BRS Deni – Super-sweet corn open-pollinated variety

Flavia França Teixeira, Israel Alexandre Pereira Filho, Walter Fernandes Meirelles, Jane Rodrigues de Assis Machado, Arley Figueiredo Portugal and Luciano Viana Cotta

Abstract: BRS Deni is a super-sweet corn open-pollinated variety, developed and released by the Brazilian Agricultural Research Corporation (Embrapa) that combines high yield and good ear and grain quality and lower production costs. The grain can be consumed fresh or canned.

Keywords: Zea mays, Shrunken-2, specialty corn

INTRODUCTION

Maize (Zea mays L.) is a food crop with numerous forms of use. For some of them, specific properties are required that can be found in cultivars classified as special. Sweet and super-sweet corn for example are considered special, due to variations in one or more alleles that modify the sugar concentration, resulting in changes in taste and flavor of the grains. The plant and ear properties and seed viability and texture of these special types of corn are also differentiated.

The sweeter flavor of the grains can be explained by the higher sugar-to-starch ratio in the endosperm than in other corn types. The grain sugar content of field corn is only 3%, that of sweet corn from 9% to 14%, while grains of the so-called super-sweet cultivars contain between 15% and 25%. These variations are genetically controlled, and the alleles that define the sweet and super-sweet phenotypes are generally recessive (Tracy 2001). Some alleles that are associated with the super-sweet corn cultivars of most widespread commercial use are shrunken-2 (sh2) (Yousef and Juvik 2002) and brittle-2 (bt2) genes (Brewbaker and Banafunzi 1975, Brewbaker 1977).

Other aspects that differentiate sweet and super-sweet from field corn are harvest maturity, cultivation practices and forms of marketing. The ears of the so-called specialty corn are harvested in the green stage, with approximately 75% moisture. For cultivation, which is labor-intensive, irrigation-dependent and requires high technology investment, small areas are often used. Sweet corn is a perishable product for human consumption with high value. Thus, sweet and super-sweet corn are classified as horticultural crops.

In the United States of America, sweet corn in fresh or processed form is one of the most widely consumed vegetables (Confederação da Agricultura e Pecuária do Brasil 2017). In Brazil however, fresh consumption is very restricted, since sweet corn is almost exclusively used for canning in the food industry, regardless of the potential for consumption as fresh green maize (Guia Veja 2013).
Between 2001 and 2009, the cultivated area and amount of sweet corn seed sold in Brazil remained stable, whereas production increased, possibly due to the higher yields of genetically improved cultivars (Miranda 2016). From 2009 to 2012, the value of the annual production of sweet corn rose from R$ 11 to 14.5 million, indicating a relative growth of around 30% in three years (Associação Brasileira do Comércio de Sementes e Mudas 2014). In 2012, in terms of volume, sweet corn was the sixth most sold vegetable in Brazil. The production cost of sweet corn was estimated at R$ 132.0 million and generated a gross return of around R$ 170.4 million, i.e., approximately 1.3 of the production costs. In 2012, the mean seed cost represented around 10.5% of the production costs and sweet corn ranked ninth among the vegetables with highest seed sales value (Associação Brasileira do Comércio de Sementes e Mudas 2014). In addition, the agro-industrial chain for sweet corn is larger than that of field corn, due to the industrial processing (canning), which adds value to the product after harvesting (Miranda 2016).

Breeding of sweet corn in Brazil was initiated at Embrapa Maize and Sorghum in the 1970s, with the introduction of basic genotypes from universities in the USA. This exotic germplasm was crossed with dent lines from field corn breeding programs in a joint program between Embrapa Maize and Sorghum and Embrapa Vegetables, and resulted in the development of the varieties BR 400 (Superdoce), BR 401 (Doce-de-ouro), BR 402 (Doce cristal), BR 420 (Docemel) and BR 421 (Lili). In the 1990s, the development of new sweet corn lines was initiated at Embrapa Maize and Sorghum, with the introgression of bt-2 and sh-2 alleles into elite lines with normal endosperm. Currently, consumers prefer cultivars classified as super-sweet with excellent quality properties, e.g., pericarp softness and flavor; desirable appearance and ear size and uniform maturation (Teixeira et al. 2013). In view of this market demand, the single-cross hybrid BRS Vivi was developed by Embrapa Maize and Sorghum (Teixeira et al. 2014) and registered by the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA), in May 2010, (Brasil 2021). Since then, the sweet maize breeding program of Embrapa Maize and Sorghum has been working to develop an open-pollinated variety, BRS Deni.

