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Review

Achieving the European Green "Deal" of Sustainable Grass Forage Production and Landscaping Using Fungal Endophytes

Dariusz Pańka [1,*], Małgorzata Jeske [1], Aleksander Łukanowski [1], Piotr Prus [2], Katarzyna Szwarc [3] and Jean de Dieu Muhire [3]

[1] Department of Biology and Plant Protection, Faculty of Agriculture and Biotechnology, UTP University of Science and Technology in Bydgoszcz, 7 Kaliskiego St., 85-796 Bydgoszcz, Poland; malgorzata.jeske@utp.edu.pl (M.J.); aleksander.lukanowski@utp.edu.pl (A.Ł.)

[2] Laboratory of Economics and Agribusiness Advisory, Department of Agronomy, Faculty of Agriculture and Biotechnology, UTP University of Science and Technology in Bydgoszcz, 430 Fordońska St., 85-790 Bydgoszcz, Poland; piotr.prus@utp.edu.pl

[3] Plant Breeding Company Grunwald Ltd. Group IHAR, Bartążek, 10-687 Olsztyn, Poland; biuro@bartazek.pl (K.S.), mujados88@gmail.com (J.d.D.M.)

* Correspondence: dariusz.panka@utp.edu.pl; Tel.: +48-523-749-479

Citation: Pańka, D.; Jeske, M.; Łukanowski, A.; Prus, P.; Szwarc, K.; Muhire, J.d.D. Achieving the European Green "Deal" of Sustainable Grass Forage Production and Landscaping Using Fungal Endophytes. *Agriculture* **2021**, *11*, 390. https://doi.org/10.3390/agriculture11050390

Academic Editor: Azucena González Coloma

Received: 4 March 2021
Accepted: 22 April 2021
Published: 25 April 2021

Abstract: The European Green Deal is the EU's latest growth strategy and action plan, which will meet the challenges concerning climate change and environmental degradation. The components of the Green Deal which are intended to prevent biodiversity loss, to reduce pollution level, and to improve food quality are: The Farm to Fork Strategy and Biodiversity Strategy. Their main aims include: Reducing the application of pesticides by 50% by 2030, reducing nutrients loss by 50% while preserving soil fertility, reducing the application of mineral fertilizers by a minimum of 20% by 2030, as well as supporting the development of organic farming to reach 25% of all the arable land in the EU. These aims are very ambitious and they pose a serious challenge. Can the European Green Deal provide an opportunity for fungal grass endophytes? This paper presented different aspects in which endophytes of the *Epichloë* genus affect colonized plants, as well as their possible applications in biological grass protection and in improving the performance properties of different grass biotopes. Literature was reviewed to provide evidence of how fungal endophytes might be used to achieve the goals of the European Green Deal strategy, in accordance with the principles of sustainable agriculture.

Keywords: sustainable grasses production; perennial ryegrass; *Epichloë*; Farm to Fork

1. Introduction

Grassland ecosystems play a significant role in both human life and economy. They are an element of our agricultural landscape, as permanent grasslands, which constitute about 25% of the global land mass. In Europe, meadows and pastures take up over 20% of the agricultural land and, when combined with rough grazing areas, they make up approximately 30% of the agricultural land. In recent decades, a gradual reduction of grassland areas has been observed in Europe. This has been caused—among others—by grassland fragmentation, abandoning land-use, limiting the cattle grazing population, as well as the increasing use of concentrates in livestock feedstuffs [1,2]. However, recent decades have also seen the development of environmental awareness amongst Europeans, as shown by their concern over the state of our natural environment. This also includes their interest in more sustainable systems for intensive agricultural production. As a result, the significance of grassland systems in Europe will be rising even more quickly. However, it is important to consider the diversity of various agricultural systems in individual European countries, their different soil types and climate conditions, as well as socio-economic factors. The research performed in recent years confirms that increasing biodiversity of grassland agroecosystems may result in producing the feed for livestock of a quality comparable—to that—of intensively fertilized grass, which in turn will significantly decrease the negative impact on the natural environment due to considerably reduced application of nitrogen fertilizers [2].

