</sup>, vermicompost extract achieved the maximum N absorption efficiency of 112.05 per cent. The use of vermicompost extract in the production of crops with a hydroponic wick method could fulfill the nutrient requirements of plants.

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## 1. Introduction

Kailan (*Brassica oleracea* L.) is a type of vegetable in a form of leaf with nutritious elements such as calcium, energy and carbohydrate full of vitamins particularly vitamin A. Kailan has a low genetic diversity with large leaves. These characteristics make kailan appealing to many customers, so that its efficiency must improve in order to satisfy the needs of society (Rambe et al., 2018).

Initially, farmers often used only land as a means for growing vegetables, but hydroponic systems seem to have a tremendous capacity for growing vegetable plants. Hydroponics is a landless method of farming that uses water as a means for plant growth (El-Kazzaz & El-Kazzaz, 2017). Water and nutrient control in hydroponic innovation focuses on the best implementation approach to satisfy plant requirements at various ages, given sufficient light and climate circumstances, in order to produce optimum results (Wachjar & Anggayuhlin, 2013). Hydroponic systems are more functional to manage,

need less labor, use fertilizers more effectively, produce plants more quickly with assured health, and demand higher market rates than conventional approaches. They also greatly accelerate planting, regardless of season and schedule of harvests, to continuously grow seeds.

Manure is commonly used as a basic fertilizer for plants due to its ample supply and ease of processing. The nutritional composition of manure extracts benefits crops as they provide nutrients to plants, boost immunity and greater susceptibility to insects and pathogens to boost growth and development of plants (Asadu & Igboka, 2014).

As suggested by Ghorbani et al. (2008), the usage of manure extract enhanced the growth, output, pest attacks resilience and the longer lifespan of tomatoes. The extract of compost manure was enabled to supply organic material as a nutritional supplement for tomato plants. The extract of compost may be used as an ecologically responsible alternative fertilizer.

Rice straw is another substance used to produce compost, which can be utilized to render an extract. Yehia & Saleh (2012) suggested that using the extract of rice straw was successful in regulating phytopathogenic fungi (*A. flavus*, *A. alternata*, *B. cinerea*) suggesting that the extraction of rice straw was a safe, ecologically responsible fungicide. Another research discovered that the extraction of rice straw generated a high number of phenolic compounds and showed strong antioxidant potential (Elzaawely et al., 2017).

Vermicompost can also be converted into vermicompost extract. Such extract has constantly been utilized to enhance the health aspect of plants, development and nutritional efficiency and to defend against various diseases and pests such as aphids, caterpillars and thrips by expanding the microbial population (Modarres Najafabadi, 2014). Moreover, the extract is also an essential element to promote the germination of linseed (levinsh et al., 2017) as well as to raise the chlorophyll concentration of legumes (levinsh, 2011). Nevertheless, several studies have investigated the benefits of compost extract in the hydroponic growth of kailan plants using the wick method.

Urea contains the nitrogen needed by vegetables, particularly leafy vegetables. Nitrogen is essential for plant growth, production and, in particular, photosynthesis, as nitrogen increases the amount of chlorophyll. In addition to promoting the development of protoplasts, proteins and nucleic acids, a sufficient supply of N will make photosynthesis more efficient (Yoldas et al., 2008). Furthermore, nitrogen serves as the primary material of proteins, nucleic acids, carbohydrates, nucleoproteins and alkaloids; adequate N is supposed to account for a large growth of vegetation and fresh leaves. Beside, N deficit restricts cell proliferation and development (Napitupulu & Winarto, 2010).

Fewer nutrient injection into organic fertilizers in compost shape or extracts is another barrier to the production of vegetables, like kailan. The workable solution is the use of a mixture of inorganic and organic fertilizers. This method may fulfill the need for nutrients in plants and may minimize inorganic chemicals in kailan plants safe for human needs. The goal of the research was to observe the impact of composting extracts extracted from rice straw, vermicompost, cow manure and urea fertilizer within the development of kailan plants utilizing the hydroponic wick method.