In the 11 years between the release of these two cultivars, the market offer of sweet corn cultivars shifted. The Ministry of Agriculture, Livestock and Food Supply came to register sweet corn cultivars in separate cultivation groups, apart from those of field corn. Currently, there are two groups for this specialty corn, identified as: Zea mays var. saccharina, which covers registries of the late 1990s, when cultivars were classified as sweet corn, with 113 cultivars at the time of registration of variety BRS Deni; and the new group Zea mays L. saccharata Koem, of super-sweet cultivars (shrunken-2 genotype). Cultivars UENF SD 08 and UENF SD 09 were the first to be recorded in this group (Pereira et al. 2019). It should be mentioned that the group Zea mays var. saccharina contains cultivars classified as sweet and super-sweet, although the more recent group is being used exclusively for super-sweet cultivars. In May 2021, these two groups of sweet corn comprised 116 registered lines. Some of them were classified as parent lines and only 67 (58%) were registered as cultivars. An analysis of the offer dynamics of these 67 cultivars for the period between the registries of cultivars BRS Vivi and BRS Deni shows that 40 new cultivars were released in that interval, which is equivalent to about 60% of the total available cultivars. The rapid growth in the offer of cultivars suggests an intensification of the sweet corn seed market, which possibly contributes to increases in yield and product quality and could boost the growth of the sector. In addition to the beneficial effects on the sweet corn production chain, the increase in the offer of cultivars favors the expansion of the genetic base of sweet corn. The registration by MAPA does not indicate the type of cultivars, however, possibly most of them are hybrids.

Open-pollinated varieties can be more advantageous than hybrids, due to the lower costs of seed multiplication. This is relevant in sweet corn because the seed production cost can be higher than that of field corn seeds, due to the low yield of sweet corn inbred lines. On the other hand, plants of open-pollinated varieties may be somewhat non-homogeneous, which is undesirable. In view of the lack of open-pollinated super-sweet corn cultivars, variety BRS Deni was developed by Embrapa to expand the options. The open-pollinated cultivar BRS Deni can stimulate sweet corn production by small farmers and in family agriculture, which may popularize green corn consumption. Thus, a new consumption habit may be created. The sale of fresh sweet corn ears on local markets could become an extra income source in small communities. The objective of this study was to describe the variety BRS Deni and its characteristics.

**BREEDING METHODS**

The variety BRS Deni was developed from a synthetic population derived from two types of parents: super-sweet lines of the Embrapa Maize and Sorghum breeding program and commercial hybrids, including BRS Vivi. Seeds from
this population were harvested and sown over three generations for recombination and selection for yield, quality and agronomic traits. The last selection was carried out in Sete Lagoas, Minas Gerais, Brazil, in 2014.

With the recombined generations, the variety was tested in trials to evaluate yield, quality and agronomics traits, using the hybrids BRS Vivi, Tropical Plus and SWB 551 as checks. The evaluation trials were conducted in: Sete Lagoas/2015 (L1), Londrina/2015 (L2), Sete Lagoas/2016 (L3), Janaúba/2016 (L4), Londrina/2017 (L5), and Passo Fundo/2017 (L6) in a randomized block design with three replications and experimental plots with four 5-m rows, spaced 80 cm apart. In these trials, the following traits were evaluated: number of days to female flowering (FF), from seedling germination until 50% of the plants in the plot emit style-stigmas; plant height (PH, cm) and first ear height (EH, cm); prolificity (PR), based on the ratio of number of ears to number of plants per plot; grain yield at maturity (GY, t ha⁻¹); unhusked ear yield of green corn (EY, tons/ha); ear length (LE, cm) and diameter (DE, mm) of unhusked ears at the green corn stage; number of grain rows per ear (NR); mean ear weight (EW, g); grain weight per ear (GW, g) at the green corn stage; and brix degrees (BR) computed as the mean of two samples of ground grains measured with a portable digital refractometer (Atago PALM-1). Analysis of variance and the Tukey mean test were performed using software GENES (Cruz 2006).

