

# Seed quality of transplanted Aman rice as impacted by rainfed in the ripening phase

## ABSTRACT

Rainfall is the main contributor to provide soil moisture for rainfed rice (Transplanted Aman) cultivation. The aim of the study was to investigate the seed quality of different transplanted Aman rice cultivars that are influenced by rainfed during ripening phases. For this, several experiments have been performed during the transplanted Aman season of 2014, 2015, and 2016 at the Bangladesh Rice Research Institute, Gazipur. Two planting dates and three rice varieties were used in the treatment, and the treatments were organized in a randomized complete block design with three replications. T. Aman rice received huge rainfall up to vegetative phase resulting no irrigation demand in all three tested years. In all the parameters of yield and yield components, the association between planting dates and variety was not significant. Also the relationship between planting dates and variety did not greatly affect the germination percentage, seedling vigor index, high density grain shoot dry weight, and root dry weight. Sixteen august planting produced a greater number of tillers  $m^{-2}$ , panicles  $m^{-2}$ , grain panicle $^{-1}$ , 1000-grain weight, grain and straw yield in the case of yield and yield components. While, the 1000-grain weight of panicles  $m^{-2}$ , grain panicle $^{-1}$ , was greatly influenced by the variety. The highest 1000 grain weight and grain yield were produced by BRRI dhan46. The SVI, HDG percent, SDW and RDW were greatly influenced by planting dates in terms of seed quality. All of these criteria were higher for planting on 16 August than for planting on 12 September. Early transplanting received more rainfall in reproductive phase than late planting. Varieties were greatly influenced by all the seed quality parameters. BRRI dhan46 received the highest GM percent, SVI, HDG percent, SDW and RDW. Specific suitable transplanting dates were selected considering minimum irrigation at reproductive phase and maximum seed quality and grain yield. Delay in transplanting demanded more irrigation and reduced seed quality and grain yield.

**Key words:** Rice, seed quality, rainfed and ripening phase.

## 1. INTRODUCTION

“Rice is extremely vulnerable to water stress at its reproductive phase and water demand at flowering stage highly impact for rice yield” [1]. “T. Aman rice is a major crop of Bangladesh agriculture as it contributes around 39% of the total rice production” [2]. “For rainfed rice (T. Aman), water stress at the vegetative phase caused about 20-25% yield reduction and that of at the reproductive caused as high as 28-50% yield reduction” [1,3].

“Bangladesh has a tropical climate with climatic conditions, such as temperature and rainfall, differing considerably. The country's total area is 14.86 million ha (147,570 square kilometers), and the area under cultivation is 8.52 million ha. While it is not uniformly spread across regions or seasons, the country receives plenty of rainfall. In Bangladesh average rainfall distribution varies from 1500 mm in the west and central zones to more than 5000 mm in the north-east and south-east zones” [4]. “During the monsoon season, most rainfall occurs between mid-June and September. There is very little rain between November and March, and there is pre-monsoon rain with thunderstorms during the time between April and May. In Bangladesh, transplanted aman rice varieties are normally grown in a rainfed environment that covers roughly 48.9% of the total rice area and contributes to 38.14% of the total production of rice” [5]. “In the Aman season, modern T. Aman varieties cover about 80.5 percent of the rice region” [6]. “Total Aman rice covers 56,25,907 hectares land with a production of 1,44,37,763 metric tons” [7]. “Modern varieties of T. Aman cover about 89% of rice area in the Aman season” [7]. “Aman rice damage by heavy rainfall and flood at the seedling stage and therefore resulting delay planting. The unpredictable rainfall often affects Aman transplanting. Flash floods affect 24% of rainfed lowland Aman rice areas, mainly at the seedling stage. Transplanted Aman usually suffers from water stress at the reproductive stage or at early ripening phases, reducing crop yield phases” [8]. “The grain productivity of rice is significantly affected by drought stress events at various crop stages caused by seasonal variability of rainfall patterns” [9].

