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From overlooked to established: the case of *Panicum gilvum* (Poaceae) in the Netherlands

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Abstract – Recent floristic surveys, herbarium revisions and analyses of observations from the online citizen-science platform waarneming.nl, have revealed the widespread presence of *Panicum gilvum* in the Netherlands — a South African species previously overlooked and often misidentified as *P. dichotomiflorum*. Although morphologically similar to *P. dichotomiflorum*, *P. gilvum* differs, among others, by its usually prostrate to ascending growth habit, its barely exserted, smaller and relatively pauciflorous inflorescence, and often smaller, blunter spikelets. It is distinguished from *P. schinzii* by its sterile lower florets. The species was first correctly identified in continental Europe in 2024 at a grain transshipment site near Ghent, Belgium. However, subsequent fieldwork and a review of herbarium specimens and photographic records revealed that many earlier observations attributed to *P. dichotomiflorum* in Dutch maize fields actually referred to *P. gilvum*. Remarkably, specimens collected multiple times between 1938 and 1951 near a wool factory in Tilburg, previously misidentified, actually belong to *P. gilvum*; these early records appear to represent isolated wool alien plants, with no direct link to the recent naturalization in maize fields. Genetic analyses confirmed the identity of the Dutch *P. gilvum* specimens, showing a clear differentiation from *P. dichotomiflorum* as well as a close affinity with authentic South African material of *P. gilvum*. The earliest naturalised Dutch records date back to 2009, and thus suggest that the species had gone largely unrecognized until now. *Panicum gilvum* now appears to be naturalized in the Netherlands and is definitely more common in maize fields than *P. dichotomiflorum*. This paper discusses the diagnostic features distinguishing the three Dutch representatives of section *Dichotomiflora*, provides illustrations of key morphological traits, and reconstructs the likely introduction and naturalization history of *P. gilvum* in the Netherlands.

Samenvatting – *Panicum gilvum* is een Zuid-Afrikaanse soort die tot dusver over het hoofd werd gezien en vaak werd verward met *P. dichotomiflorum*. Recente floristische inventarisaties, herbariumrevisies en analyses van waarnemingen via het online citizen-scienceplatform waarneming.nl hebben de wijdverbreide aanwezigheid van *P. gilvum* in Nederland aan het licht gebracht. Hoewel morfologisch sterk lijkend op *P. dichotomiflorum*, verschilt *P. gilvum* onder meer door zijn meestal liggende tot opstijgende habitus, zijn nauwelijks uit de bovenste bladschede uittredende, kleinere en relatief armbloemige bloeiwijze, en vaak kleinere, stompere aartjes. Van *P. schinzii* onderscheidt de soort zich door de steriele onderste bloem. De soort werd voor continentaal Europa in 2024 voor het eerst correct benoemd nabij Gent, België, op een overslagterrein voor graan. Veldonderzoek en onderzoek van herbariummateriaal en fotowaarnemingen toonden echter aan dat talrijke eerdere vondsten uit Nederlandse maïsakkers die aan *P. dichotomiflorum* waren toegeschreven, in werkelijkheid *P. gilvum* betroffen. Daarnaast bleek dat exemplaren die tussen 1938 en 1951 herhaaldelijk werden verzameld bij een wolfabriek in Tilburg, maar toen verkeerd waren benoemd, eveneens tot *P. gilvum* behoren; deze oude vondsten lijken geïsoleerde woladventieven te zijn en staan vermoedelijk los van de recente ingeburgerde populaties in maïsakkers. Genetische analyses van de Nederlandse specimens van *P. gilvum* bevestigden de determinatie: ze toonden een nauwe verwantschap met authentiek Zuid-Afrikaans materiaal van deze soort en een duidelijke genetische scheiding van *P. dichotomiflorum*. De vroegst ingeburgerde Nederlandse populaties dateren uit 2009, wat dus wijst op een lange, onopgemerkte aanwezigheid. *Panicum gilvum* blijkt inmiddels in Nederland ingeburgerd en is in maïsakkers duidelijk algemener dan *P. dichotomiflorum*. De drie Nederlandse vertegenwoordigers van sectie *Dichotomiflora* kunnen als volgt worden onderscheiden:

1a. Onderste bloem (bijna) altijd mannelijk (meeldraden aanwezig); top van het aartje meestal stomp-afgerond, soms iets spits . . . . . *Panicum schinzii*
b. Onderste bloem altijd steriel; top van het aartje spits-toegespitst 2

2a. Bloeiwijze niet of nauwelijks uit de bovenste bladschede tredend, doorgaans klein (3–18 cm, zelden groter) en eerder armbloemig, met het bovenste blad gevouwen en stijf rechtopstaand; aartjes spits, ongeveer 2,5–2,8 mm lang; bloeiwijzetakken vrijwel glad of met enkele zeer korte stekeltjes; bovenste kroonkafje (palea) meestal ongeveer even lang en breed als de fertiele lemma; plant vaak liggend-opstijgend; bladen altijd eerder smal, 3–8 mm breed . . . . . ***Panicum gilvum***

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b. Eindelingse bloeiwijze bij rijpheid duidelijk uit de bovenste bladschede tredend, vaak groter en rijkbloemiger; aartjes spits tot toegespitst, vaak langer (≥ 3 mm, soms korter); bloeiwijzetakken zeer ruw door talrijke stekeltjes; bovenste kroonkafje (palea) meestal smaller en korter dan de fertiele lemma, soms afwezig; plant opgaand-rechtopstaand; bladen vaak breder, tot 15 mm breed, meestal vlak en vaak teruggebogen . . . . . *Panicum dichotomiflorum*

Dit artikel bespreekt en illustreert de belangrijkste onderscheidende kenmerken van deze drie soorten en reconstrueert de vermoedelijke introductie- en vestigingsgeschiedenis van *Panicum gilvum* in Nederland.