Variety BRS Deni was characterized based on the methodology for distinguishability, homogeneity, and stability (DHS) indicated for field corn (Brasil 2020), in Sete Lagoas, in 2015 and 2016. The variety was evaluated on a 1 to 5 scale in

### Table 1. Summary of analysis of variance and agronomic trait means of the cultivar evaluation trials of sweet corn in Sete Lagoas/2015 (L1), Londrina/2015 (L2), Sete Lagoas/2016 (L3), Janaúba/2016 (L4), Londrina/2017 (L5) and Passo Fundo/2017 (L6)

| Trait   | Block/Location df | Block/Location MS | Block/Location F | Treatment (T) df | Treatment (T) MS | Treatment (T) F | Location (L) df | Location (L) MS | Location (L) F | T x L df | T x L MS | T x L F | Error df | Error MS | Error F | Mean | CV (%) | Means |
|---------|-------------------|-------------------|------------------|------------------|-----------------|-----------------|----------------|----------------|--------------|---------|---------|--------|---------|---------|--------|-------|-------|--------|
| FF      | 6                 | 0.56              | 10               | 2.99             | 6.87*           | 3               | 2.58           | 4              | 0.44         | 0.81    | 30      | 0.53   | 6       | 0.81    | 0.53   | 59.92 | 1.50  | 60.44  |
| PH      | 6                 | 223.22            |                  | 508.47           | 3.47            | 22614.96        | 146.42         | 66.75          | 261.50       |         |         |        |         |         |        |       |       |         |
| EH      | 6                 | 159.82            |                  | 517.75           | 3.79            | 3541.02         | 136.58         | 75.95          | 132.32       |         |         |        |         |         |        |       |       |         |
| PR      | 8                 | 0.0134            | 12               | 0.0984           | 1.53            | 0.0678          | 0.0619         | 0.0240         | 1.0235       |         |         |        |         |         |        |       |       |         |
| GY      | 8                 | 0.37              |                  | 0.88             | 1.24            | 0.88            | 0.71           | 0.41           | 3.32        |         |         |        |         |         |        | 1.0235|       |         |
| EY      | 8                 | 4                 |                  | 3.26             | 0.64            | 5.07**          | 5.07**         | 5.08           | 4.88*       |         |         |        |         |         |        |       |       |         |
| Mean    | 8                 | 1.22              |                  | 3.26             | 0.64            | 5.07**          | 5.07**         | 5.08           | 4.88*       |         |         |        |         |         |        |       |       |         |
| CV (%)  | 8                 | 10.35             |                  | 10.40            | 19.22           | 10.35           | 10.35          | 10.35          | 9.86        |         |         |        |         |         |        |       |       |         |
| Means   |                   |                   |                  | BRS Vivi 0.9150  |                | BRS Vivi 0.9150 | Tropical Plus 0.9980 | SWB 551 1.1245 | BRS Deni 1.0564 |

1 FF: number of days to female flowering, PH: plant height, EH: first ear height, PR: prolificity, GY: grain yield at maturity, EY: unhusked ear yield at green corn stage 2 Trial in environments 1, 3 and 4; 3 Trial in environments 1 to 5; 4 Trial in environments 1, 2, 4 and 5; 5 Trial in environments 1 to 6; 6 Trial in environments 1 and 3; 7 Means followed by the same letter did not differ by the Tukey test at 5% probability. ** and * F test significant at 1 and 5% probability, respectively.
Sete Lagoas, in 2019, for reaction to white spot, corn stunt, common rust and leaf anthracnose, as follows: 1 - highly resistant, 2 - resistant, 3 - moderately resistant, 4 - susceptible and 5 - highly susceptible.

**PERFORMANCE**

Analyses of variance and means of yield and agronomic traits of sweet corn cultivars are shown in Table 2. It is noteworthy that the percentage variation coefficient (CV%) in the analysis of variance of grain yield at maturity was below 20%, according to the recommended threshold (Brasil 2017) for inclusion in tests of cultivation and use for field corn.

Sweet corn is harvested and sold at the green corn stage; in other words, the production of green corn ears corresponds to the yield. The comparison of means showed that the mean grain yield at the end of the cycle was only 3.35 t ha⁻¹, as expected for sweet corn, although this estimate is far below the average field corn yield in Brazil, which exceeds 5 t ha⁻¹ (IBGE 2021). The estimated mean ear yield of green corn on the other hand was 10.35 t ha⁻¹ and was associated with a CV (%) of 9.86, indicating good experimental precision.