Drought could be described as the lack of sufficient moisture needed for a plant to grow properly and to finish its life cycle. In rainfed regions, the lack of sufficient moisture leading to drought is a typical phenomenon, induced by rainfall and inadequate irrigation. Drought impacts the growth and productivity of plants and, consequently, decreases rice grain production. The decline in yield can rely on the crop's developmental phase. The sensitivity of rice yield towards ground soil moisture varies with the most vulnerable stage of growth at flowering, followed by the stage of booting and grain filling [10, 11]. “Yield losses are

dependent upon the duration and intensity of the stress intervals. Rice is very sensitive to drought stress, and if drought stress occurs in midseason or at the flowering stage, it can affect the grain numbers as well as spikelet fertility, causing yield losses up to 92% [12] and severe yield losses can occur if drought prevails at terminal or lateral crop stages" [13]. According to Pantuwan *et al.* [14] and Ovenden *et al.* [15], drought stress affects source-to-sink distribution and leads to reduced grain productivity.

Drought has been one of the main abiotic restraints in Bangladesh for rice cultivation under rainfed conditions and induces a large yield loss. It is possible to resolve the delay in crop growth caused by water stress at the seedling stage, but water stress at the reproductive stage can cause significant decreases in rice yield. On the reproductive stage or at early ripening stages, transplanted aman typically suffers from water deficit, reducing crop yield phases. With early transplantation on 1 June, a crop growth simulation model showed a yield potential of 7,218 t/ha under low water stress during flowering and maturity process, while high water stress during flowering, maturity and all flowering and maturity phases resulted in a yield reduction of 46 percent, 37 percent and 73 percent respectively [16].

Water tension disrupts the filling of grains and the quality of rice grains [17, 18]. Water stress decreases grain weight after the flowering stage [19]. Boonjung and Fukai (1996) [20] recorded that "there was a small impact on subsequent growth and grain yield when drought occurred during vegetative stages. The reduction in yield by up to 30 percent was due to decreased panicle number per unit area and spikelet number per panicle". They also estimated that drought reduced the percentage of filled grains by up to 40 percent at the grain filling point, and decreased the individual grain mass by 20 percent. During grain filling, the impact of stress was also related to its magnitude. At that point, tension hastened maturity. The findings indicate that the variance in yield components due to the availability of water is correlated with the variation in the development of dry matter at specific growth stages. Rahman and Yoshida (1984) [21] suggested that the rate of grain filling was impaired by water tension, decreased yield per panicle of rice by 29-40% in the small-seeded variety IR747 (L) and 19-32% in the large-seeded variety PP, R13-12-3. The length of the grain filling had no bearing on it. O" Toole (1982)[22] stated that the response of rice yield to soil water status varies with growth stage being most vulnerable at flowering, followed by booting and grain filling stage. Due to water stress in the flowering stage, further reduction in grain yield is primarily due to the reduction in fertile panicle and filled grain percentage. The

remobilization of accumulated carbon reserves and water deficit during grain-filling increased plant senescence and accelerated grain-filling was also stimulated by water tension. Senescence caused by water deficiency typically shortens the time of grain filling which may result in a decrease in grain weight. Water deficiency-related yield loss after anthesis is attributed to decreased panicle numbers and enhanced sterility [23]. The early stage of grain ripening is the third vulnerable stage and the ripening period is inhibited by drought. In Bangladesh, T. Aman rice is mainly grown in a rainfed state. During November, this crop suffers from drought at the ripening stage.

No adequate information is available on the impact of rainfed in the ripening phase on rice yield and seed quality. This experiment was therefore carried out to investigate the impact of rainfed in the ripening stage on rice yield and seed quality.

## **2. MATERIALS and METHODS**

### **2.1 Study area**

The experiment was performed at the BRRF farm, Gazipur, Bangladesh during T. Aman season to examine the seed quality of rice which are affected by rainfed during the ripening phase of 2014, 2015 and 2016. The experimental field situated at 23° 59' 33" N latitude and 90° 24' 19" E longitude and at elevation of 8.4 m from the mean sea level [24] and it's characterized by sub-tropical climate. The location was under the agro-ecological Zone at Madhupur tract (AEZ 28).

### **2.2 Climatic condition of the study area**

The area is situated under subtropical Zone which was characterized high temperature and high humidity. During the T. Aman season there are sufficient rainfalls for growing the crops. However, sometimes where the crops suffered due to lack of rainwater, irrigation was given. Day length, maximum-minimum temperature gradually decreased from early to late in T. Aman season. On the other hand, the temperature increased on the onset of the T. Aman season and it gradually decreased with the advance of Boro season. But the Boro season rainfall was limited and irrigation water was given as and when necessary. The bright sunshine hours were high in the Boro season compared to the T. Aman season.