A gradual increase of grass importance can be also seen in the non-agricultural sector. This is related to the intensive urban and infrastructural development observed in recent times. Grasslands are a significant element of the landscape. Lawn varieties constitute the main component of recreational areas, sports facilities, backyard gardens and others. Furthermore, they have been successfully applied to reclaim difficult and degraded lands. Thus, grasslands play an important role in handling the negative impact that economic growth may have on the environment. To a large extent, they determine the life quality of communities, both in urban and rural areas. Apart from their undeniable aesthetic value, they are also characterized by high biocenotic value, which increases biodiversity. Grunnarsson et al. [3], based on their research, claimed that the problem of biodiversity is acknowledged and considered important by inhabitants of urbanized areas. In order to experience the positive effect of greenery, people need to be provided with green areas with an abundance of plant species, with their lushness and the exuberance of natural sounds.

The problems of biodiversity loss, the devastation of natural environment, and climate change have been a concern of the European Community for many years. The European Union's policies and activities respectively address these issues. The European Green Deal, presented on 11 December 2019, is the latest growth strategy and action plan, which meets the challenges concerning climate change and environmental degradation. It is an action for sustainable EU economy, aimed at turning the above-mentioned challenges into new opportunities for sustainable, resource-efficient, and climate-neutral development. The components of the Green Deal, which are intended to prevent biodiversity loss, to reduce pollution levels, and to improve food quality, were the strategies presented on 20 May 2020: The Farm to Fork Strategy and the Biodiversity Strategy. They constitute the elements of sustainable development of EU's agricultural and rural areas due to the common agricultural policy. The main aims include: Reducing the application of chemical plant protection and dangerous pesticides by 50% by 2030, reducing nutrients loss by 50% while preserving soil fertility, reducing the application of mineral fertilizers by a minimum of 20% by 2030, as well as supporting the development of organic farming to reach 25% of all the arable land in the EU. These aims are very ambitious and they pose a serious challenge. However, they are also an opportunity for dynamic and sustainable development of the European Community, as well as for its increased competitiveness on the global market. The slogan "From Farm to Fork" has been expanded as "Our food, our health, our planet, our future" and it perfectly represents the significance of our future goals. However, a literal approach to reducing production means or simply increasing the area for organic production would inevitably lead to a failure. Only modern, innovative solutions that are an alternative to the ones used so far can guarantee successfully reaching the above goals.

Can the European Green Deal provide an opportunity for epichloid grass endophytes? The research conducted so far globally indicates that it should do so. The presence of symbiotic endophytic fungi of the *Epichloë* genus may benefit the growth and development of the grass they colonize. The positive effect of *Epichloë* spp. on the plant may be very wide and include better resilience, higher green matter, and dry matter yields, as well as a higher seed yield [4]. Moreover, such plants are characterized by better tolerance to unfavorable environmental conditions, e.g., higher resilience to periods of water shortages [5], infection by pathogens [6], and pest damage [7]. Such effects result mainly due to the strong influence of the endophyte on plant metabolic processes, as well as the production of hormones and numerous metabolites in the colonized plants [8]. The exact mechanisms of such impact are often not fully recognized.

Using these symbiotic organisms for biological improvement of grass would reduce the application of chemical plant protection products and synthetic fertilizers, thus preserving the natural environment. It would also contribute to more economical use of water resources in the locations where grass and endophytes associate. With the use of endophytes, many varieties of grass grown for feed and seeds or to shape landscapes would be cultivated in a more sustainable manner, not requiring high costs of care and maintenance, more efficient in the use of resources, as well as being less harmful to the environment. Such a solution would present an opportunity to use local species and varieties of grass.

This paper presented different aspects in which endophytes of the *Epichloë* genus affect colonized plants, as well as their possible applications in biological grass protection and in improving the performance properties of different grass biotopes. Literature was reviewed to provide evidence of how fungal endophytes might be used to achieve the goals of the European Green Deal strategy, in accordance with the principles of sustainable agriculture.

