



Annual Research & Review in Biology

21(3): 1-7, 2017; Article no.ARRB.38096
ISSN: 2347-565X, NLM ID: 101632869

Optimizing Sowing Date for French bean Varieties under Bangladesh Condition

F. M. Jamil Uddin^{1*}, Md. Abul Kashem¹, A. K. M. Mominul Islam¹
and Md. Abdur Rahman Sarkar¹

¹Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

Authors' contributions

This work was carried out in collaboration between all authors. Author FMJU designed the study, wrote the protocol and first draft of the manuscript. Author MAK managed the literature searches, conducted the experiment and performed the statistical analysis. Authors AKMMI and MARS approved the protocol, supervised the experiment, managed the analyses and reviewed the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARRB/2017/38096

Editor(s):

- (1) Ahmed Medhat Mohamed Al-Naggar, Professor, Department of Agronomy and Plant Breeding, Faculty of Agriculture, Cairo University, Egypt.
(2) George Perry, Dean and Professor of Biology, University of Texas at San Antonio, USA.

Reviewers:

- (1) Martín Maria Silva Rossi, Argentina.
(2) Bhallan Singh Sekhon, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, India.
(3) Zinga Innoent, University of Bangui, Central African Republic.

Complete Peer review History: <http://www.sciencedomain.org/review-history/22398>

Original Research Article

Received 11th November 2017
Accepted 7th December 2017
Published 21st December 2017

ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University to determine the optimum sowing date for selected French bean varieties under Bangladesh condition. The experiment consisted of two factors namely; (i) variety viz. BARI Jhar Sheem-1, BARI Jhar Sheem-2 and BARI Jhar Sheem-3, and (ii) sowing date viz. 5 November, 20 November and 5 December. The experiment was laid out in randomized complete block design with three replications. Variety and sowing date showed significant effect on most of the plant characters viz. plant height, leaf area plant⁻¹, number of pods plant⁻¹, number of seeds pod⁻¹, number of seeds plant⁻¹, weight of seeds plant⁻¹, weight of 1000 seeds, seed yield and stover yield. The highest seed yield (0.66 t ha⁻¹) was obtained from BARI Jhar Sheem-3 and the lowest (0.46 t ha⁻¹) was obtained from both BARI Jhar Sheem-1 and BARI Jhar Sheem-2. The highest seed yield (0.65 t ha⁻¹) was obtained from 20 November sowing and the lowest one (0.36 t ha⁻¹) was obtained from 5 November sowing. The interaction between variety and sowing date had significant influence on the yield

*Corresponding author: E-mail: drjamil@bau.edu.bd;

contributing characters and yield of French bean. Results showed that the yield contributing characters and yield of French bean varieties were increased with sowing on 20 November and decreased with very early or late sowing. BARI Jhar Sheem-3 produced the highest seed yield (0.76 t ha^{-1}) when sown on 20 November compared to very early or late sowing condition.

Keywords: French bean; seed yield; pulse crop; vegetable crop.

1. INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is a vegetable crop belonging to the family Leguminosae (s.f. Papilionaceae), has been reported to be a native of Central and South America (Peru and Columbia) [1]. It is also known as Farashi shim [2], Basic bean, Navy bean, Pinto bean, Raj bean, Snap bean, String bean, Pole bean and Green bean [3]. French bean is a good source of protein, carbohydrate, calcium, iron, phosphorus and vitamins, particularly vitamin B [4,5]. Canned and home-prepared red kidney beans are used in salads, meat and fish dishes [6]. Recently, in Bangladesh French bean cultivation is gaining popularity for its demand as a commodity for export, and is grown in Sylhet, Cox's Bazar, Chittagong, Chittagong Hill Tracts and some other parts of the country on limited scale in the winter.

