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# Effect of Different Crop Establishment Methods and Organic Sources of Nutrients on Finger Millet in South Eastern Ghat Zone of Odisha, India

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Organic agriculture appears to be a way to maintain desired crop production in future. In terms of nutrients, organic farming practices vary with the availability of local resources of manures and its quantity needs to be identified to meet the nutritional needs of finger millet. So, a field experiment was conducted at Regional Research and Technology Transfer Sub-Station (OUAT), Malkangiri, Odisha during rainy season of 2019-2021 to find out the effect of organic nutrient sources on yield and economics of finger millet under different establishment methods. Three crop establishment

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methods (line sowing, transplanting and broadcasting) and six different organic sources of nutrients (FYM @ 5 t $ha^{-1}$, VC @ 2 t $ha^{-1}$, FYM @ 2.5 t $ha^{-1}$ + VC @ 1 t $ha^{-1}$, Compost prepared by Waste decomposer @ 5 t $ha^{-1}$, FYM @ 5 t $ha^{-1}$ + Bio NPK @ 5 kg $ha^{-1}$ and *Gliricidia* leaf manure @ 2.5 t $ha^{-1}$) were laid out in split-plot design with three replications. The recorded data revealed that significantly highest number of tillers (2.55 $hill^{-1}$), fingers (5.52 ear $head^{-1}$), finger length (6.53 cm) along with highest yield (1259 kg $ha^{-1}$), net return (Rs. 14709 $ha^{-1}$) and B: C ratio (1.48) were obtained with transplanted condition. Growth and yield attributes of finger millet was significantly varied by application of different organic sources of nutrients and it was observed that application of FYM @ 2.5 t $ha^{-1}$ + VC @ 1 t $ha^{-1}$ recorded highest number of tillers (2.52 $hill^{-1}$), fingers (5.76 ear $head^{-1}$), finger length (6.72 cm) and grain yield (1327 kg $ha^{-1}$) followed by application of FYM @ 5 t $ha^{-1}$ + Bio NPK @ 5 kg $ha^{-1}$and both were statistically at par in respect to all above parameters. But, highest net return (Rs. 18923 $ha^{-1}$) and B: C ratio (1.65) was obtained with the application of FYM @ 5 t $ha^{-1}$ + Bio NPK @ 5 kg $ha^{-1}$. So, transplanting of finger millet with the application of FYM @ 5 t $ha^{-1}$ + Bio NPK @ 5 kg $ha^{-1}$ should be recommended for the studied region as organic nutrient management.

*Keywords: Establishment method; finger millet; organic nutrients; yields.*

## 1. INTRODUCTION

Finger millet [*Eleusine coracana* (L.) Gaertn] is one of the most important millet crop grown in different parts of the world. In India, it is cultivated in about 1004 thousand ha with production of 1755 thousand tonnes during 2019-20 [1]. Karnataka, Maharashtra, Uttar Pradesh, Tamil Nadu, Uttarakhand and Odisha are the major producing states. In Odisha, finger millet is cultivated in an area of 43 thousand ha with production of 33 thousand tonnes and productivity of finger millet is very less in Odisha (767 kg $ha^{-1}$) as compared to national average i.e. 1747 kg $ha^{-1}$ [1]. The crop is being cultivated mainly in rainfed areas in resource-poor soils [2]. It is well adapted in extreme weather condition [3,4] and plays a major role for socio-economic condition of the small and marginal farmers. As per the nutritional aspect, it has huge importance and grain of finger millet contains 66.8, 7.2, 1.9 and 11.2 g of carbohydrate,protein,total fat and total dietary fibre, respectively in 100 g of grain which is equivalent to 1342 KJ energy [5]. Finger millet contains higher amount of calcium (364 $mgg^{-1}$) and iron (4.62 $mgg^{-1}$), those are responsible for strengthening bones and improves anemia and malnutrition [5,6]. Modern crop production practices like use of chemical fertilizers caused in decline soil organic matter and quality of agricultural soil [7,8]. In recent years declining organic carbon and deficit in many essential nutrients in soils is a major worry among the scientists [9]. The current global demand is to adopt eco-friendly production practices in view of the safe, healthy and nutritious food. The use of different organic fertilizers which emphasizes on local or farm resources are good option for safe, healthy and nutritious food. Hence an attempt has been taken to develop the organic nutrient management practices for finger millet. Use of well decomposed farm yard to the crops is being practiced since long back [10]. Use of vermicompost in agriculture has several advantages [11]. Compost prepared by using waste decomposer is another option for organic nutrient management. Bio-NPK contains nitrogen fixer, phosphate solubilizing and potassium mobilizing bacteria and plays an important role in plant nutrition and found positive contribution to soil fertility, resulting in higher crop yield [12]. *Gliricidia* leaf manure is another option for organic agriculture; it improves soil health by improving soil physical, chemical and biological properties [13]. So, various organic nutrient sources are available and need to be test in finger millet. On other hand, method of crop establishment is an important agronomic factor for crop production. Under such circumstances, adoption of proper establishment method and organic source of nutrients can improve finger millet productivity and profitability. Therefore, an investigation was under taken to study the effect of different crop establishment methods and organic nutrient sources on finger millet in South Eastern Ghat Zone of Odisha, India.