## 2. Materials and Method

### 2.1 Research Location

The operational state of this research was performed under a greenhouse located in the Soil Science Laboratory, College of Agriculture, the University of Lampung. In timespan, the

research was on deliberation between the month of January and October 2018

### 2.2 Research Design

This research is deliberated using a completely randomized factorial design. The initial element was the form of compost, i.e. no extract, rice straw compost extract, cow manure compost extract and vermicompost extract. The second element was nitrogen fertilizer applications of 0 kg ha<sup>-1</sup> (0 g plant<sup>-1</sup>), 100 kg ha<sup>-1</sup> (0.4 g plant<sup>-1</sup>) and 200 kg ha<sup>-1</sup> (0.8 g plant<sup>-1</sup>). Every procedure was replicated three times, and each cycle consisted of six plants. Each mixture was then implemented to 18 plants out of 216 crops gathered for the research.

### 2.3 Compost

Cow manure fertilizer was purchased from a field store. Rice straw compost was rendered by arranging the field for chopped rice straw and applying cow manure at a 2:1 ratio or equivalent to 10 cm cow manure and 20 cm rice straw. The combined elements were coated with a cover slip and rotated over on weekly basis. Later on, water was applied to enable decomposition, which lasted for over 3 months. Vermicompost was collected from the Great Giant Fruit Company, Central Lampung, in an established or fully prepared environment. Worms utilized to produce vermicompost were *Lumbricus rubellus*. The worms were fed with pulp decays and pineapple during the vermicompost phase.

### 2.4 Compost Extraction

The compost was collected by placing 1 kg of each compost substance in a cloth bag, putting the bag in a jar and inserting 50 g of sugar or 20 ml of molasses and 10 liters of water (1:10 ratio of compost material to water). The mixture was then oxygenated with an aquarium air compressor. The extract of compost was prepared to be utilized after 48 hours (Kováčik et al., 2015). The results for the analysis of composting extract (rice straw, cow manure vermicompost) is shown in Table 1. Based on the research laboratory, the N content of the extract of vermicompost was relatively higher to the rest of the extracts. The content of P and Organic-C of the three compost extracts was quite similar (Table 1).

### 2.5 Hydroponic Media

The seeding medium utilized hydroponic tubes with mattresses to position the net pot and the rock wool. A wick crafted of flannel cloth to soak compost extract was placed at the bottom of the net pot (El-Kazzaz & El-Kazzaz, 2017).

**Table 1.** The analysis of compost extract (cow manure, rice straw, vermicompost)

No.	Analysis	Cow Manure Extract	Rice Straw Extract	Vermicompost Extract
1.	Total N (mg kg <sup>-1</sup> )	28.04	21.13	35.01
2.	Dissolved P (mg kg <sup>-1</sup> )	25.83	26.51	23.35
3.	Dissolved K (mg kg <sup>-1</sup> )	161.11	319.69	179.01
4.	Organic-C (%)	0.01	0.02	0.01
5.	Ca (mg kg <sup>-1</sup> )	73.42	66.54	15.91

**Table 2.** The effects of the application of three types of compost extract and urea on plant fresh weight, canopy fresh weight, dry weight, and plant root fresh weight of the kailan plants every week.

Treatment	Plant Fresh Weight (g)	Canopy Fresh Weight (g)	Dry Weight (g)	Plant Root Fresh Weight (g)
Compost Extract				
None	39.52 a	12.82 a	1.13 a	27.23 c
Cow Manure	44.10 c	14.01 b	1.17 b	27.22 b
Rice Straw	42.43 b	19.54 c	1.49 c	22.93 a
Vermicompost	93.92 d	61.37 d	7.17 d	33.40 d
LSD 5%	0.36	0.37	0.16	2.36
Urea Fertilizer				
0 kg ha <sup>-1</sup>	50.19 a	8.00	2.38	25.51
100 kg ha <sup>-1</sup>	54.38 b	8.11	2.51	29.21
200 kg ha <sup>-1</sup>	60.42 c	9.02	2.77	28.36
LSD 5%	0.31	0.32 ns	0.14 ns	2.04 ns

Note: The numbers accompanied by the same letter in the same column were not different at the LSD 5% level.