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INTRODUCTION

The most recent edition of the Heukels' Flora (Duistermaat 2020) recognizes six *Panicum* species as part of the Dutch flora. Two of these, the American *P. dichotomiflorum* Michaux and the South African *P. schinzii* Hack. ex Schinz, belong to the pantropical section *Dichotomiflora* (Hitchc.) Hitchc. & Chase ex Honda (Zuloaga 2022), which is characterized, for instance, by glabrous or nearly glabrous leaf sheaths and a lower glume no more than one-quarter the length of the spikelet. The genus is often assumed to be well known in western Europe, yet its taxonomy remains poorly understood. For example, two of the six species currently recorded in the Netherlands (*P. barbipulvinatum* Nash and *P. hillmanii* Chase) were only relatively recently added to the identification keys. *Panicum schinzii*, too, went unrecognized for a long time and was only identified among herbarium material of *P. dichotomiflorum* some twenty years ago (Reijerse & Stolwijk 2002, Verloove 2001).

Since 2008, presumed *Panicum schinzii* has been recorded by F.W. Bomble (2014) in maize fields near Aachen in North Rhine-Westphalia (Germany). Remarkably, in these populations, the lower floret was sterile rather than staminate, as is typical for *P. schinzii*. Moreover, the spikelets appeared a bit large for the species, raising questions about the identity of the taxon involved. The author noted the taxon's occurrence just across the nearby Dutch border in Limburg, and also illustrated plants from Mamelis. After the publication, F.W. Bomble tentatively considered the plants to represent a third species, *P. gilvum* Launert, although this conclusion was never published.

In the autumn of 2024, unusual *Panicum* plants were observed at the Sifferdok in the Ghent-Terneuzen canal zone (Province of East Flanders, Belgium), on a grain transshipment site. The plants bore a strong resemblance to *P. dichotomiflorum* but stood out due to their strictly prostrate habit, a panicle barely exserted from the upper leaf sheath, even late in the season, and relatively small, bluntly pointed spikelets. Interestingly, this location frequently yields South African weeds, despite no direct import of grain from that region. Further investigation revealed that the exotic plants on the site were most likely introduced indirectly via Australia, where several South African species have become naturalized in agricultural fields. The simultaneous discovery of *Eragrostis parviflora* (R.Br.) Trin., an Australian species, at the same site in autumn 2024, appeared to support this hypothesis (Verloove & Gonggrijp 2026). The deviant *Panicum* plants were therefore keyed out using Australian Floras (e.g. Webster 1987 and various online Floras for New South Wales and Victoria), which – surprisingly – pointed to *P. gilvum*, a South African species that is naturalized in Australia. Additional sources, such as Zuloaga's recent monograph on the section (2022) and a recent key for the identification of South African grasses (Fish et al. 2015), also led to this determination, though not always unambiguously, as the species is poorly understood and its circumscription varies between authors.

Consequently, the material was subjected to genetic analysis, alongside an authentic South-African specimen of *Panicum gilvum* preserved at the Meise Botanic Garden Herbarium (BR [BR0000005940370]). Following e-mail correspondence in the early 2020s with F.W. Bomble, who mentioned similar deviating plants from near Aachen and the adjacent south of the Province of Limburg (the Netherlands), the first author recognised the relevance of these populations and included them in the analysis, together with morphologically aberrant individuals collected in 2008 in Torhout (Province of West Flanders, Belgium). The results confirmed that the plants from the Ghent harbour, Limburg, and Torhout were genetically identical to South African *P. gilvum* and are clearly distinct from *P. dichotomiflorum* (Verloove et al., in prep.).

In 2025, special attention was given to *Panicum* plants occurring in Dutch (and Belgian) maize fields. Photographs of *P. dichotomiflorum* published on the website waarneming.nl were carefully examined, and specimens present in the herbarium of Naturalis Biodiversity Center in Leiden (L) were also consulted via the online Naturalis Bioportal, by which nearly 250 specimens were verified. In addition, we analysed approximately 15 physical *Panicum* collections from L and BR, specifically selected for their relevance, in particular recent collections and specimens formerly collected near wool-processing factories. It then became apparent that *P. gilvum* is widely naturalized in the Netherlands, particularly in maize fields, with the earliest naturalized populations dating back to 2009 in the Province of Limburg. Earlier collections, notably those from 1938–1951 from near a wool and leather factory in Tilburg, likely represent isolated wool adventive plants and do not appear to be directly related to the recent established populations. In Dutch maize fields, the species is now far more common than *P. dichotomiflorum*.

This article provides a detailed comparative account of the three representatives of section *Dichotomiflora* currently present in the Netherlands, including illustrations of diagnostic characters. It also outlines their current distribution and reconstructs the likely history of naturalization of *Panicum gilvum*.

DESCRIPTION AND RECOGNITION OF *PANICUM GILVUM*

Panicum gilvum was only relatively recently described by Launert (1970a), who argued that the taxon did not differ significantly from what had earlier been described by Pilger (1940) as *Panicum laevifolium* Hack. (= *P. schinzii*) var. *contractum* Pilg. Interestingly, Launert noted that the type material used by Pilger in fact belonged to a different species (*P. impeditum* Launert, which had not yet been described at the time), although Pilger's description corresponded to what Launert considered

P. gilvum. Given that *P. gilvum* is by no means easily confused with *P. schinzii*, Launert elevated it to species rank. At the time, the species was known only from southwestern Africa.