## 2. MATERIALS AND METHODS

The experiment was carried out at the research farm of Regional Research and Technology Transfer Sub-Station (OUAT), Malkangiri, Odisha ($18^0$22' N latitude, $81^0$52' E longitude and at an elevation of 185m above mean sea level) during rainy season of 2019, 2020 and 2021. Initial

basic chemical properties of the surface soil (0-15 cm) were pH of 5.5, available nitrogen, phosphorus and potassium as 211.21, 15.60 and 151.28 kg ha$^{-1}$, respectively. The soil texture of the experimental site was sandy loam. Different weather data during experimentation are presented in Figs. 1 and 2. Experiment was conducted in a split-plot design with three replications. Three different crop establishment methods (M1-Line sowing, M2- Transplanting and M3- Broadcasting) were accommodated in main plots. Sub plots were fitted with six different organic nutrient sources viz. N1- FYM @ 5 t ha$^{-1}$, N2- VC @ 2 t ha$^{-1}$, N3- FYM @ 2.5 t ha$^{-1}$ + VC @ 1 t ha$^{-1}$, N4- Compost prepared by Waste decomposer @ 5 t ha$^{-1}$, N5- FYM @ 5 t ha$^{-1}$ + Bio NPK @ 5 kg ha$^{-1}$ and N6-*Gliricidia* leaf manure @ 2.5 t ha$^{-1}$. Compost prepared by Waste decomposer according to the guidelines of Chandra et al. [14]. *Gliricidia* fresh leaf was applied on the surface of ploughed soil and mixed into soil immediately before sowing or transplanting. Sowing was done in the last week of July and used 10 kg seeds ha$^{-1}$ for line sown (22.5 cm row to row distances) and broadcasted condition. Seed rate of 6 kg ha$^{-1}$ used for transplanted crop and four weeks old seedlings transplanted in main field with a spacing of 22.5 cm x 10 cm. Finger millet variety Bhairabi was taken in this experiment and applied organic nutrients as per treatments condition during last ploughing. All other cultural operations up to the harvest of finger millet were followed uniformly as per recommended package of practices to get a healthy crop. The crop was harvested in the second and third week of November. Observations on plant height (cm), number of tillers hill$^{-1}$, number of fingers ear head$^{-1}$, finger length (cm) and yield (kg ha$^{-1}$) were recorded at harvest. The plant height (cm) was measured from the base of the plant to the tip of the upper leaf. Ten plants and ten ear heads were picked at random from each plot for estimation of number of tillers hill$^{-1}$ and number of fingers ear head$^{-1}$, respectively. Finger length (cm) was measured from the base of the finger to the tip of the finger. The crop was harvested plot wise and grain yield obtained from net plot was converted into kg ha$^{-1}$. Economic parameters such as cost of production, gross return, net return and benefit cost ratio were calculated by considering all inputs and outputs as per local situation. Data were statistically analyzed using analysis of variance (ANOVA) as split-plot design [15] in MS Excel 2010. Further significant differences between the treatments were compared with the critical difference at ±5% probability level.