**Table 3.** The effects of the application of three types of compost extract and urea on the average height of the kailan plants every week

Treatment	Plant Height (cm)			
	1 WAP	2 WAP	3 WAP	4 WAP
Compost Extract				
None	12.38 a	17.92 a	22.83 a	28.68 a
Cow Manure	14.34 b	19.75 b	26.52 b	32.51 b
Rice Straw	16.01 c	21.82 c	28.25 c	35.67 c
Vermicompost	18.69 d	26.72 d	38.05 d	59.27 d
LSD 5%	0.47	0.11	0.88	0.11
Urea Fertilizer				
0 kg ha <sup>-1</sup>	14.24 a	19.79 a	26.43 a	35.65 a
100 kg ha <sup>-1</sup>	15.20 b	21.69 b	29.08 b	39.26 b
200 kg ha <sup>-1</sup>	16.63 c	23.16 c	31.23 c	42.18 c
LSD 5%	0.41	0.09	0.76	0.09

Note: The numbers accompanied by the same letter were not different at the LSD 5% level.

## 2.6 Application of Compost Extract

The compost extract as showcased in an organic fertilizer form has been added to each hydroponic tube. Each tub needed 3 liters of compost extract adequate for 6 plants. Since the research utilized laborious hydroponics with zero water or nutrient stirrer, the extract was stirred regularly. Stirring permitted the nutrients within the compost extract to be consumed efficiently by the plant and hindered the compost extract from being settled.

## 2.7 Urea Application

Urea was added by disintegrating the different doses within a water of 150 ml and combining the solution with the compost extract within hydroponic bathtub. The urea was then granted to plants in one week duration after planting (WAP).

## 2.8 Observation of Variables and Absorption of N

Assessment of variables involved calculation of number of leaves (3, 4 WAP), plant height (1, 2, 3, 4 WAP), plant fresh weight (4 WAP), plant dry weight (4 WAP), canopy fresh weight (4 WAP), leaf greenness (SPAD) and root weight (4 WAP). The absorption of nitrogen was determined using the Formula [1] and N uptake efficiency has been determined using Formula [2] (Habbib et al., 2016)

N uptake = percent N × plant dry weight (g) .....[1]

ESN = (SP-SK)/HP × 100% .....[2]

Note: SP: N uptake of fertilized plants (kg N ha<sup>-1</sup>)

SK: N uptake of unfertilized plants (kg N ha<sup>-1</sup>)

HP: N fertilizer provided (kg N ha<sup>-1</sup>)

## 2.9 Data Analysis

Collected data were analyzed for homogeneity of variances using the Bartlett test and the additive model was assessed using what is termed as the *Tukey test*. If the conditions were fulfilled, an interpretation of the variance test was done. Divergence of the mean values was checked using the test of least significant difference (LSD) at a significance level of 5%.

## 3. Results

Plants with the size of 200 kg ha<sup>-1</sup> of urea had the maximum average fresh weight compared to other treatments (Table 2). The measured variables of overall fresh weight of the fruit, fresh weight of the canopy, dry weight of the canopy and fresh weight of the root had the greatest value of plants grown in vermicompost extract relative to other treatments. (Table 2).

**Table 4.** The effects of the application of three types of compost extract and urea on the average number of leaves of the kailan plants after 3 and 4 weeks.

Treatment	Number of Leaves	
	3 WAP	4 WAP
Compost Extract		
Without	11.67 a	13.00 a
Cow Manure	12.67 b	14.67 b
Rice Straw	13.67 c	14.67 b
Vermicompost	17.00 d	23.00 c
LSD 5%	0.66	0.77
Urea Fertilizer		
0 kg ha <sup>-1</sup>	12.50 a	14.75 a
100 kg ha <sup>-1</sup>	13.50 b	16.50 b
200 kg ha <sup>-1</sup>	15.25 c	17.75 c
LSD 5%	0.57	0.67

Note: The numbers accompanied by the same letter were not different at the LSD 5% level.