**Table 1: Physical and chemical properties of the soil of the experimental plot BRRF Farm, Gazipur, Bangladesh**

Analyses	Value	Method
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Soil texture	Clay loam	Hydrometer
Clay (%)	43	
Silt (%)	37	
Sand (%)	20	
Organic carbon (%)	1.30	Walkley-Black
Organic matter (%)	1.58	
pH (1:1 soil: water)	6.73	Potentiometric
Total N (%)	0.11	Micro-Kjeldahl
Available P (ppm)	5.03	Modified Olsen's
Exchangeable K (meq/100 g soil)	0.23	Flam photometer
Available S (ppm)	33.8	
Available Mn (ppm)	78	
Available Zn (ppm)	4.0	
Available Cu (ppm)	5.18	
Available Ca (ppm)	5.0	
Available Mg (ppm)	0.18	
Available Fe (ppm)	84	

#### 2.4 Treatments and experimental design

Two planting dates ( $D_1$ = 16 August and  $D_2$ = 12 September) and three varieties of rice ( $V_1$ = BRR1 dhan40,  $V_2$ = BRR1 dhan41 and  $V_3$ = BRR1 dhan46) were used in the treatment. The treatments were arranged with three replications in a Randomized Complete Block (RCB) design. The plot scale was 4 m × 4 m. At 20 cm × 20 cm spacing, thirty days of old seedlings @ three seedlings per hill were transplanted. Fertilizers as N,  $P_2O_5$ ,  $K_2O$  and S were applied @ 80-60-40-10 kg ha<sup>-1</sup> from urea, triple super phosphate, muriate of potash and gypsum, respectively. One third of urea and other all fertilizers were applied at the basal. At 15 days after transplanting (DAT) and 7 days before panicle initiation (PI) stage, the rest of the urea was applied in approximately consecutive splits as top-dressed, followed by their integration with the soil. All other cultural operations were conducted for proper crop management as and when appropriate. The weather data was collected by the BRR1 Plant Physiology Division. Data on yield and yield components were documented at maturity. The Germination percentage (GM%), Seedling vigor index (SVI), High density grain percentage (HDG%), Shoot dry weight (SDW) and Root dry weight (RDW) of harvested crop seeds were also taken for seed quality performance monitoring.

#### 2.5 Seed Germination (GM%)

Using the standard protocol (ISTA 1985), seed germination experiments were performed with three replicates of 100 seeds in Petri dishes containing two filter papers moistened at 25°C with 7 ml of distilled water. On the seventh day, the first counts of natural germination were taken (abnormal seeds were not considered as germinated). Structures (hulls) covering any ungerminated firm seeds were extracted and germination experiments were continued for a further 7 days before final germination counts were taken.

### **2.6 Seedling vigor index (SVI)**

As suggested by Abdul-Baki *et al.* (1973) [25], it was determined using the following formula, expressed as.

Vigor Index (VI) = Germination (%) x Seedling length (cm)

In order to measure the seedling length, five standard seedlings were randomly chosen for the germination test to measure the seedling length on the tenth day. From the collar area to the tip of the primary leaf, the seedling length was determined. In centimetres, the mean seedling length was expressed.

### **2.7 High Density grains (HDG)**

HDG was measured by soaking the grains in a 1.20 specific gravity salt solution using the gravity salt process (Padmaja Rao *et al.*, 1985)[26]. The HD grain index (HDGI) was measured and expressed as a percentage by dividing the number of HD grains by the number of spikelets (Mallik *et al.*, 1990) [27] on main branches (PB), secondary branches (SB) and panicles (P).

### **2.8 Shoot and Root dry weight**

Shoot and root were gathered to establish Shoot dry weight (SDW) and Root dry weight (RDW), put on an oven (65°C, 72 h) and measured.

### **2.9 Statistical Analysis**

Using the Crop Stat Analysis package, the collected data was analyzed.