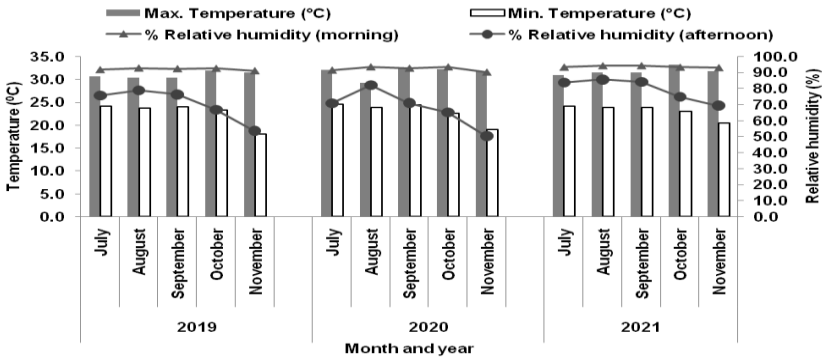


**Fig. 1. Monthly mean temperature and mean relative humidity during cropping period**

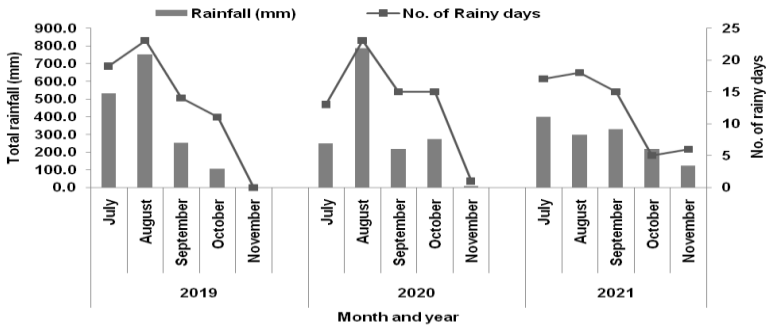


**Fig. 2. Monthly total rainfall and number of rainy days during cropping period**

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of Crop Establishment Methods

It was observed that different crop establishment methods had significant effect on the growth and yield parameters (Tables 1 and 2). Line sown crop (M1) recorded highest plant height (82.74, 85.49 and 85.81 cm in 1st, 2nd and 3rd year, respectively) as compared to broadcasted (M3) and transplanted (M2) crop. But, significantly highest tillers (2.21, 2.69 and 2.76hill$^{-1}$ in 1st, 2nd and 3rd year, respectively) were recorded with transplanted crop. Significantly highest numbers of fingers earhead$^{-1}$ (5.40, 5.58 and 5.57 in 1st, 2nd and 3rd year, respectively) and finger length (6.49, 6.55 and 6.56 cm in 1st, 2nd and 3rd year, respectively) was recorded with finger millet cultivated in transplanted condition as compared to line sown and broadcasting. Finger millet cultivation with broadcasting recorded least yield attributing characters. Larger space in transplanted condition may help in the efficient utilization of different resources viz. land, light, and nutrients [16] and ultimately helps in obtaining higher number of tillers, fingers and more finger length. Highest finger millet grain yield of 1230, 1252 and 1294 kg ha$^{-1}$ obtained with transplanting condition as compared to 1217, 1235 and 1257 kg ha$^{-1}$ by line sown crop in 1st, 2nd and 3rd year, respectively. Finger millet in broadcasted condition recorded lowest grain yield (1045-1215 kg ha$^{-1}$). These results are in conformity with the findings of Pradhan et al. [17]. There was no significant difference between line sown and transplanted crop for grain yield. Better establishment techniques like transplanting influenced growth and yield attributes [17,18,19] which might have enhanced the grain yield. Grain yield in the broadcasted condition was less and it may due to be weeds stresses followed by less growth and yield attributes. Total cost of cultivation (Rs. 35109 ha$^{-1}$) was higher with line sown crop due to addition labour cost involved in making line and sowing. On other hand, cost of cultivation was more with broadcasted crop (Rs. 34279 ha$^{-1}$) as compared to transplanted crop (Rs. 32760 ha$^{-1}$). It was due to be more labour required for weeding in broadcasted crop. Among the different crop establishment methods highest gross return (Rs. 47469 ha$^{-1}$), net return (Rs. 14709 ha$^{-1}$) and B: C ratio (1.48) were obtained with finger millet cultivated in transplanted condition followed by line sown and broadcasted condition. Higher total grain yield with least cost of cultivation in transplanted condition was responsible for more economic return with transplanted crop. Transplanted finger millet is more economical as per the others previous study [17,18].