Crop yield varies from variety to variety due to internal and external factors of the plant. A suitable variety is of primary importance for harnessing potential yield [7]. Those varieties which are high yielding, less prone to disease incidence and mature in a shorter period of time are preferred to the growers. Sowing date is an important factor for the yield of French bean. The optimum sowing date depends on the existing cropping pattern and prevailing environmental conditions. In principle, delay in sowing beyond the optimum date results in a progressive reduction in the potential yield of the crop [8]. The positive effect of environmental factors on the growth and yield could be harnessed if the information on optimum time of sowing is made available [9]. French bean can be grown well at 19–27°C. The pod set of French bean was poor at/or above 30°C day and 25°C night temperature [10]. Vyas et al. [11] also reported the seed yield variation due to different sowing dates. However, the farmers often sow the seeds of French bean early or late without knowing the optimum sowing time. During the winter a short cool season (November–February) prevails in Bangladesh, which starts with the fall of temperature, humidity and ends with sudden rise in temperature [12]. Hence, planting time for

bean is very critical in Bangladesh and sowing of seed should be done carefully so that the crop can take the best advantage of the entire cool period. Considering the above facts, the present study was undertaken with the objectives to identify a optimum sowing date for French varieties under Bangladesh condition to maximize their seed yield and high economic return.

2. MATERIALS AND METHODS

The research work was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2015 to March 2016. The experimental site belongs to the Old Brahmaputra Floodplain agro-ecological zone (AEZ-9) and is located at 24.75°N latitude, 90.50°E longitude and an average altitude of 18m. The region occupies a large area of Brahmaputra sediments, which are laid down before the river shifted into its present Jamuna channel 200 years ago [13,14]. The soil of the experimental field is slightly acidic (pH 6.80) with low organic matter content (1.19 %) and high soil bulk density (1.64 g cm^{-3}). Experimental area characterized by comparatively heavy rainfall, high humidity, high temperature and relatively long day during April to September. On the other hand, scanty rainfall, low humidity, low temperature and shorter day during November to March. During the winter season (November–March) average temperature was 10–25°C. The experiment consists of two factors namely, Factor A: Variety (3) - BARI Jhar Sheem-1, BARI Jhar Sheem-2 and BARI Jhar Sheem-3; and Factor B: Sowing Date (3) - 5 November, 20 November and 5 December. The experiment was laid out in a Randomized Complete Block Design with three replications. Firstly, the land was ploughed with a power tiller and kept open to sunlight. Afterwards the experimental plot was prepared by several ploughing and cross ploughing followed by laddering to break the clods and to level the soil. The weeds and stubble were removed from the plot. The land was fertilized with urea, triple super phosphate (TSP) and muriate of potash (MoP) @ 100, 22 and 150 kg ha^{-1} , respectively. The whole amount

of TSP and MoP were applied as basal during final land preparation, where as urea was applied at two equal split. The first half at basal and other half of urea was top dressed at 30 days after sowing (DAS) of seeds. Before seed sowing, Carbendazem @ 5 g kg⁻¹ seed was mixed with the seed uniformly for controlling soil borne diseases. Three seeds were sown at a depth of 5.0 cm per hill. One healthy seedling per hill was kept and the other one removed after 15 days of seedlings emergence. Weeding was done manually in the plots from time to time to keep the plots free from weeds and facilitated better soil aeration. A light irrigation was applied in the experimental plots to keep the soil moisture at field capacity. At the early stage of growth, some plants were attacked by insect pests (mainly aphids) and other insects. Ovide (Malathion 57E) and Sevin 85SP (1-naphthyl methylcarbamate) were sprayed twice at the rate of 2 mL L⁻¹ at 7 days interval. The five plants were selected randomly from each plot to record the data on crop characters and yield of French bean. Mature dry pods were harvested by hand picking and weighed to estimate the yield of dry seeds. As the seeds were sown in the field at three different times, the crops were harvested at different times when they reached maturity. Harvesting was started from 14 February in BARI Jhar Sheem-1 and BARI Jhar Sheem-3 and continued up to 14 March. BARI Jhar Sheem-2 was harvested during 28 February to 30 March. The crop bundles were sundried for five days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks. The collected seeds were dried in the sun for reducing the moisture content at a constant level. The dried seeds and stover were cleaned and weighed. Data were recorded on plant height (cm) at harvest, number of pods plant⁻¹, length of pod (cm), number of seeds pod⁻¹, number of seeds plant⁻¹, weight of seeds plant⁻¹, weight of 1000 seeds; and seed and stover yields (t ha⁻¹). The collected data were compiled and analyzed statistically using the analysis of variance technique with computer package program MSTAT-C and the difference among treatment means were adjudged by Duncan's Multiple Range Test [15].