**Table 5.** The effects of the application of three types of compost extract and urea on the leaf greenness and N uptake of the kailan plants every week

Treatment	Leaf Greenness (SPAD)	N Uptake (g)
Compost Extract		
Without	111.8a	2.23 b
Cow Manure	143.6b	2.09 a
Rice Straw	152.7c	2.42 c
Vermicompost	183.8d	6.32 d
LSD 5%	0.32	0.20
Urea Fertilizer		
0 kg ha <sup>-1</sup>	127.88 a	2.86 a
100 kg ha <sup>-1</sup>	149.95 b	3.21 b
200 kg ha <sup>-1</sup>	166.23 c	3.73 c
LSD 5%	0.28	0.17

Note: The numbers accompanied by the same letter were not different at the LSD 5% level.

**Table 6.** The efficiency of N uptake by kailan plants given three types of compost (cow manure, rice straw, vermicompost) and urea applications

Treatment	N Uptake Efficiency (%)		
	Cow Manure Extract	Rice Straw Extract	Vermicompost Extract
100 kg ha <sup>-1</sup>	28.53	0.01	112.05
200 kg ha <sup>-1</sup>	38.70	6.83	86.39

Variance analyzes found that the compost extracts is crucial for plant fresh weight, fresh weight of the root and dry weight of the canopy (Table 2), plant height (Table 3) and number of leaves (Table 4) of the kailan plants. The treatment of urea at a dose of 200 kg ha<sup>-1</sup> provided the maximum plant height relative to other treatments (Table 3). The application of nitrogen had a very prominent impact on plant height and had a significant impact on the growth of leaves and the average fresh weight of the plants, the fresh weight of the canopy, the dry weight of the canopy and the fresh weight of the root seemed to be unchanged by the application of N. There was no association between compost extracts and N applications for all variables observed.

The study of the variation revealed that the N uptake and greenness of the kailan leaves greatly influenced the use of the compost extract (Table 5). The findings of the urea-N study revealed very large variations in the N absorption and greenness of the kailan leaves. No variations were found in N

uptake and leaf greenness for the various combinations of compost extract and N fertilization.

Vermicompost extract usage as a fertilizer has been correlated with the maximum absorption capacity of N relative to other compost extracts (Table 6). Vermicompost extract with an addition of 100 kg ha<sup>-1</sup> of N led to an increase in a greater return of 112.05 per cent compared to 86.39 per cent of the N treatment at 200 kg ha<sup>-1</sup> (Table 6).

Based on examination in the greenhouse, the kailan plants were healthy and well grown and established. Vegetative output was equally distributed among plants requiring various treatments, but during subsequent production there were variations in crop production between plants receiving compost extract and urea and plants receiving control treatment.



#### 4. Discussion

The performance of nitrogen fertilizer in plants acquiring vermicompost extract was very high, particularly at a low nitrogen dose ( $100 \text{ kg ha}^{-1}$ ) with an effectiveness of 112.05 per cent (Table 6). Proof of high productivity was backed by a slightly higher fresh weight plant (93.92 g), dry weight (7.17 g), fresh canopy (61.37 g) relative to plants grown with all other extracts, as seen in Table 2. Piya et al. (2018) suggested vermicompost contains significant micro and macro nutrients, and enhanced microbial and biomass respiration had a beneficial impact on crop production and efficiency in different crops such as okra, cucumbers, lettuce, strawberries and cabbage. The use of vermicompost has had a beneficial impact on the production and efficiency of tomato plants relative to the use of chemical fertilizer (Kashem et al., 2015). Harvested vermicompost may be utilized as a foliar fertilizer. A more in-depth research on the compost extract utilization and its combination with N fertilizer for growing kailan plants is required to decide optimum doses, treatment cycles and combinations to optimize growth and production.