### 3.2 Effect of Organic Sources of Nutrients

Growth and yield attributes of finger millet was significantly varied by application of different organic sources on nutrients (Tables 1 and 2). Based on yearly and pooled data, it was observed that application of FYM @ 2.5 t ha$^{-1}$ + VC @ 1 tha$^{-1}$ (N3) recorded highest plant height and number of tillers hill$^{-1}$followed by application of FYM @ 5 t ha$^{-1}$ + Bio NPK @ 5 kg ha$^{-1}$ (N5); and both N3 and N5 were statistically at par. Based on pooled analysis, highest plant height (87.69 cm) and number of tillers (2.52 hill$^{-1}$) were observed with N3 followed by N5 (plant height of 86.31 cm and number of tillers 2.45 hill$^{-1}$).On other hand, application of *Gliricidia* leaf manure @ 2.5 t ha$^{-1}$ recorded lowest plant height (77.87 cm) and number of tillers (2.14 hill$^{-1}$).Number of fingers ear head$^{-1}$ was found to vary between 4.60-5.58 during 2019, 4.80-5.84 during 2020 and 4.81-5.85 during 2021. Based on pooled analysis, significantly highest numbers of finger earhead$^{-1}$(5.76) was recorded with the application of FYM @ 2.5 t ha$^{-1}$ + VC @ 1 t ha$^{-1}$ (N3) followed by application of FYM @ 5 t ha$^{-1}$ + Bio NPK @ 5 kg ha$^{-1}$ i.e. N5 (5.61). Same trends were also followed for finger length and highest finger length of 6.72 cm was recorded with the application of FYM @ 2.5 t ha$^{-1}$ + VC @ 1 t ha$^{-1}$ (N3) followed by application of FYM @ 5 t ha$^{-1}$ + Bio NPK @ 5 kg ha$^{-1}$ i.e. N5 (6.62). Both N3 and N5 were statistically at par. Application of *Gliricidia* leaf manure @ 2.5 t ha$^{-1}$ recorded lowest number of fingers (4.74 hill$^{-1}$) and finger length (5.66 cm).Nutrients supplied through N3 and N5 could have released adequate nutrients into the soil solution to match the required absorption pattern of finger millet and resulted in superior growth and yield attributing characters of finger millet. Irrespective of years and pooled analysis, grain yield of finger millet was significantly influenced by different organic sources of nutrients. Highest grain yield of 1291, 1320 and 1370 kg ha$^{-1}$ obtained with N3 followed by 1238, 1268 and 1317 kg ha$^{-1}$ with N5 during 2019, 2020 and 2021, respectively. Based on pooled analysis, significantly highest grain yield obtained with N3 (1327 kg ha$^{-1}$) followed by N5 (1274 kg ha$^{-1}$) and N6 recorded lowest grain yield (1108 kg ha$^{-1}$). Regarding grain yield, both N3 and N5 were statistically at par. The increase in grain yield is a result of better growth and yield components obtained with respective treatments.

**Table 1. Growth attributes of finger millet as influenced by crop establishment methods and organic sources of nutrients**