Table 2. Summary of analysis of variances and means for ear and grain quality traits in sweet corn trials in Sete Lagoas/2015 (L1) and 2016/(L2)

|   | LE (cm)³ | DE (mm) | NR |
|---|----------|---------|----|
| **SV** | **df** | **MS** | **F** | **MS** | **F** | **MS** | **F** |
| Block/Location | 4 | 0.32 | 1.00 | 0.33 |
| Treatment (T) | 3 | 1.96 | 2.44 | 104.20 | 10.30 | * | 0.40 | 4.76 |
| Location (L) | 1 | 6.00 | 16.57 | * | 9.75 | 9.73 | * | 0.03 | 0.08 |
| T x L | 3 | 0.80 | 2.43 | 10.11 | 2.84 | 0.08 | 0.34 |
| Error | 12 | 0.33 | 3.57 | 0.25 |
| Mean | | 16.48 | 40.00 | 14.98 |
| CV (%) | | 3.49 | 4.72 | 3.31 |
| **Means**¹ | | | |
| BRS Vivi | 17.00 | 46.03 | a | 15.10 |
| Tropical Plus | 16.74 | 39.51 | b | 15.26 |
| SWB 551 | 15.70 | 36.89 | b | 14.90 |
| BRS Deni | 16.51 | 37.60 | b | 14.67 |

|   | EW (g) | GW (g) | BR |
|---|--------|--------|----|
| **SV** | **df** | **MS** | **F** | **MS** | **F** | **MS** | **F** |
| Block/Location | 4 | 58.49 | 149.99 | 0.57 |
| Treatment (T) | 3 | 5471.24 | 6.68 | 44.16 | 0.16 | 6.82 | 4.60 |
| Location (L) | 1 | 618.13 | 10.57 | * | 54.30 | 0.36 | 0.33 | 0.57 |
| T x L | 3 | 818.81 | 4.80 | * | 259.86 | 2.70 | 1.48 | 0.98 |
| Error | 12 | 170.57 | 96.24 | 0.81 |
| Mean | | 158.77 | 104.19 | 15.64 |
| CV (%) | | 8.22 | 9.41 | 7.84 |
| **Means**² | | | |
| BRS Vivi | 201.46 | 100.37 | 16.13 |
| Tropical Plus | 158.66 | 106.76 | 16.84 |
| SWB 551 | 135.70 | 105.04 | 14.47 |
| BRS Deni | 139.25 | 104.62 | 15.04 |

¹ LE: length of unhusked ears at green corn stage, DE: diameter of unhusked ears at green corn stage, NR: number of grain rows per ear, EW: mean ear weight at green corn stage, GW: mean grain weight per ear at green corn stage, BR: brix degrees; ² Means followed by the same letter did not differ by the Tukey test at 5% probability. ** Significant F test at 1 and 5% probability, respectively.
very high levels of yield and quality for most relevant characters of sweet corn, especially green corn ear yield and ear weight, similar to the commercial hybrids used as controls. It is worth mentioning that the mean of brix degrees in the trial exceeded 15, which classifies the cultivars under study as super-sweet (Tracy 2001).

Significant differences between cultivars were found for some traits, e.g., the hybrid Tropical Plus takes fewer days to female flowering, is earlier and has a shorter plant height. In terms of ear diameter, the performance of BRS Deni was similar to that of Tropical Plus and SWB 551, which are suitable for the canning industry.

A location effect on plant and ear height, prolificity, grain yield at maturity, ear length and diameter and mean ear weight was detected, which indicates that the location effect must be evaluated to obtain favorable results in sweet corn yield and quality. There was a low interaction between traits and locations for some traits, including ear yield and mean ear weight, which directly affect yield. Thus, cv. BRS Deni should be evaluated under different environmental conditions to generate data about the yield potential. According to the results at the evaluation locations, cultivar BRS Deni is recommended for cultivation in the states of Goiás, Minas Gerais, Paraná and Rio Grande do Sul and in the Federal District.