Although Launert appeared to have a sound understanding of the *Panicum* species occurring locally within this complex – an impression reinforced by his editorial supervision of Renvoize's extensive treatment of the genus in Flora Zambesiaca (Renvoize 1989) – certain aspects of his protologue caused confusion in the decades that followed. One particular issue is his mention of male lower florets – "Flosculus inferior masculus (semper?)" – a notation he himself apparently questioned. However, both syntypes preserved at Naturalis (*Dinter 2544*, L [L 0044857]; *Seydel 2210*, L [L 0044858]) clearly have sterile lower florets. The same observation applies to material preserved at the Meise herbarium (BR [BR0000005940370]). More recent treatments (e.g., Fish et al. 2015, Ryves et al. 1994, Webster 1987, Zuloaga 2022) also consistently describe the lower floret as sterile. Additionally, AusGrass2 (2025) notes that Australian populations deviate from Launert's original description in this particular respect. It is therefore safe to state that the lower floret in *P. gilvum* is sterile, not male. The origin of Launert's observation remains unclear – perhaps he assumed that, due to its close affinity with *P. schinzii* (which normally does have male lower florets), this would also be the case for *P. gilvum*, without verifying it properly. Notably, in Renvoize's later treatment of the genus in Flora Zambesiaca (1989), produced under the editorial supervision of Launert & Pope, the lower floret is described as sterile, clearly contradicting Launert's 1970 protologue and likely reflecting either a correction of an earlier error or new insight gained in the intervening years.

In any case, the original description of *Panicum gilvum* was ambiguous from the outset. Moreover, due to the species' clear geographical disjunction from its American look-alike *P. dichotomiflorum*, identification keys that included both taxa were long unavailable. The two species were perhaps first keyed out side by side in the work Alien Grasses of the British Isles (Ryves et al. 1994) – although *P. gilvum* had already been briefly mentioned and illustrated earlier by Clement (1981). At that time, the species was still poorly known: it keyed out as an erect plant with acuminate spikelets and a lower palea that was "poorly developed or absent". Based on such characters, however, *P. gilvum* cannot be reliably keyed out. A more comprehensive global revision of section *Dichotomiflora* became available only recently (Zuloaga 2022). While this represents a considerable improvement, the key still contains inconsistencies. Notably, it refers to the lower palea of *P. gilvum* as "reduced", whereas in reality, it is typically more developed than that of *P. dichotomiflorum*. Although Zuloaga's revision is undoubtedly a milestone in the taxonomy of the group, the identification key is not without shortcomings. An important issue arises in the very first dichotomy of the key, where species are separated into those with "Lower palea conspicuous, as long as the lower lemma; lower flower staminate" and those with "Lower palea reduced; lower flower absent". This formulation suggests that in species with a sterile lower floret – such as *P. gilvum* – the lower palea is by definition reduced. However, this is inaccurate: in such taxa, the lower palea may be absent, reduced, or well-developed. By conflating floral sexuality with palea development, the key imposes a correlation that does not hold consistently across the group. A more appropriate approach would have been to base the first dichotomy solely on the condition of the lower floret – typically staminate versus sterile – without reference to the lower palea, which is highly variable in sterile-flowered taxa (very rare exceptions occur, most notably in *P. schinzii*, where the lower floret may occasionally be sterile). Nonetheless, the description and the key overall are fairly accurate and allow for identification of *P. gilvum* with some confidence.

Since its introduction into Australia, the species has understandably been included in both national and regional Floras and identification keys. The critical specimens recently found in maize fields in our region key out as *P. gilvum* without difficulty. It should be remembered, however, that *P. dichotomiflorum* is not officially recognized as part of the Australian flora, and thus not included in keys — although our own genetic research confirms its presence there (Verloove et al., in prep.).

In the following section, we explore in more detail the diagnostic features that distinguish *Panicum dichotomiflorum*, *P. gilvum*, and *P. schinzii*. We discuss both features mentioned in various Flora accounts (which have been thoroughly tested for reliability) as well as new characteristics that we found useful for distinguishing the three taxa.

Habitus

Panicum gilvum generally differs from both related species by its predominantly **prostrate to ascending** growth habit (Fig. 1 & 2). This interpretation is supported by most sources (with the exception of Ryves et al. (1994), as previously noted). In the protologue, Launert (1970a) described it as "Culmi (...) prostrati vel leviter geniculati-ascendentes (…)", while Webster (1987) referred to "Flowering culms basally decumbent (…)", and Zuloaga (2022) described the species as having "(…) culms decumbent, rooting at the lower nodes, geniculate, then ascending (…)". In practice, however, this habit can be somewhat variable: plants may range from prostrate to ascending, depending on growing conditions. The culms of *P. dichotomiflorum* and *P. schinzii* are on average more geniculate-ascending to erect, although some overlap occurs.

Prostrate individuals of *Panicum gilvum* are mostly observed in open, sparsely vegetated habitats – for instance between paving stones, as was also the case in 2024 on a quay at the Sifferdok in the port of Ghent. In maize fields, which represent the species' most common habitat locally, plants tend to adopt a more ascending habit due to competition for light. Even then, however, they remain considerably more slender than *P. dichotomiflorum* and often also than *P. schinzii*, rarely exceeding a height of 30–50(–60) cm.

Leaves, sheaths, and blades

The leaves of *Panicum gilvum* also provide reliable diagnostic features. The **blade of the uppermost leaf**, which partially encloses the inflorescence, is **conspicuously folded** (Fig. 3 & 4). This fold is often so pronounced that the emerging inflorescence may become somewhat distorted, being compressed within the fold. This folding also results in the upper leaf blade standing rigidly upright, in contrast to *P. dichotomiflorum*, where it typically bends back (Fig. 5).

The **leaf blade** of *Panicum gilvum* is also usually **narrower** than that of the other two species, typically only 3–8 mm wide, whereas in *P. dichotomiflorum* and *P. schinzii* it may reach up to 15 mm in width. Additionally, the lower leaf sheaths in *P. gilvum* are often tinged pink, a feature that appears to be less commonly observed in the other species.