3. RESULTS AND DISCUSSION

3.1 Effect of Variety

The variety had significant influence on growth, crop characteristics and yield of French bean (Table 1). The tallest plant (35.72 cm), highest

length of dry pod (11.34 cm), weight of 1000 seeds (555.4 g), seed yield (0.66 t ha⁻¹) and stover yield (1.07 t ha⁻¹) were found in BARI Jhar Sheem-3, whereas the maximum number of pods plant⁻¹ (5.73), number of seeds pod⁻¹ (4.73), highest number of seeds plant⁻¹ (21.77), weight of seeds plant⁻¹ (5.19 g) were found in BARI Jhar Sheem-1. On the other hand, the shortest plant (31.71 cm), shortest length of dry pod (9.15 cm), lowest weight of seeds plant⁻¹ (4.42 g) from BARI Jhar Sheem-2, and lowest weight of 1000 seeds (269.3 g), and stover yield (0.74 t ha⁻¹) were obtained from BARI Jhar Sheem-1, whereas, minimum number of pods plant⁻¹ (3.41) and seeds plant⁻¹ (11.35) were obtained from BARI Jhar Sheem-3 (Table 1). These results are in conformity with Sharma et al. [16]. Das et al. [17] stated that the genotype with relatively bolder seeds, more number of seeds pod⁻¹ and higher bearing capacity per plant generally produced higher seed yield.

3.2 Effect of Sowing Date

Sowing date had significant influence on growth and yield parameters of French bean at harvest (Table 2). The tallest plant (41.20 cm) and highest length of dry pod (10.86 cm) were obtained from 5 November, whereas weight of seeds plant⁻¹ (5.23 g), weight of 1000 seeds (396.40 g), seed yield (0.65 t ha⁻¹) from 20 November, and number of pods plant⁻¹ (5.29), seeds pod⁻¹ (4.56), seeds plant⁻¹ (18.47) and the highest stover yield (1.28 t ha⁻¹) from 5 December sowing (Table 2). On the other hand, the lowest number of pods plant⁻¹ (4.42), stover yield (0.44 t ha⁻¹), weight of seeds plant⁻¹ (4.51 g), seed yield (0.36 t ha⁻¹) were obtained from 5 November, length of dry pod (9.94 cm), number of seeds pod⁻¹ (3.68), number of seeds plant⁻¹ (15.61) from 20 November, and shortest plant (29.83 cm) and weight of 1000 seeds (326.40 g) were found in 5 December sowing (Table 2). Yoldas and Esiyok [18] reported that early sowing of snap bean produced higher plant height than the late sowing. Dapaah et al. [19] reported that yield advantages were also obtained from mid to late November sown beans. Opposite result on the number of seeds plant⁻¹ was also reported elsewhere [20,21]. They stated that the lowest yield during the time of late sowing was due to a short vegetation period of the crop. On the other hand, Venkata et al. [22] observed significant variation in all yield contributing characters due to different sowing dates from second fortnight of October to first

Table 1. Effect of variety on the yield contributing characters and yield of French bean

Variety	Plant height (cm)	No. of pods plant ⁻¹	Length of pod (cm)	No. of seeds pod ⁻¹	No. of seeds plant ⁻¹	Wt. of seeds plant ⁻¹	Wt. of 1000 seeds (g)	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
BARI Jhar Sheem-1	35.59a	5.73a	10.79b	4.79a	21.77a	5.19a	269.3c	0.46b	0.74b
BARI Jhar Sheem-2,	31.71b	5.62a	9.15c	3.74b	17.03b	4.42b	292.2b	0.46b	1.06a
BARI Jhar Sheem-3	35.72a	3.41b	11.34a	3.74b	11.35c	5.17a	555.4a	0.66a	1.07a
LSD _{0.05}	0.68	0.18	0.30	0.15	0.73	0.21	12.31	0.03	0.04
Level of significance	**	**	**	**	**	**	**	**	**
CV (%)	3.63	6.82	5.31	6.52	8.00	7.95	6.05	9.93	8.07

In a column, the mean values with common letter do not differ significantly at 1% level of probability as per DMRT.