## **3. RESULTS AND DISCUSSION**

### **3.1 Yield and Yield Components**

The relationship between planting dates and variety was negligible in all the yield and yield variable parameters over the years. Only the key effect has therefore been defined and discussed below:

#### **3.1.1 Effect of planting dates on yield and yield components**

The planting dates have had a major impact on yield and yield materials, regardless of the year (Table 2 and 3). Irrespective of year, planting on 16 August resulted in higher numbers of  $m^{-2}$  tillers,  $m^{-2}$  panicles,  $panicle^{-1}$  grain, 1000-grain weight, grain and straw yield. On 12 September planting, the grain yield substantially decreased may be attributed to a decline in rainfall, temperature and solar radiation during the ripening process (Fig. 1 & 2 and Table 4), while rainfall during the vegetative and reproductive phase was higher in 2014 than in 2015 and 2016, but there was no rainfall in all three years during the ripening phase and plants were suffered due to lack of water. This finding agrees with the results of Boonjung and Fukai (1996) [28]; Moonmoon and Islam (2017) [29]. Effective tillers  $hill^{-1}$ , complete spikelets  $panicle^{-1}$ , filled grains  $panicle^{-1}$ , 1000-grain weight and grain yield  $hill^{-1}$  were recorded to be more destructive by drought stress at grain filling (anthesis to maturity), followed by panicle initiation point. This may be attributed to a substantial decrease in the photosynthetic rate resulting in decreased production of panicle and grain filling; consequently, the yield of rice was significantly reduced.

### 3.1.2 Effect of variety on yield and yield components

Irrespective of year, varieties were severely impacted by panicles  $m^{-2}$ , grain  $panicle^{-1}$  and 1000 grain weight, but the number of tillers  $m^{-2}$  grain and straw yield was not greatly affected (Table 2 and 3). Due to the higher number of  $m^{-2}$  panicles, grain  $panicle^{-1}$  and 1000 grain weight, BRRi dhan46 gave the highest grain yield.

**Table 2.** Effect of planting date and variety on tiller number and yield components in T. Aman season of 2014, 2015, and 2016.

Treatments	Tiller $m^{-2}$ (no.)			Panicle $m^{-2}$ (no.)			Grain $panicle^{-1}$ (no.)			1000- grain wt. (g)		
	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016
	<b>Planting dates</b>											
16 August	223	229	230	201	198	199	100	96	97	23.77	24.16	23.15
12 Sept	210	205	206	187	183	184	94	89	90	22.58	22.56	22.60
LSD at 5%	2.0	12.95	10.85	3.0	2.27	2.25	5.09	2.51	2.49	1.10	1.06	1.04
	<b>Varieties</b>											
BRRi dhan40	218	219	218	194	189	190	93	91	92	22.23	22.30	22.32
BRRi dhan41	216	213	215	195	189	189	96	90	91	23.53	23.68	23.65
BRRi dhan46	217	220	221	196	194	194	97	95	96	23.76	24.13	24.15
LSD at 5%	NS	NS	NS	NS	2.78	2.76	3.02	3.07	3.04	1.35	1.30	1.28

NS=Not significant.

**Table 3.** Effects of date and variety planting, on rice grain and straw yield during 2014, 2015, and 2016 of T. Aman season.

Treatments	Grain yield (t ha <sup>-1</sup> )			Straw yield (t ha <sup>-1</sup> )		
	2014	2015	2016	2014	2015	2016
<b>Planting dates</b>						
16 August	4.48	4.50	4.49	6.02	6.00	6.02
12 Sept	3.56	3.50	3.49	5.47	5.41	5.43
LSD at 5%	0.48	0.49	0.47	0.63	0.58	0.58
<b>Varieties</b>						
BRRi dhan40	3.96	3.95	3.94	5.67	5.70	5.73
BRRi dhan41	3.97	3.92	3.91	5.65	5.57	5.59
BRRi dhan46	4.13	4.12	4.12	5.90	5.86	5.88
LSD at 5%	NS	NS	NS	NS	NS	NS

NS=Not significant

**Table 4.** Effects of planting date and variety on the flowering and maturity date in T. Aman season during 2014, 2015, and 2016.