Subtle differences in leaf coloration have also been noted in the field: plants of *Panicum gilvum* often appear bluish-green (Fig. 3), whereas *P. dichotomiflorum* tends to be more yellowish-green. These tendencies, however, doubtlessly account for only part of the variation observed in both species. Interestingly, however, Renvoize (1989) in Flora Zambesiaca distinguished *P. schinzii* from *P. gilvum* by its "bluish-green foliage", suggesting that subtle foliar colour differences may indeed exist among the three species. Nonetheless, such variation does not appear consistent or clear enough to allow for reliable vegetative separation of the taxa.

Fig. 1. Habit of *Panicum gilvum* Launert at the margin of a maize field in Heijenrath in the south of the Province of Limburg, the Netherlands, on 20 July 2025. Depending on growing conditions, the habit of the plants ranges from prostrate to ascending; however, in open and sparsely vegetated habitats they are almost invariably prostrate. The plants shown on the photo are mainly exposed but are, at least from July onwards, partly shaded by the maize. Prostrate growth still dominates, but several (flowering) stems have become geniculately ascending. Photo: Sipke Gonggrijp.

Fig. 2. Habit of *Panicum gilvum* Launert at the margin of a maize field in Heijenrath in the south of the Province of Limburg, the Netherlands, on 20 July 2025. Stems are typically prostrate to geniculately ascending; inflorescences are relatively small, sparsely flowered, and remain partly enclosed by the upper leaf for an extended period. Photo: Sipke Gonggrijp.

Fig. 3. Two inflorescences of a freshly collected specimen of *Panicum gilvum* Launert from Gulpen in the south of the Province of Limburg, the Netherlands, on 20 July 2025. The inflorescence remains at least partly enclosed by the uppermost leaf blade for a prolonged period; this blade is conspicuously folded and relatively narrow compared with those of *P. schinzii* Hack. ex Schinz and *P. dichotomiflorum* Michaux. Photo: Sipke Gonggrijp.

Fig. 4. Close-up of an inflorescence of *Panicum gilvum* Launert from Mamelis in the south of the Province of Limburg, the Netherlands, on 2 October 2022. Spikelets are bluntly acute at the apex and relatively small; the inflorescence branches are very inconspicuously scabrous to nearly smooth. Photo: F. Wolfgang Bomble.

Inflorescence

The **inflorescence** of *Panicum gilvum* clearly differs from that of both other species. As previously noted, it remains at least **partially enclosed** by the uppermost leaf blade for a considerable time (Fig. 3 & 4). Spikelets may already contain mature seeds before the inflorescence has emerged from the leaf sheath, indicating the occurrence of at least partial cleistogamy. The prolonged enclosure of the inflorescence is considered a key characteristic by most authors. Launert (1970a) stated: “Panicula (…) si non omnino tamen aliqua ex parte vaginis superioribus foliorum inclusa (…)”, Webster (1987) described the inflorescence as “not fully exserted”, and Zuloaga (2022) referred to it as “terminal, contracted, partially included in the upper blades panicle [sic: included in the upper leaf sheath]”. According to Fish et al. (2015) the inflorescence is “(...) enclosed in two uppermost leaves and not extending beyond the leaf apex”. Renvoize (1989) added that it is sparsely branched, with the branches appressed. In contrast, the terminal inflorescences of *P. dichotomiflorum* and *P. schinzii* typically become fully exserted, with widely divaricating branches (Fig. 5).

In general, the inflorescence of *Panicum gilvum* is also **smaller** and **less floriferous**. Zuloaga (2022) considered the small, pauciflorous inflorescences, which are partly enclosed in the upper sheath, as a key characteristic. However, it should be noted that its size may sometimes be considerably underestimated. Launert (1970a) reported lengths of only 5–7.5(–10) cm, and Zuloaga (2022) gave a range of 3–10 cm in length. Also,

Fig. 5. An inflorescence of *Panicum dichotomiflorum* Michaux from Beernem in the Province of West Flanders, Belgium, on 20 August 2025. In contrast with *P. gilvum* Launert, the inflorescence is soon fully exserted from the upper leaf; this upper leaf is also often broader and more flexible than in *P. gilvum*, not stiff and folded as a continuation of the stem. – In the Netherlands, plants identified as *P. dichotomiflorum* from maize fields almost exclusively proved to belong to *P. gilvum*, and reliable photographic material of true *P. dichotomiflorum* from the Netherlands is therefore scarce; a Belgian specimen is illustrated instead. Photo: Hilde Fontier.

Fig. 6. Two spikelets of *Panicum dichotomiflorum* Michaux from Leiden in the Province of Zuid-Holland, the Netherlands, on 12 October 2018 (*K. van Zoest s.n.*, L [L.4594510]). Spikelets are usually distinctly longer, with a more acute to shortly acuminate apex; the branches are clearly scabrous. Photo: Koen van Zoest.

according to Launert (1970b), the inflorescence is at most 2 cm wide. Webster (1987) proposed more realistic dimensions for the inflorescence as a whole, measuring 70–180 mm in length. Our own observations suggest that, in some cases, the inflorescences may even exceed this range (in extreme cases, up to 30 cm in length; see also Flora of New South Wales Online 2025).

Fieldwork conducted in 2025 revealed an additional useful diagnostic feature: in *P. gilvum*, the inflorescence **branches** and spikelet **pedicels** are **nearly smooth or only very sparsely scabrous** (Fig. 4) – i.e., they bear few and very short prickles – whereas in *P. dichotomiflorum* they are distinctly rough, with numerous and significantly longer prickles (Fig. 6). Although this character is not mentioned in identification keys, it appears diagnostically valuable. Several Floras have made indirect reference to it in the species descriptions. For instance, Webster (1987) described the main and lateral branches of the inflorescence in *P. gilvum* as “smooth”, while Zuloaga (2022) described those of *P. dichotomiflorum* as “scaberulous”. *P. schinzii* is variable in this regard (Webster 1987).