**OTHER TRAITS**

Characteristics of the variety BRS Deni assessed in the DHS evaluations and related to product quality and pathogen reaction are presented in Table 3. The stem diameter, degree-days to male flowering and length and number of tassel branches of variety BRS Deni were classified as intermediate. The ears have oblique insertion, a conical-cylindrical shape, good husk cover, on average 11 husk layers per ear, straight grain rows, white cobs and a cob-to-ear diameter ratio of 0.605. The grains are light yellow with colorless pericarp and grain depth of 1.0 cm. The 1000-grain and hectoliter weight were estimated at 142.3 g and 61 kg, respectively. As expected, these weight-to-volume ratios were low for sweet corn seeds, due to the wrinkled grain texture at maturity. Thus, the ear- and grain-related properties indicate that the quality of the variety is suited for fresh consumption as well as for the canning industry.

**Table 3.** Means of traits related to ears, grains and pathogen reactions of the super-sweet corn variety BRS Deni

| Characteristics* | Means |
|------------------|-------|
| Stem diameter    | 23.45 mm |
| Tassel stem length | 46.7 cm |
| Number of degree days from sowing to 50% pollen shed | 951.5 |
| Number of secondary branches on tassel | 15.75 |
| Ear slope | Oblique |
| Ear weight with husk at green grain stage | 225 g |
| Husking degree | High (ear completely covered) |
| Number of husk layers | 11 layers |
| Ear shape | Conical/Cylindrical |
| Grain row direction from ear base to apex | Straight |
| Ratio ear to cob diameter | 0.605 |
| Cob color | White |
| Percentage of ear weight corresponding to grains (at 13% moisture) | 80.21% |
| Stigma-style color | Absent |
| Grain color | Light yellow |
| Pericarp color | Absent |
| Grain depth | 1.0 cm |
| 1000-grain weight (adjusted to 13% moisture) | 142.30 g |
| Hectoliter grain weight | 0.61 kg |
| Reaction to white spot ** | 4: susceptible |
| Reaction to maize stunt ** | 3: moderately resistant |
| Reaction to common rust ** | 2: resistant |
| Reaction to leaf anthracnose ** | 2: resistant |

* Planting occurred in spatial and/or temporal isolation from other maize crops to avoid pollen contamination. Mean stand 50,000 plants/ha; rows spaced 80cm and plants 20 cm apart. ** Pathogen reaction scale from 1 to 5, where: 1 - highly resistant, 2 - resistant, 3 - moderately resistant, 4 - susceptible and 5 - highly susceptible.
In the pathogen reaction evaluations under the conditions of Sete Lagoas, in 2019, variety BRS Deni was classified as susceptible to white spot, moderately resistant to corn stunt and resistant to common rust and leaf anthracnose.

**SEED PRODUCTION**

Cultivar BRS Deni was protected and registered, respectively, by the Ministry of Agriculture, Livestock and Food Supply (MAPA) on September 24, 2019 (N. 20200059) and on May 25, 2021 (N. 45998). The Secretariat of Innovation and Business of the Brazilian Agricultural Research Corporation (Embrapa-SIN) is responsible for basic seed production.

**CONCLUSION**

The open-pollinated variety BRS Deni had a similar performance as the cultivars BRS Vivi, Tropical Plus and SWB 551 for plant height, prolificity, grain yield at maturity, ear yield at the green corn stage, ear length, number of grain rows per ear, ear weight, grain weight per ear and brix degrees. These results suggest that the yield and quality levels of the open-pollinated variety BRS Deni are similar to those of commercial hybrids for most of the relevant traits for sweet maize. BRS Deni is an option for super-sweet corn cultivation for coupling good ear and grain yield and quality with less expensive seed production, which may allow a reduction in the production cost of sweet corn. Thus, the variety BRS Deni is recommended for fresh ear production as well as for canning. However, sweet corn is still little known by Brazilian consumers, especially among the lower income population and in the interior of the country. The open-pollinated cultivar BRS Deni can stimulate the production of sweet corn by small farmers and in family agriculture, which can popularize green corn consumption. Thus, a new consumption habit may be created. The sale of fresh sweet corn ears on local markets may become an extra income source in small communities.