Planting dates	Variety	Date of flowering	Date of maturity
16-Aug	BRRi dhan40	Oct 24±3	Nov 25± 2
	BRRi dhan41	Oct 26± 3	Nov 27± 2
	BRRi dhan46	Oct 29±2	Nov 29± 2
12-Sep	BRRi dhan40	Nov 14± 3	Dec 17± 2
	BRRi dhan41	Nov 12±2	Dec 15±2
	BRRi dhan46	Nov 09±1	Dec 10± 2

### 3.2 Seed Quality

The relationship between planting dates and variety was not significant for seed quality in every years, such as GM %, SVI, HDG %, SDW and RDW (Table 5 and 6).

#### 3.2.1 Effect of planting dates on seed quality

Planting dates significantly affected the SVI, HDG percent, SDW and RDW, but planting dates did not significantly affect the GM percent. Above these criteria performed well for planting on 16 August than for planting on 12 September. Significantly reduced seed quality (SVI, HDG percent, SDW and RDW) in later planting could be due to decreased rainfall in the ripening period (Fig 1 and Table 4), while GM percent did not decrease significantly. Sehgal *et al.*, 2018 [30] found that water stress interferes with grain filling and rice grain quality.

#### 3.2.2 Effect of variety on seed quality

Variety has a substantial influence on all the parameters. In BRRi dhan46, the highest GM percentage was reported (95.00), followed by BRRi dhan41 and the lowest in BRRi dhan40 (88.83). In BRRi dhan46, the SVI was also the highest and in BRRi dhan40, the lowest. The HDG percent also followed the same pattern as the GM percent and SVI percentage. In BRRi

dhan46 (45.0 mg), the SDW was the highest, followed by BRR I dhan40 and the lowest in BRR I dhan41 (39.67 mg). The variety of rice also had a major influence on RDW, but BRR I dhan46 (45.0 mg) was the highest and BRR I dhan41 was the lowest (36.66 mg) (Table 5 and Table 6).

**Table 5.** Impact of date and variety planting, on seed quality of rice in T. Aman season during 2014, 2015, and 2016.

Treatments	GM%			SVI			HDG%		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
<b>Planting dates</b>									
16 August	93.00	93.00	93.11	1371.97	1306.56	1284.33	86.26	89.94	84.70
12 Sept	91.00	92.00	92.11	1196.68	1152.33	1214.33	82.97	85.43	85.65
LSD at 5%	1.7	ns	ns	145.31	142.46	189.80	2.56	0.61	ns
<b>Varieties</b>									
BRR I dhan40	88.83	90.66	90.68	1242.97	1208.17	1165.00	82.23	86.99	83.59
BRR I dhan41	92.17	92.50	92.48	1270.68	1214.50	1309.67	84.48	87.34	85.06
BRR I dhan46	95.00	94.66	94.65	1333.73	1265.67	1273.33	87.13	88.72	86.89
LSD at 5%	2.11	2.42	2.40	NS	NS	NS	3.15	0.74	1.46

NS=Not significant.

**Table 6.** Shoot and root dry weight (mg) of 10 days of seedling as impacted by the planting and variety date in the 2014, 2015 and 2016 T. Aman season.

Treatments	Shoot dwt of 10 Seedling (mg) at 10 days old			Root dwt of 10 Seedling (mg) at 10 days old		
	2014	2015	2016	2014	2015	2016
<b>Planting dates</b>						
16 August	42.46	42.44	35.55	41.78	41.17	35.55
12 Sept	40.47	40.88	50.00	40.04	39.66	48.88
LSD at 5%	1.56	0.83	26.75	1.35	0.81	28.80
<b>Varieties</b>						
BRR I dhan40	42.58a	41.33	39.87	40.92	40.09	45.00
BRR I dhan41	39.93b	39.67	40.00	41.89	38.47	36.66
BRR I dhan46	42.25a	44.00	45.00	41.42	42.68	45.00
LSD at 5%	1.91	1.02	NS	NS	0.99	NS

NS=Not significant.