Spikelets

The **lower flower** is **sterile** in both *Panicum gilvum* and *P. dichotomiflorum*, while it is nearly always male (with stamens present) in *P. schinzii* (Fig. 7). Launert (1970a) caused some confusion in this regard (as previously noted), but examination of the type material clarifies the matter: the lower flower is sterile and this has been acknowledged by all subsequent authors, including Renvoize (1989). In *P. schinzii*, occasional reference is made to rare forms in which the lower flowers are also sterile (e.g., Verloove 2001). However, in most cases, these flowers are in an advanced stage with stamens already fallen. Very exceptionally, the lower flowers in *P. schinzii* can indeed be sterile: recently, such material was collected in a maize field in Markluiden (*P. van der Knaap s.n.*, 23 October 2023, L – unmounted and without barcode). The taxonomic significance of this trait remains uncertain, as these plants are otherwise morphologically typical of *P. schinzii*; nevertheless, they will be included in our ongoing genetic studies of the group.

The palea of the lower floret also provides some indication, although this character has been described inconsistently across different sources. In both *Panicum gilvum* and *P. schinzii*, the **palea** is (nearly) **as long and wide as the fertile lemma**. In *P. dichotomiflorum*, the palea shows some variability: in certain plants (sometimes classified as *P. chloroticum* Nees ex Trin.) it may be absent altogether, while in most others it is slightly narrower and often a little shorter than the fertile lemma. However, the difference is usually subtle, and in some specimens the palea may closely resemble that of *P. gilvum*. Several Flora accounts (e.g., Fish et al. 2015, Renvoize 1989, Zuloaga 2022) describe the palea of the lower floret in *P. gilvum* as reduced or absent and conspicuously shorter than the lower lemma, which contrasts with observations from the northwestern European material. This inconsistency may partly reflect the introduction of populations representing only a limited portion of the morphological diversity found within the species’ native South African range, or possibly environmental influences on spikelet development. In any case, the diagnostic value of this character appears to be limited.

The venation of the lower glume is also reported to differ, though there is much uncertainty here as well. Launert (1970a) described the venation in *Panicum gilvum* as “indistinct (3–)5–7 nerves”. In contrast, Webster (1987), Fish et al. (2015), and Zuloaga (2022) state that the lower glume is either nerveless or 1-nerved. In *P. dichotomiflorum*, the lower glume is reported to have 1–3 nerves, while in *P. schinzii* it is 1-nerved (Zuloaga 2022).

Fig. 7. Spikelets of *Panicum schinzii* Hack. ex Schinz from Maastricht in the south of the Province of Limburg, the Netherlands, on 13 September 2021. The spikelets are small, blunt or bluntly acute at the apex; the lower florets are almost always male, with anthers protruding at anthesis. Photo: Sipke Gonggrijp.

In practice, this character is not entirely reliable: at early flowering, the lower glume in *P. gilvum* is usually un-nerved or only faintly nerved, whereas 1–3 nerves are more evident in *P. dichotomiflorum*. Later in flowering, the lower glume in *P. gilvum* may become more distinctly nerved, occasionally even showing 3–5 nerves. Notably, in Renvoize's later treatment of the genus in Flora Zambesiaca (1989), produced under the editorial supervision of Launert & Pope, the lower glume is described as having only 0–1 nerves, clearly contradicting Launert's 1970 description. This discrepancy may reflect a correction of an earlier error, further observation and revised understanding, or simply the inherent unreliability of this character, which can vary depending on developmental stage or season.

The number of nerves on the upper glume is frequently noted as a distinguishing characteristic, particularly the higher number in *Panicum gilvum*. According to Launert (1970a) and Fish et al. (2015), there are 11–14 nerves, while Webster (1987) and Ryves et al. (1994) reported 9–11, and Zuloaga (2022) mentioned 9–11(–13). In *P. dichotomiflorum* and *P. schinzii*, the number of nerves is lower, ranging from 7–9 (Zuloaga 2022). In reality, the difference between the three species may be minimal in this regard, and the marginal nerves are often difficult to interpret.

The three species also differ subtly in the shape and length of the spikelets. On average, *Panicum gilvum* and *P. schinzii* have the smallest **spikelets**, typically measuring around **2.5–2.8 mm** in length, at least in our material. Interestingly, in the Prodromus einer Flora von Südwestafrika, Launert (1970b) distinguished these two species solely based on spikelet size, reporting ranges of 2.0–3.4 mm for *P. gilvum* and 2.0–2.5(–2.6) mm for *P. schinzii*. According to Renvoize (1989) and Fish et al. (2015) they can exceptionally even reach 4 mm in length in *P. gilvum*. Webster (1987) noted that the Australian specimens, measuring only 2.3–3 mm in spikelet length, differ from the South African ones in having smaller spikelets. It is possible that, like in Australia, only a portion of the variation of *P. gilvum* is present in western Europe, particularly a small-flowered variant. This is significant, as, although the spikelets in *P. dichotomiflorum* are also variable in length, they are often more than 3 mm long in western Europe. The **apex** of the **spikelets** also differs slightly, ranging (in extreme forms) from obtuse-rounded (*P. schinzii*) (Fig. 7), **acute** (*P. gilvum*) (Fig. 4) to acuminate (*P. dichotomiflorum*). However, nuance is required here, as the spikelets of the latter species may sometimes be simply acute (Fig. 6), showing no or only minimal difference from those of *P. gilvum*.