*** = Significant at 1% level of probability*

Table 2. Effect of sowing date on the yield contributing characters and yield of French bean

Sowing date	Plant height (cm)	No. of pods plant ⁻¹	Length of pod (cm)	No. of seeds pod ⁻¹	No. of seeds plant ⁻¹	Wt. of seeds plant ⁻¹	Wt. of 1000 seeds (g)	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
5 November	41.20a	4.42c	10.86a	4.56a	16.08b	4.51b	326.4b	0.36c	0.44c
20 November	31.98b	5.05b	9.94c	3.681c	15.61b	5.04a	396.4a	0.65a	1.14b
5 December	29.83c	5.29a	10.49b	4.03b	18.47a	5.23a	394.1a	0.57b	1.29a
LSD _{0.05}	0.68	0.18	0.30	0.15	0.73	0.21	12.31	0.03	0.04
Level of significance	**	**	**	**	**	**	**	**	**
CV (%)	3.63	6.82	5.31	6.52	8.00	7.95	6.05	9.93	8.07

In a column, the mean values with common letter do not differ significantly at 1% level of probability as per DMRT.

*** = Significant at 1% level of probability*

Table 3. Interaction effect of sowing date and variety on the yield contributing characters and yield of French bean

Interaction		Plant height (cm)	No. of pods plant ⁻¹	Length of pod (cm)	No. of seeds pod ⁻¹	No. of seeds plant ⁻¹	Wt. of seeds plant ⁻¹	Wt. of 1000 seeds (g)	Seed yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)	Biological yield (t ha ⁻¹)	Harvest index (%)
Variety	Sowing date											
BARI Jhar Sheem-1	5 November	42.17a	5.58b	11.74a	5.7a	23.77b	6.02b	274.4e	0.19f	0.26f	0.44h	40.46bc
	20 November	33.17c	4.29d	9.34c	3.64de	13.18d	3.91d	272.2e	0.55c	0.82d	1.37f	39.17c
	5 December	31.45d	7.33a	11.29b	5.02b	28.35a	5.64bc	261.1e	0.65b	1.13c	1.79d	35.29d
BARI Jhar Sheem-2	5 November	39.74b	5.04c	9.36c	3.99c	15.04c	4.07d	297.8d	0.43d	0.54e	0.97g	43.73b
	20 November	29.21e	7.51a	9.47c	3.98c	23.47b	5.67bc	273.3e	0.64b	1.45b	2.09b	30.39e
	5 December	26.17f	4.31d	8.63d	3.24f	12.58d	3.51e	305.6d	0.31e	1.19c	1.49e	20.10f
BARI Jhar Sheem-3	5 November	41.71a	2.63f	11.48ab	3.98c	9.42e	3.44e	406.9c	0.45d	0.51e	0.96g	47.59a
	20 November	33.56c	3.36e	11.01b	3.42ef	10.18e	5.53c	643.8a	0.76a	1.16c	1.93c	40.36bc
	5 December	31.89d	4.2d	11.53ab	3.82cd	14.47c	6.54a	615.6b	0.76a	1.54a	2.29a	32.27de
LSD _{0.05}		1.17	0.32	0.52	0.25	1.26	0.37	21.31	0.05	0.07	0.09	3.53
Level of significance		**	**	**	**	**	**	**	**	**	**	**
CV (%)		3.63	6.82	5.31	6.52	8.00	7.95	6.05	9.93	8.07	6.53	10.21

In a column, the mean values with common letter do not differ significantly at 1% level of probability as per DMRT.

*** = Significant at 1% level of probability*

fortnight of December and varieties of French bean. They found that November is the most suitable sowing time to get maximum seed yield which was in conformity with Jena [23]. Moniruzzaman et al. [9] reported that BARI Jhar Sheem-1 and BARI Jhar Sheem-2 produced maximum pod yield when sown during 10 - 20 November.