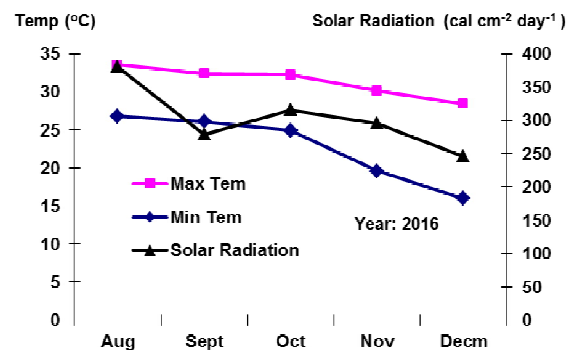
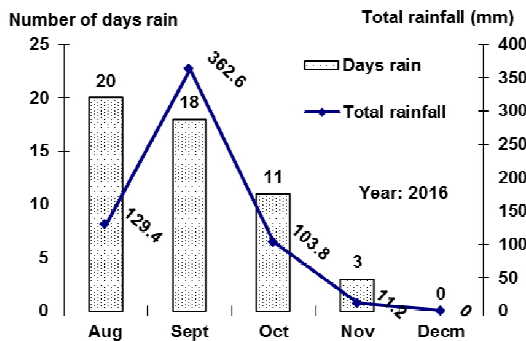
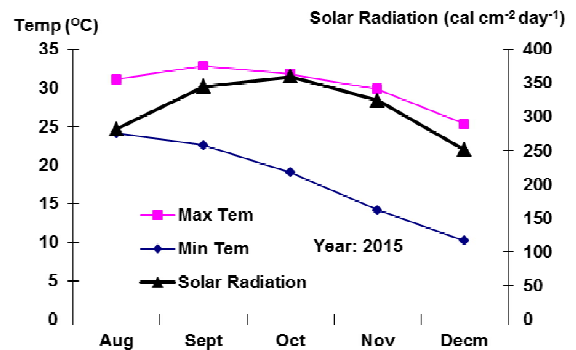
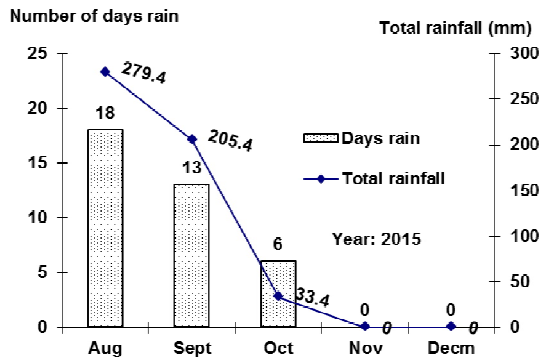
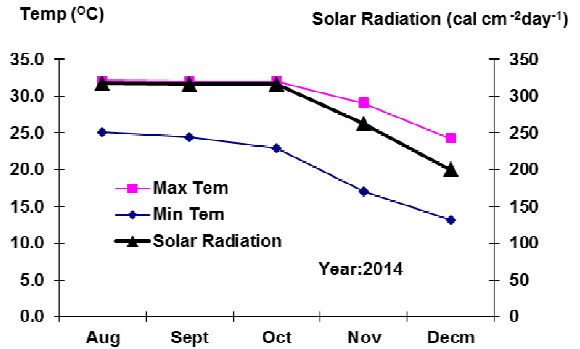
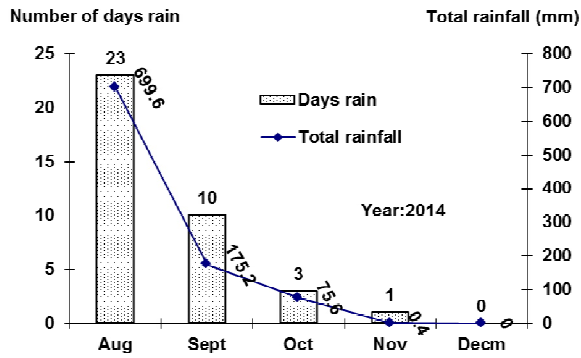


Fig. 1. Monthly number of rainy days and total rainfall during T. Aman 2014,2015 and 2016

Fig. 2. Monthly temperature and solar radiation during T. Aman 2014,2015 and 2016

#### 4. CONCLUSIONS

Planting on August 16 yielded higher grain yields than planting on September 12. BRRI dhan46 was the top yielder among the varieties, compared to BRRI dhan40 and BRRI dhan41. In view of seed quality, 16 August performed better than planting on 12 September. In the case of varieties, the highest in terms of GM%, SVI, HDG%, SDW and RDW was BRRI dhan46.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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