Key to the Dutch species of Panicum sect. Dichotomiflora

In summary, it can be stated that the three species are relatively easy to distinguish, although a combination of characteristics is almost always required for accurate identification. Based on the key below, the three species of *Panicum* section *Dichotomiflora* occurring in the Netherlands can be identified.

1a. Lower flower (nearly) always male (presence of stamens). Spikelet apex usually obtuse-rounded, occasionally subacute (Fig. 7) . . . . . *Panicum schinzii*
b. Lower flower always sterile. Spikelet apex acute-acuminate (Fig. 4 & 6) 2

2a. Inflorescence not or not fully emerging from the upper leaf sheath, generally small (3–18 cm, rarely larger) and somewhat sparsely flowered, with the upper leaf folded and rigidly erect (Fig. 3 & 4). Spikelets acute, approximately 2.5–2.8 mm long. Inflorescence branches nearly glabrous or sparsely covered with very short prickles (Fig. 4). Palea of the lower flower usually approximately as long and wide as the fertile lemma. Plant often prostrate-ascending (Fig. 1 & 2). Leaves always relatively narrow, 3–8 mm wide . . . . . ***Panicum gilvum***
b. Terminal inflorescence clearly exserted from the upper leaf sheath at maturity, often larger and more floriferous, with the upper leaf flat and often hanging (Fig. 5). Spikelets acute to acuminate, often longer (3 mm or more, sometimes shorter). Inflorescence branches very rough due to numerous prickles (Fig. 6). Palea of the lower flower usually narrower and shorter than the fertile lemma, sometimes absent. Plant ascending-erect. Leaves often broader, up to 15 mm wide, usually flat, often drooping (Fig. 5) . . . . . *Panicum dichotomiflorum*

Physical specimens examined[1]

The specimens of *Panicum gilvum* examined are listed in chronological order.

Netherlands

Province of North Brabant — Tilburg, wool factory, 25 September 1938, *J. Kern & Th.J. Reichgelt 3891* (L [L3096767]); Tilburg, near wool mill, October 1939, *J. Kern & Th.J. Reichgelt s.n.* (BR [BR0000033046143]); cultivated from Tilburg wool-washing facility, August 1941, *J. Kern & Th.J. Reichgelt 4013* (L [L.3096762]); cultivated from a wool-adventive specimen from Tilburg in Reichgelt's garden, Nijmegen, 22 July 1942, *Th.J. Reichgelt s.n.* (L [L.1293669]); Tilburg, wool factory, 28 September 1947, *J. Kern & Th.J. Reichgelt 8763* (L [L 3096776]); Tilburg, wool factory, 28 September 1947, *J. Kern & Th.J. Reichgelt 8764* (L [L.3096780]); originating from the wool factory of B. Pessers in Tilburg (adventive), cultivated in Reichgelt's garden, Nijmegen, July 1948, *Th.J. Reichgelt s.n.* (L [L.3096814], [L.3096815]); Tilburg, 8 September 1950, *A.W. Kloos s.n.* (L [L.3096843]); Tilburg, grounds of the Pessers wool factory, 4 October 1950, *S.J. van Ooststroom 4955* (L [L.3096818]); Tilburg, wool and hides factory Bern. Pessers, 2 October 1951, *A.W. Kloos Jr.* (L [L.3096778]).

Province of Zeeland — Sint Kruis, Heirweg, margin of a maize field on a sand ridge, three plants, 27 August 2017, *A. de Zwart s.n.* (L [L.3987609]).

Province of Limburg — Savelsbos, Schone Grub, 20 July 2025, *S. Gonggrijp* 867 (L).

All specimens listed above were originally identified as *Panicum dichotomiflorum* or as *P. laevifolium* (*P. schinzii*), with the exception of our specimen collected in 2025 (*S. Gonggrijp 867*), which was identified as *P. gilvum* at the time of collection. Notably, at least the 1938 collection was at one point also referred to *P. hygrocharis* Steud., another African species (Kloos 1947). However, this determination was apparently never annotated on the herbarium sheets and, as confirmed by the present study, was incorrect. Moreover, although the name *P. hygrocharis* was suggested to Kloos by P. Jansen, he did not adopt this determination in his treatment of the genus for Flora Neerlandica (Jansen 1951), an indidication of serious doubt.

[1] Dutch labels were translated to English by the authors.

DISTRIBUTION

Panicum gilvum was originally described from Okahandja in Namibia and has since been found in other regions of southwestern Africa, specifically in Botswana and parts of South Africa (Cape and Northern Provinces) (POWO 2025). Zuloaga (2022) also reports it – in a very disjunct distribution – from Kenya; however, the basis for this is unclear, as the species is not mentioned in Flora of Tropical East Africa by Clayton & Renvoize (1982) and is not recorded for Kenya in the African Plant Database (2025).

Launert (1970a) had previously assumed that *Panicum gilvum* was confined to southwestern Africa. However, the species has been found in Australia for at least several decades, although its introduction history appears to be poorly documented. The exact date of its initial arrival there is uncertain, but herbarium records and botanical databases provide evidence of its presence in Australia from at least the 1940s (e.g., coll. *G. Davis s.n.* from Rose Hill near Guyra, New South Wales, dated 24 February 1941, NSW [NSW113086]). The species was already recorded as 'naturalized' by that time, and its actual introduction likely occurred in the early 1930s (there are various Australian collections from the 1930s, though these are not available online and thus cannot be verified). According to Webster (1987), *P. gilvum* is found in the eastern states of New South Wales, Queensland (Brisbane), and Victoria. The Atlas of Living Australia also lists it from multiple locations in Tasmania, with isolated records in Southern Australia and Northern Territories, although these could not be verified. It should be noted that in Australia, *P. gilvum* is often confused with *P. dichotomiflorum*. The latter species is officially entirely unrecorded in Australia, yet several records identified as *P. gilvum* actually correspond to *P. dichotomiflorum*. Our own research, based on Australian sequences, online herbarium data, and iNaturalist records, confirms the presence of both *P. gilvum* and *P. dichotomiflorum* across multiple regions (Verloove et al., in prep). Their actual distribution remains subject for further study. While the specific pathway of introduction in Australia remains unclear, it is likely that the species was unintentionally introduced via contaminated seed, agricultural equipment, or other human-mediated vectors, which is common for grass species.