**REFERENCES**

ABRASEM - Associação Brasileira do Comércio de Sementes e Mudas (2014) 2º Levantamento de dados socioeconômicos da cadeia produtiva de hortaliças no Brasil. Available at: <http://www.abcsem.com.br/imagens_noticias/Apresenta%C3%A7%C3%A3o%20completa%20dos%20dados%20da%20cadeia%20produtiva%20de%20hortali%C3%A7as%20nas%20regi%C3%B5es%20do%20Brasil.pdf>. Accessed on: July 14, 2021.

Brasil. Ministério da Agricultura, Pecuária e Abastecimento (2017) Formulários para registro de cultivares – formulários e requisitos para VCU. Available at <https://www.gov.br/agricultura/pt-br/assistente/insuimos-agropecuarios/insuimos-agricolas/semes-registro-nacional-de-cultivares-2013-rc-1/formularios-para-registro-de-cultivares>. Accessed on July 5, 2021.

Brasil. Ministério da Agricultura, Pecuária e Abastecimento (2020) Proteção de Cultivares. Milho (Zea mays L.). Descritores mínimos do milho (Zea mays L.). Available at <https://www.gov.br/agricultura/pt-br/assistente/insuimos-agropecuarios/insuimos-agricolas/protecao-de-cultivar/fracidos>. Accessed on July 5, 2021.

Brasil. Ministério Da Agricultura, Pecuária E Abastecimento (2021) Registro Nacional de Cultivares-RNC. Available at <https://sistemas.agricultura.gov.br/snpn/cultivarweb/cultivares_registradas.php>. Accessed on July 2, 2021.

Brewbaker JL and Banafunzi N (1975) Hawaiian Super-sweet #6 corn. HortScience 10: 427.

Brewbaker JL (1977) Hawaiian Super-sweet #9 corn. HortScience 12: 355.

Confederação da Agricultura e Pecuária do Brasil (2017) Levantamento e quantificação da cadeia produtiva de hortaliças do Brasil. Confederação da Agricultura e Pecuária do Brasil, Brasília, 79p. Available at <https://www.cnbrascy.org.br/assets/arquivos/brasil/sectores/agricultura-e-pecuaria/9201-levantamento-sistematico-da-producao-agricola-agricultura-e-pecuaria_08.pdf>. Accessed on: July 14, 2021.

Cruz CD (2006) Programa Genes: estatística experimental e matrizes. Editora UFV, Viçosa, 285p.

Guia Veja (2013) Revolução na quitanda. Revista Veja 2321: 108-110.

IBGE – Instituto Brasileiro de Geografia e Estatística (2021) Levantamento sistêmático da produção agrícola. Available at <https://www.ibge.gov.br/estatisticas/economicas/agricultura-e-pecuaria/9201-levantamento-sistematico-da-producao-agricola.html?&t=resultados>. Accessed on July 5, 2021.

Pereira MG, Gonçalves GMB, Durães NNL, Crevelari JA, Ferreira Júnior JA and Entringer GC (2019) UENF SD 08 and UENF SD 09: Super-sweet corn hybrids for Northern Rio de Janeiro, Brazil. Crop Breeding and Applied Biotechnology 19: 235-239.

Miranda AR (2016) Aspectos econômicos de mercado do milho-doce. In Pereira Filho IA and Teixeira FF (eds) O cultivo do milho-doce. Embrapa, Brasília, p. 291-298.

Teixeira FF, Miranda R, Paes MCD, Souza SM and Gama EEG (2013) Melhoramento do milho-doce. Embrapa Milho e Sorgo, Sete Lagoas, 32p.

Teixeira FF, Paes MCD, Gama EEG, Pereira Filho IA, Miranda RA, Guimaraes PEO, Parentoni SN, Cota LV, Meirelles WF, Pacheco CAP, Guimaraes

---

**Crop Breeding and Applied Biotechnology - 22(1): e40892214, 2022**
BRS Deni – Super-sweet corn open-pollinated variety

LJM, Silva AR and Machado JRA (2014) BRS Vivi: single-cross super-sweet corn hybrid. Crop Breeding and Applied Biotechnology 14: 124-127.

Tracy WF (2001) Sweet corn. In Hallauer AR (ed) Specialty corn. CRC Press, Boca Raton, p. 155-198.

Yousef GG and Juvik JA (2002) Enhancement of seedling emergence in sweet corn by markers-assisted backcrossing of beneficial QTL. Crop Science 42: 96-104.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.