The use of vermicompost extract as a plant nutritional source coupled with nitrogen fertilizer at a  $100 \text{ kg ha}^{-1}$  dosage was able to decrease N losses relative to the application of nitrogen nitrogen fertilizer at a dosage of  $200 \text{ kg ha}^{-1}$ . This revealed that the concentration of N consumed by kailan was greater than the amount of N added by urea, which implies that any N did not come from the added urea, but from the vermicompost extract. This suggested that it was not necessary to apply urea to the kailan production using the hydroponic wick method since the vermicompost extraction had fulfilled the N specifications of the kailan plants. Baligar et al. (2001) mentioned the amount of nutrients generated from fertilizer was the aspect that most affected absorption performance. The greater the release, the higher the performance of fertilization, since the absorption efficiency is affected by the combination between both the plant's necessities and the quantity of fertilizer nutrients delivered.

Kailan soils inoculated with vermicompost extract developed the tallest in each observation week (Table 3). The Vermicompost extract contained growth-stimulating nutrients in earth crust, that can be easily assimilated by the roots of the plant and spread to all areas of the plant. Kováčik et al. (2015) reported the utilization of vermicompost extract induced strong vegetative growth in regards of plant height and stem length. Pant et al. (2009) tested the number of leaves to have improved substantially when plants were exposed with vermicompost extract. In comparison, crops cultivated with vermicompost extract had the largest number of leaves in this research relative to crops cultivated with other treatments (Table 4) because vermicompost extract produced the largest benefit in the N-nutrient content rather than within any other compost extracts (Table 1). Based on levinsh (2011), the vermicompost extract is responsible for the growth of plants hormones such as auxin and cytokinin, which could promote leaf development and the creation of strong quantities of chlorophyll to accelerate the photosynthesis process.

Urea produced ample N to promote the growth of apical meristems, which raised plant height. When their N criteria

were fulfilled, the plants would grow higher, with an increased foliage area to perform photosynthesis process. A relatively high N supply would boost the carbohydrates synthesis to proteins and is used to metabolize the cell wall (Fahmi et al., 2010). In addition, the utilization of urea at a  $200 \text{ kg ha}^{-1}$  dosage resulted in the maximum rate of leaves at 3 WAP and 4 WAP ages relative to any other treatment (Table 4). Building from Yeshiwas et al. (2018), the use of high nitrogen fertilizers would multiply the amount of nitrogen with tissues of particular plants, thereby promoting subsequent leaf growth.

The injection of nitrogen in the form of  $200 \text{ kg}$  of urea  $\text{ha}^{-1}$  resulted in maximum yield of kailan, as shown by the overall fresh weight. The average fresh weight, fresh canopy weight, and dry canopy weight were higher in plants given this treatment so a higher number of leaves would give a wider area of leaf that could improve photosynthesis. Photosynthetic plants were used to produce plant organs, and the bigger the plant organs were, the more water the plant could consume. Photosynthesis has played an important role from the vegetative period, including growth and production processes, to the generative stage, including crop and seed fabrication processes, as well as in post-harvest process improvements.

The deployment of the vermicompost extract improved the yield of kailan, as shown by the overall fresh weight. The vermicompost extract contained high amounts of N (Table 1) and several forms of microbes and was full of nutrients. In addition, the vermicompost extract contained the highest humus, hormones that could promote plant development, enzymes and other substances that could offers protection from pests and diseases (Hanc et al., 2017). As a result, the advantageous substances found in vermicompost extract could improve productivity, development and harvest output and could manage the threat to plant growth.

The kailan plants were harvested for their leaves, and therefore fresh weight of the canopy was a key determinant to the production of kailan. The thickest fresh weight canopy was seen in plants cultivated with a treatment of vermicompost extract since this extract had the maximum N content in comparison to any other compost extract and therefore better served the nutritional needs of the kailan plants for vegetative growth. This finding was identical to Pant et al. (2011) that vermicompost extract had a direct impact on the cultivation of pakchoi (*Brassica rapa* ssp. chinensis), mainly due to mineral elements (particularly N) needed at a massive dose to most crops.