Outside of Australia, *Panicum gilvum* has occasionally been recorded as a casual wool adventive species in western Europe, at least in the British Isles (Clement 1981, Ryves et al. 1994), and possibly elsewhere (the identification of many obscure *Panicum* species listed by Probst (1949) for Central Europe should be verified). Although the species became a weed in Clement's garden for several years, it failed to establish permanently in the British Isles. It is not mentioned in contemporary British Floras (e.g., Stace 2019). In the Netherlands, herbarium records indicate that *P. gilvum* occurred repeatedly between 1938 and 1951 near the Pessers wool factory in Tilburg (Fig. 8). These early records likely represent repeated introductions of individual plants, without evidence of temporary established populations; they are not directly related to the more recent naturalized populations in maize fields, which date back to 2009.

The recent naturalization history of *Panicum gilvum* in western Europe has been reconstructed with some difficulty through herbarium collections, field notes, online citizen science platforms, and publications. Current evidence suggests that the first established populations were found around 2007 in the northern border region of West and East Flanders in Belgium

Fig. 8. Herbarium specimen from the herbarium of Naturalis Biodiversity Center (L) in Leiden, the Netherlands, collected near a wool mill in Tilburg in 1951 by Kloos. Like several other specimens from this locality collected between 1938 and 1951, it has been misidentified and belongs to *Panicum gilvum* Launert rather than to *Panicum dichotomiflorum* Michaux. Photo: Naturalis Biodiversity Center, Leiden.

(Hoste et al. 2026), close to the Dutch border. The exact year of introduction, however, will likely remain unknown. Interestingly, fieldwork conducted by the first and the third author in 1999 in maize fields in the wider Aalter area – where *P. gilvum* is now common – yielded several collections of *P. dichotomiflorum*. These specimens have since been re-examined and confirmed as *P. dichotomiflorum*, suggesting that *P. gilvum* was either absent or still extremely rare in that area at the time. By now, *P. gilvum* has become fairly widespread in the northern parts of these two Belgian provinces, and in parts of this region it is much more common than *P. dichotomiflorum*. It has also spread to other provinces like Antwerp and Limburg, but its exact distribution there still needs to be assessed, although it appears to be much more scattered than in West and East Flanders.

Almost simultaneously, from 2008 onwards, the species was also recorded in the vicinity of Aachen in the far west of Germany, representing the first verifiable published record of the species on the European continent, albeit under the erroneous name *Panicum schinzii* (Bomble 2014, Bomble et al. 2025).

Bomble (2014) also documented the species from Mamelis, Province of Limburg, the Netherlands, since 2009. He had been surveying the same area intensively since 2005, mainly for *Echinochloa*, and is confident that he would not have overlooked large populations of *Panicum gilvum* before 2009, when the species first drew his attention. This implies that *P. gilvum* either arrived only shortly before or was still too inconspicuous to be noticed earlier. Based on photographs from waarneming.nl (recorded as *P. dichotomiflorum*, *P.* spec., and partially also *P. schinzii*), the naturalization history of the species in the Netherlands can be further refined. The earliest records indeed originate from Limburg. It is likely no coincidence that, in subsequent years, new distribution centres primarily emerged in regions bordering Belgium, particularly in the provinces of North Brabant and Zealand. In these three provinces, *P. gilvum* is at present known from numerous widely dispersed localities and is clearly established (Fig. 9).

In Limburg, as of late September 2025, the species has been observed at multiple locations based on photographic evidence, including Crapoel, Eckelrade, Epen, Eperheide, Eyserheide, Geuldal, Gulpen, Heijenrath, Herkenrade, IJzeren, Maastricht, Mamelis, Mechelen, Mheer, Savelsbos, Schin op Geul, Stokhem, Vijlen, and Wahlwiller. A similarly extensive number of locations have been reported in North Brabant, such as Alphen, Baarle-Hertog (België), Baarle-Nassau, Bergeijk, Bladel, Boekel, Boerdonk, Breda, Chaam, Gilze, Hooge Mierde, Middelbeers, Munnekens-Vinkel, Oosterhout, Reusel, Rijen, Tilburg, Ulicoten, Veghel, and Veldhoven. Although fewer locations are known in Zealand, the species appears to have also become established there in recent years, particularly around Eede in Zeelandic Flanders. It should be noted that the latter area is adjacent to the Belgian area where established populations of *P. gilvum* were first observed, although for years they remained misidentified (Hoste et al. 2026). Further north in the Netherlands, *P. gilvum* is much rarer, though distinct distribution centres are evident around Rhenen in the Province of Utrecht, where the species has been present for at least ten years. The species was also documented in 2019 from Geesteren in the Province of Overijssel and in Gorinchem in the Province of South Holland in 2025. Finally, its presence was also documented from the Province of Gelderland (Lobith, 2019, and Wageningen, 2025). Nearly all records are based on photographic observations; almost no herbarium specimens have been examined. Therefore, while these observations provide a reliable overview of the species' distribution, individual identifications should be treated with caution, as occasional misidentifications cannot be ruled out.

The species' current known distribution across the Netherlands is illustrated in the map provided in this article (Fig. 9).