| Treatments | Plant height (cm) | | | | No. of tillers hill$^{-1}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2021 | Pooled | 2019 | 2020 | 2021 | Pooled |
| **Methods of crop establishment** | | | | | | | | |
| M1 | 82.74 | 85.49 | 85.81 | 84.68 | 2.09 | 2.41 | 2.45 | 2.32 |
| M2 | 76.78 | 80.73 | 81.71 | 79.74 | 2.21 | 2.69 | 2.76 | 2.55 |
| M3 | 81.49 | 83.79 | 84.02 | 83.10 | 1.92 | 2.25 | 2.29 | 2.16 |
| SEm (±) | 1.15 | 0.85 | 0.75 | 0.66 | 0.05 | 0.03 | 0.04 | 0.03 |
| CD (5%) | 4.51 | 3.36 | 2.93 | 2.60 | 0.21 | 0.10 | 0.17 | 0.13 |
| **Organic sources of nutrients** | | | | | | | | |
| N1 | 79.23 | 80.38 | 78.83 | 79.48 | 1.98 | 2.38 | 2.43 | 2.26 |
| N2 | 80.60 | 83.12 | 85.43 | 83.05 | 2.13 | 2.49 | 2.55 | 2.39 |
| N3 | 83.21 | 88.42 | 91.42 | 87.69 | 2.33 | 2.58 | 2.64 | 2.52 |
| N4 | 79.52 | 82.12 | 80.30 | 80.65 | 1.96 | 2.41 | 2.47 | 2.28 |
| N5 | 82.58 | 87.33 | 89.01 | 86.31 | 2.23 | 2.54 | 2.59 | 2.45 |
| N6 | 76.89 | 78.64 | 78.07 | 77.87 | 1.81 | 2.29 | 2.32 | 2.14 |
| SEm (±) | 0.84 | 0.64 | 0.88 | 0.52 | 0.07 | 0.05 | 0.05 | 0.04 |
| CD (5%) | 2.43 | 1.84 | 2.55 | 1.50 | 0.19 | 0.14 | 0.13 | 0.12 |

*M1-Line sowing; M2- Transplanting; M3- Broadcasting; N1- FYM @ 5 t ha$^{-1}$; N2- VC @ 2 t ha$^{-1}$; N3- FYM @ 2.5 t ha$^{-1}$ + VC @ 1 t ha$^{-1}$; N4- Compost prepared by Waste decomposer @ 5 t ha$^{-1}$; N5- FYM @ 5 t ha$^{-1}$ + Bio NPK @ 5 kg ha$^{-1}$; N6- Gliricidia leaf manure @ 2.5 t ha$^{-1}$*

**Table 2. Yield attributes, yield and economics (mean data of three years) of finger millet as influenced by crop establishment methods and organic sources of nutrients**

| Treatments | No. of fingers ear head$^{-1}$ | | | | Finger length (cm) | | | | Grain yield (kgha$^{-1}$) | | | | Cost of cultivation (Rs. ha$^{-1}$) | Gross return (Rs. ha$^{-1}$) | Net return (Rs. ha$^{-1}$) | B: C ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2021 | Pooled | 2019 | 2020 | 2021 | Pooled | 2019 | 2020 | 2021 | Pooled | | | | |
| **Methods of crop establishment** | | | | | | | | | | | | | | | | |
| M1 | 5.22 | 5.38 | 5.43 | 5.34 | 6.07 | 6.29 | 6.52 | 6.29 | 1217 | 1235 | 1257 | 1236 | 35109 | 46605 | 11495 | 1.35 |
| M2 | 5.40 | 5.58 | 5.57 | 5.52 | 6.49 | 6.55 | 6.56 | 6.53 | 1230 | 1252 | 1294 | 1259 | 32760 | 47469 | 14709 | 1.48 |
| M3 | 4.74 | 5.24 | 5.31 | 5.09 | 5.74 | 6.11 | 6.14 | 6.00 | 1045 | 1191 | 1215 | 1151 | 34279 | 43489 | 9209 | 1.29 |
| SEm (±) | 0.11 | 0.05 | 0.03 | 0.06 | 0.10 | 0.07 | 0.06 | 0.06 | 22.4 | 10.7 | 7.8 | 12.2 | - | - | - | - |
| CD (5%) | 0.44 | 0.19 | 0.12 | 0.24 | 0.38 | 0.27 | 0.23 | 0.22 | 88.1 | 42.1 | 30.5 | 48.1 | - | - | - | - |
| **Organic sources of nutrients** | | | | | | | | | | | | | | | | |
| N1 | 4.94 | 5.15 | 5.37 | 5.16 | 5.68 | 6.02 | 6.15 | 5.95 | 1090 | 1184 | 1189 | 1154 | 28147 | 43567 | 15420 | 1.55 |
| N2 | 5.33 | 5.57 | 5.57 | 5.49 | 6.37 | 6.40 | 6.65 | 6.47 | 1214 | 1238 | 1268 | 1240 | 43147 | 46749 | 3602 | 1.08 |
| N3 | 5.58 | 5.84 | 5.85 | 5.76 | 6.60 | 6.80 | 6.75 | 6.72 | 1291 | 1320 | 1370 | 1327 | 35647 | 50054 | 14407 | 1.4 |
| N4 | 4.89 | 5.29 | 5.28 | 5.15 | 6.04 | 6.34 | 6.34 | 6.24 | 1131 | 1199 | 1233 | 1188 | 38147 | 44822 | 6675 | 1.17 |
| N5 | 5.37 | 5.73 | 5.73 | 5.61 | 6.51 | 6.63 | 6.71 | 6.62 | 1238 | 1268 | 1317 | 1274 | 29147 | 48070 | 18923 | 1.65 |
| N6 | 4.60 | 4.80 | 4.81 | 4.74 | 5.41 | 5.70 | 5.86 | 5.66 | 1021 | 1147 | 1157 | 1108 | 30064 | 41863 | 11799 | 1.39 |
| SEm (±) | 0.13 | 0.11 | 0.07 | 0.09 | 0.09 | 0.10 | 0.08 | 0.06 | 30.9 | 12.1 | 18.7 | 12.3 | - | - | - | - |
| CD (5%) | 0.39 | 0.32 | 0.20 | 0.27 | 0.27 | 0.28 | 0.23 | 0.17 | 89.2 | 34.8 | 53.9 | 35.5 | - | - | - | - |