3.3 Interaction Effect between Variety and Sowing Date

The interaction effect between variety and sowing date on growth and yield parameters were found to be significant at harvest (Table 3). The tallest plant (42.17 cm), highest length of dry pod (11.74 cm), maximum number of seeds pod⁻¹ (5.72) were obtained from the treatment combination of BARI Jhar Sheem-1 × 5 November sowing, number of pods plant⁻¹ (7.51) from BARI Jhar Sheem-2 × 20 November, number of seeds plant⁻¹ (28.35) from treatment combination of BARI Jhar Sheem-1 × 5 December, weight of seeds plant⁻¹ (6.54 g), stover yield (1.54 t ha⁻¹) and biological yield (2.29 t ha⁻¹) from treatment combination of BARI Jhar Sheem-3 × 5 December, weight of 1000 seeds (643.80 g) and the highest seed yield (0.76 t ha⁻¹) from BARI Jhar Sheem-3 × 20 November, and the highest harvest index (47.59 %) from BARI Jhar Sheem-3 × 5 November sowing (Table 3). On the other hand, shortest plant (26.17 cm), length of dry pod (8.63 cm), number of seeds pod⁻¹ (3.24), harvest index (20.10 %) were obtained from the combination of BARI Jhar Sheem-2 × 5 December, number of pod plant⁻¹ (2.63), seeds plant⁻¹ (9.42), weight of seeds plant⁻¹ (3.44 g) in the treatment combination of BARI Jhar Sheem-3 × 5 November; weight of 1000- seeds (272.22 g), seed yield (0.19 t ha⁻¹), stover yield (0.26 t ha⁻¹) and biological yield (0.44 t ha⁻¹) from the combination of BARI Jhar Sheem-1 × 5 November sowing date (Table 3). These results are in agreement with the findings of Yoldas and Esiyok [18]. Similar results were also reported in other pulses [24,25].

4. CONCLUSION

French bean a minor crop of Bangladesh and gaining popularity day by day. However, owing to lack of information with regard to proper variety selection and sowing date adjustment, the yield obtained is far below the potential. The present study was therefore conducted to find out a suitable variety and optimum date of sowing in the mymensingh region of Bangladesh. In this experiment, we observed that among the three

varieties, BARI Jhar Sheem-3 performed very well when planted on 20 November for obtaining good growth and highest seed yield. But this experiment consists of only three varieties and sowing dates. Therefore, in future more varieties and sowing dates should be included to find the most suitable date of sowing as well as variety for Mymensingh or for the whole country to draw a clear conclusion. In addition, multi-location trial and 1-2 years repetition of the experiment for confirmation of the results should also be taken into account.

ACKNOWLEDGEMENT

The Authors are thankful to Bangladesh Agricultural University Research System (BAURES) for funding the current research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Swiader JM, Ware GW, McCollum JP. Producing vegetable crops. 4th ed. Interstate publishers, Inc. Danville, Illinois, USA.1992;223-249.
2. Rashid MM. Sabji Biggan. In Bangla. 1st Ed., Bangla Academy Rashid Publishing House, Dhaka. 1993;387-390.
3. Tindall HD. Vegetables in the tropics. McMillan Education Limited. 1988;527.
4. Messina V. Nutritional and health benefits of dried beans. The American Journal of Clinical Nutrition. 2014;100(Supp 1):437S-442S.
5. Wiesinger JA, Cichy KA, Glahn RP, Grusak MA, Brick MA, Thompson HJ, Tako E. Demonstrating a nutritional advantage to the fast-cooking dry bean (*Phaseolus vulgaris* L.). Journal of Agricultural and Food Chemistry. 2016;64(45):8592-8603.
6. Begum A, Ahad A, Kaiser OM, Islam MM, Anam MK. Effect of sowing dates and fertilizer treatments on the reproductive variability of French bean (*Phaseolus vulgaris*). Pakistan Journal of Biological Sciences. 2003;6(22):1897-1901.
7. Amanullah JI, Hayat TF, Khan AI, Khan. Effect of sowing dates on yield and yield components of mash bean varieties. Asian Journal Plant Science. 2002;42(1):622-624.
8. Vange T, Obi IU. Effect of planting date on some agronomic traits and grain yield of