HABITAT

In its native range, *Panicum gilvum* is found on sandy soils and at the margins of vleis (shallow, often temporarily wet depressions), dams, seasonal rainwater pans, and waterholes, in ephemeral water bodies, and in disturbed habitats (Fish et al. 2015, Launert 1970a, Renvoize 1989). The species is sometimes explicitly considered a hygrophyte (Fish et al. 2015). It is therefore notable that in Australia, it is also found in drier habitats. Webster (1987) reported it from various types of dry to semi-humid shrubland and woodland. More recent Australian sources regard it as a weed of cultivation (Flora of New South Wales Online 2025) and in Victoria, it has recently become more widespread, especially in areas receiving good summer rains or irrigation (Flora of Victoria Online 2025).

In the Netherlands and elsewhere in western Europe, *Panicum gilvum* is primarily, though not exclusively, found in maize fields. It is also regularly observed between street cobbles, mainly in regions where the species occurs in maize fields, undoubtedly germinating from seeds dropped along the road from vehicles transporting silage maize after harvest. To date, the species has not been recorded in more natural habitats in the Netherlands. Nonetheless, occasional occurrences have been documented on temporarily exposed river or pond banks, such as along the River Meuse in Maastricht in 2022 and at a pond at a golf course in Crapoel in 2023 in the south of the Province of Limburg.

A DUTCH VERNACULAR NAME

The Dutch name "Gevouwen gierst" (Folded Millet) was proposed and accepted for *Panicum gilvum*. The name is based on a distinctive feature of the plant: the uppermost leaf, which partially encloses the inflorescence, is clearly folded upwards. This folding is so pronounced that it often results in the inflorescence being slightly distorted, as it gets compressed within the fold.

The epithet 'gilvum' refers to a yellowish or golden colour, but this characteristic is not prominent in this species, making it less relevant for naming.

INTRODUCTION VECTOR

Panicum gilvum was undeniably introduced to Europe in the past via wool imports (e.g., Clement 1981), a finding confirmed by our own herbarium research, which shows repeated, isolated introductions of individual plants in the Netherlands between 1938 and 1951. Given that both South Africa and Australia were significant suppliers of wool and that *P. gilvum* has been naturalized in Australia since the 1930s, it is conceivable that the species could have been introduced to our regions from both its primary and secondary distribution areas.

However, it is highly unlikely that the recently naturalized populations of *Panicum gilvum* in western Europe are in any way linked to former wool-associated adventive occurrences. In the past, the species was never able to establish itself permanently, and the last records of its presence in the Netherlands date back to 1951 in Tilburg (Province of North Brabant), whereas the naturalization of *P. gilvum* likely began only about 20 years ago, initially in Limburg.

So, how did *Panicum gilvum* arrive here about 20 years ago? South Africa is not a major trade partner of western European countries, at least not for products that could have facilitated the unwanted introduction of *P. gilvum* seeds, such as cereals or other agricultural goods. Recent observations in the port of

Fig. 9. Current distribution of *Panicum gilvum* Launert in the Netherlands, based on verified records from waarneming.nl. Two distinct distribution centres occur in the provinces of Limburg and North Brabant, with smaller clusters and isolated records situated in other parts of the country.

Ghent, Belgium (Verloove & Gonggrijp 2026), may provide an explanation. It was found that many South African weeds, having first become naturalized in Australia, subsequently arrived in Europe. Australia has long been a significant exporter of grains and oilseeds. Plants of *Panicum gilvum* found in Ghent in 2024, along with the Australian *Eragrostis parviflora*, most likely originated from Australia. The ecology of the species further supports this scenario: in South Africa, *P. gilvum* occurs primarily in natural habitats, whereas in Australia it is also common in strongly anthropogenic habitats, including as a weed in arable fields. This makes the indirect introduction via the secondary Australian range far more plausible than direct introduction from the primary South African range. It is highly plausible that *P. gilvum* was repeatedly imported in recent years, possibly even over the past decades, into animal feed, with undigested seeds subsequently spreading to fields via manure.

A similar scenario could very well have played out with *Panicum schinzii*, a species which is also native to South Africa and is also naturalized in Australia.

CONCLUDING REMARKS

It is rather uncommon for two species that are genetically and geographically completely separated to exhibit such strong morphological similarities. Our genetic analyses have shown that *Panicum gilvum* is much more closely related to *P. schinzii*, which also originates from South Africa, than to the American *P. dichotomiflorum*. Yet, the morphological resemblance to the latter is much greater, to the extent that the syntypes of *P. gilvum* preserved in Naturalis (L) were re-determined as *P. dichotomiflorum* by Reijerse & Stolwijk in the late 1990s, implicitly

considering *P. gilvum* as a synonym of *P. dichotomiflorum*. This was a mistake, which has now been clarified.

Undoubtedly, the actual distribution of *Panicum gilvum* in the Netherlands will be further refined in the coming years now that attention has been drawn to the species. It will also be interesting to investigate whether the species occurs in other habitats.

Given the ongoing spread of *Panicum gilvum* across maize fields, it will be essential to monitor its interaction with other agricultural species. This could help assess any potential competition or ecological shifts resulting from its presence in crops and disturbed habitats. The question can also be raised to what extent the species has benefited from the prolonged taxonomic confusion with *P. dichotomiflorum*. Although no species-specific herbicides exist for *Panicum* species, it has been shown that certain species are more sensitive to specific herbicides, and this is also true for *P. dichotomiflorum* and *P. schinzii*. For instance, large interspecific differences in sensitivity to HPPD-inhibiting herbicides were observed in Belgian maize fields (de Cauwer et al. 2014). Given their genetic relationship, herbicides targeting *P. schinzii* may likely be more effective against *P. gilvum*, while the species has probably been controlled for years with herbicides that are effective against *P. dichotomiflorum* (and therefore possibly less effective against *P. gilvum*).

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