*M1-Line sowing; M2- Transplanting; M3- Broadcasting; N1- FYM @ 5 t ha$^{-1}$; N2- VC @ 2 t ha$^{-1}$; N3- FYM @ 2.5 t ha$^{-1}$ + VC @ 1 t ha$^{-1}$; N4- Compost prepared by Waste decomposer @ 5 t ha$^{-1}$; N5- FYM @ 5 t ha$^{-1}$ + Bio NPK @ 5 kg ha$^{-1}$; N6- Gliricidia leaf manure @ 2.5 t ha$^{-1}$*

The beneficial effect of FYM may be explained by the fact that it supplied available plant nutrients as well as it had solubilizing effect of soil nutrients [20] and application of vermicompost in soil has several advantages [21]. On other hand, Bio-NPK plays an important role in plant nutrition and resulting in higher crop yield [12]. The above factors may be responsible for the higher grain yield with N3 and N5. There was a variation in cost of cultivation in respect to different organic sources of nutrients due to difference in inputs and their prices. Based on mean data of three years, highest gross return (Rs. 50054 $ha^{-1}$) was recorded with N3 followed by N5 (Rs. 48070 $ha^{-1}$) and N2 (Rs. 46749 $ha^{-1}$). But, highest net return (Rs. 18923 $ha^{-1}$) and benefit cost ratio (1.65) were recorded with N5 followed by N1 and N3. Though the yield was highest in N3 but the highest net return and benefit cost ratio was obtained with N5 as cultivation cost was higher in N3.

## 4. CONCLUSION

Highest finger millet grain yield obtained in transplanted crop (1259 kg $ha^{-1}$) followed by line sown crop (1236 kg $ha^{-1}$). In case of organic sources of nutrients, highest yield (1327 kg $ha^{-1}$) was recorded with the application of FYM @ 2.5 t/ha + VC @ 1 t/ha followed by application of FYM @ 5 t/ha + Bio NPK @ 5 kg/ha (1274 kg $ha^{-1}$) and both are statistically at par. In terms of economic return, highest net return (Rs. 14709 $ha^{-1}$) and B: C ratio (1.48) was recorded with transplanted crop and application of FYM @ 5 t/ha + Bio NPK @ 5 kg/ha (net return- Rs. 18923$ha^{-1}$; B: C ratio- 1.65).In view of above, sowing of finger millet in last week of July and transplanting of four weeks old seedlings with application of FYM @ 5 t $ha^{-1}$ + Bio NPK @ 5 kg $ha^{-1}$ should be opted as organic nutrient management for better outcome in experimental region.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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