Since the beginning of this research, it has been convincing that the injection of  $200 \text{ kg ha}^{-1}$  nitrogen fertilizer would sufficient to fulfill the needs for N to improve the productivity and output of the kailan plants. This hypothesis resonates to the work of Baloch et al. (2014), which mentioned that the use of adequate amounts of nitrogen contributed in optimizing the overall development of plants, particularly leaves, stems, and roots. That being said, the study of variation for canopy dry weight, canopy fresh weight, and root fresh weight variables revealed no variations between the effects of the different N procedures. Improved nitrogen efficiency was also supported by the fact that the

maximum N absorption was achieved in plants with vermicompost extract relative to any other treatment (Table 5). This was enabled since the N content of the extract of vermicompost was larger than any other extract, which allowed crops to consume a greater dose of N. Even so, crops with N deficit displayed significant decline and decreased quality of leaves, which decreased the amount of photosynthesis and chlorophyll (Asadu & Igboka, 2014).

The use of nitrogen at a dosage of 200 kg ha<sup>-1</sup> demonstrated the maximum absorption of nutrient within N in comparison to other therapies (Table 5). The N obtainable for use within this analysis was derived from nitrogen treatments and extracts. Based on Prasetya et al. (2009), the rise in plant N absorption was associated with a rise in plant growth, including total fresh weight, higher height of the crops and the number of leaves. The amount of leaf is often placed as a measure for the assessment of plant development and growth rates. It is evident that leaves are among the most essential parts of plant given to their rich content of chlorophyll, that is valuable for assessing the amount of N consumed by plants along with their development. Chlorophyll levels have been affected by a variety of causes, including nitrogen consumed by plants (Bojović & Marković, 2009).

The maximum leaf greenness was achieved in crops cultivated with vermicompost extract treatment relative to crops cultivated with other compost treatments (Table 5). This is since the vermicompost extract's N quality was higher relative to any other treatment, leading to a better greenness quality of leaves. This becomes compatible with the findings of Os et al., 2005 that mentioned the use of N could improve leaf growth, leaf nitrogen production and photosynthetic ability. Martínez-Alcántara et al. (2016) suggested that since N, P, K and other components found in solvent organic fertilizers were accessible to be consumed by kailan crops, photosynthesis was able to function efficiently and generate another photosynthesis.

Likewise, the maximum degree of leaf greenness was reached in plants with 200 kg ha<sup>-1</sup> of extra urea relative to other urea treatments (Table 5). Increased dose as a supply to N was significant in generating plant performance. The larger the dose of nitrogen used, the larger the degree of SPAD as well as the quality of carotenoid provided by the leaves (Pangaribuan & Hendarto, 2018).

A control treatment with no urea demonstrated a relatively weaker growth levels and weaker yield of kailan plants relative to any other treatment containing fertilizers. Building from Rambe et al. (2018), the N deficit restricts the development of proteins and any other alternative nutrients in the creation of new cells of the crops and would decrease the plant chlorophyll level as well as the photosynthesis level. As a consequence, it led to reduction of photosynthesis and growth of crops, consistent with our findings. Onyango et al. (2012) clarified that the N content of leaf vegetables will result in higher N fertilization.

## 5. Conclusion

Kailan plants cultivated on vermicompost extract with an addition of 100 kg of urea ha<sup>-1</sup> exhibited the highest

absorption efficiency of N (112.05%). As a consequence, wick hydroponics utilizing compost extract as a N source can be preferred. The use of vermicompost extract produced the best outcomes for all measured variables, including number of leaves, plant height, canopy fresh weight, total plant fresh weight, canopy dry weight, leaf greenness level, root fresh weight, N uptake and the quality of N uptake. A degree of 200 kg ha<sup>-1</sup> urea fertilization culminated in the maximum harvested kailan plants, overall fresh weight of the plant, number of leaves, leaf greenness and N uptake. Eventually, interaction among the compositions are none to be seen.

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## 10 Declaration of Competing Interest

The authors declare no competing financial or personal interests that may appear and influence the work reported in this paper.

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