- upland rice varieties at Makurdi, Benue State, Nigeria. *Journal of Sustainable Development Agricultural Environment*. 2006;2(1):1-9.
9. Moniruzzaman M, Rahman SML, Kibria MG, Rahman MA, Kaiser MO. Performances of vegetable French bean as influenced by varieties and sowing dates in Rabi season. *International Journal of Sustain Crop Production*. 2007;2(5): 69-73.
 10. Abdalla MMF, Fischbeck. Growth and fertility of five stocks of field beans (*Phaseolus vulgaris* L.) grown under three temperature regimes and the effect of natural water stress on seed index of a collection of *Vicia faba* L. *Zeitschrift fur Ackerund Pflanzenbau*. 1978;147(2):81-91.
 11. Vyas JS, Autkar KS, Wanjari KB. Effect of sowing rates on French bean in nontraditional area of Maharashtra. *Annals of Plant Physiology*. 1990;4(1):29-35.
 12. Banglapedia. National encyclopedia of Bangladesh. 2014;33-34.
 13. FAO-UNDP (Food and Agriculture Organization of the United Nations Development Programme). Land resources appraisal of Bangladesh agricultural development. Agro-economical region of Bangladesh; BGD/ 81/035. Technical Report No. 2, FAO, Rome, Italy; 1988.
 14. Islam AKMM, Meirvenne V, Islam MM. Proximal soil sensing system for paddy field variability mapping: The potential of a proximal soil sensor for soil properties mapping. Saarvucken, Germany: VDM Verlag Dr. Muller. 2011;1-60.
 15. Gomez KA, Gomez AA. Statistical procedure for agricultural research. *Procedure for Agriculture Work*. 1984;207-215.
 16. Sharma BK, Kushwah SS, Verma KS, Singh OP. Studies on French bean (*Phaseolus vulgaris* L.) varieties under different N, P, K and S levels for growth, yield and economics. *Journal of Horticulture Science*. 2013;8(2):268-270.
 17. Das R, Thapa U, Debnath S, Lyngdoh YA, Mallick D. Evaluation of French bean (*Phaseolus vulgaris* L.) genotypes for seed production. *Journal of Applied and Natural Science*. 2014;6(2):594-598.
 18. Yoldas F, Esiyok D. Effects of sowing dates and cultural treatments on growth, quality and yield of processing beans. *Pakistan Journal of Biological Science*. 2007;10(4):2470-2474.
 19. Dapaah HK, Mckenzie BA, Hill GD. Influence of sowing date and irrigation on the growth and yield of pinto beans (*Phaseolus vulgaris*) in a subhumid temperate environment. *Journal of Agricultural Science*. 2000;134(5):33-43.
 20. Escalante JA, Miranda S, Kohashi SJ. Manual removal of reproductive organs: Their effect on flowering duration and age at physiological maturity in French bean (*Phaseolus vulgaris* L.). 1989;234-235.
 21. Radulovich RA. AQUA, a model to evaluate water deficits and excesses in tropical cropping. *Agricultural and Forest Meteorology*. 1990;2(4):253-261.
 22. Venkata SY, Srinivasulu BS, Balakrishna M. Influence of sowing dates on growth and yield of French bean (*Phaseolus vulgaris* L.) varieties under Rayalaseema Region of Andhra Pradesh. *Journal of Agro ecology and Natural Resource Management*. 2015;2(2):145-149.
 23. Jena JC. A short note on influence of date of sowing on vegetable pod yield of French bean under Terai zone of West Bengal and Orissa. *Journal of Horticulture*. 2003; 32(31):112-113.
 24. Uddin FMJ, Sarkar MAR, Mamun AA. Effect of variety, date of planting and level of phosphorus on shoot dry matter and yield on mungbean. *Journal Agroforestry Environment*. 2010;4(2):121-124.
 25. Uddin FMJ, Sarkar MAR, Mamun, AA. Effect of variety, date of planting and level of phosphorus on growth characteristics and seed yield on mungbean. *Bangladesh Journal of Seed Science and Technology*. 2010a;4(1-2):179-184.

© 2017 Uddin et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://sciencedomain.org/review-history/22398>