2. Epichloid Endophytes of Grasses

Symbiotic associations of grasses with microorganisms are ubiquitous and widespread. They include mycorrhizal, arbuscular fungi (e.g., *Rhizophagus* spp.) and fungal species of the genus *Epichloë* (Clavicipitaceae, Ascomycetes), formerly *Neotyphodium* (asexual form of many *Epichloë* species) [9–13]. At present, it is estimated that approximately 900 pooid grass species are infected by one or more strains of *Epichloë* endophytes [14]. These endosymbionts are also referred to as epichloid endophytes [15]. The best studied associations are that of perennial ryegrass (*Lolium perenne* L.) infected by *E. festucae* var. *lolii* (formerly *N. lolii*), tall fescue (*Lolium arundinaceum* (Schreb.) Darbysh.) (syn. *Festuca arundinacea* Schreb.) infected by *E. coenophiala* (formerly *N. coenophialum*), and meadow fescue (*L. pratense* (Huds.) Darbysh.) (syn. *F. pratensis* Huds.) infected by *E. uncinata* (formerly *N. uncinatum*) [16,17] due to the importance of listed grass species for forage production and turf purposes. Other associations of grasses, e.g., red fescue (*Festuca rubra* L.), orchardgrass (*Dactylis glomerata* L.), timothy (*Phleum pratense* L.), and *Elymus* spp. with epichloid endophytes are also common in many European countries but have been seldom studied so far [18–21]. Endophyte infections of wild *Triticum* and *Aegilops* (related to *Triticum*) were also found [22,23]. This, however, indicates a high diversity of *Epichloë* endophytes in nature as an abundant source of strains, which may be potentially used for inoculation of new hosts, in breeding programs, in genetically-modified plants to produce new cultivars of commercial crop grasses with higher resistance to stress factors [24–26]. Their potential is attracting more attention from researchers worldwide, although there are still no practical applications up to now and they may be significant in the near future. However, it needs more extensive research yet.

Epichloid endophytes are symptomless fungi that colonize intercellular spaces of leaf sheaths and shoot meristems of grasses. A characteristic feature of these fungi is their vertical transmission via seeds [27,28]. It involves the growth of the mycelium into primordia of kernels (Figure 1). Seeds produced by infected plants contain the same genotype of the endophyte as the maternal parent. The presence of endophytes confers many benefits to the host plant, including higher persistence, drought and salinity tolerance, resistance or deterrence to insect feeding, resistance to nematodes and pathogens, and improved mineral nutrition [4–8].

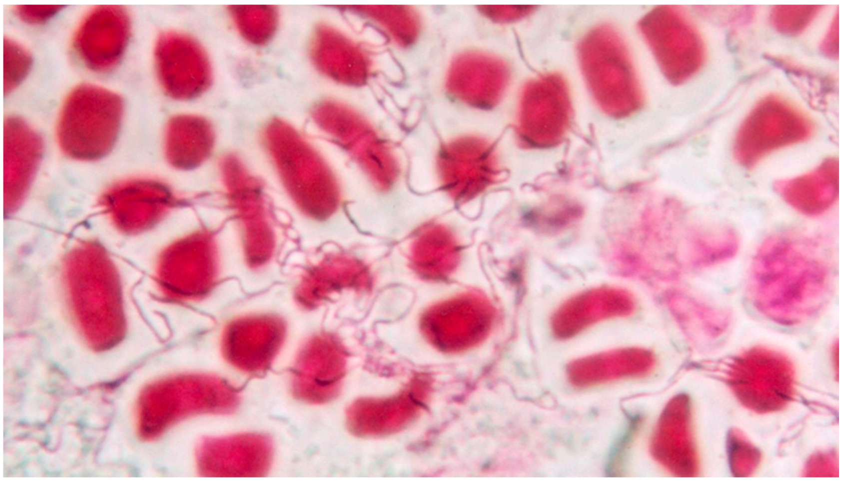

Figure 1. Mycelium of *Epichloë festucae* var. *lolii* stained with Bengal rose in perennial ryegrass seeds (Phot. D. Pańka).

3. Grass-Endophyte Symbiosis Enhance Host Tolerance to Drought Stress

One of the most important advantages of the endophyte presence for the host grass is greater resistance to drought stress [5]. It is also the most documented abiotic stress in the literature related to the grass-endophyte associations [29–31]. Adaptations of endophyte-infected grasses to drought stress can be categorized as drought avoidance, tolerance, and recovery from drought [32]. Some of the adaptations may be considered both as drought avoidance and drought tolerance. The improved water uptake from the soil by a well-developed root system, more efficient regulation of transpiration by stomata, and accumulation of solutes, likely soluble carbohydrates for water storage in plant tissues, are such examples [33–36]. Drought tolerance adaptations allow plants to withstand water deficit periods and include: Efficient water use [37,38], accumulation and translocation of assimilates (e.g., glucose, fructose, polyols, proline, mannitol, amino acids) [39–42], maintaining cell walls' elasticity [43,44], and osmotic adjustment to maintain turgor and physiological processes [45,46]. Lolines (see Section 6) also lower the osmotic potential, reducing the implications of drought stress [8]. Higher level of antioxidants produced by the grass-endophyte associations protecting cell membranes from reactive oxygen species (ROS) are also considered a drought tolerance mechanism [47–50]. Drought stress recovery mechanisms are based mainly on a rapid water uptake from soil and reactivation of physiological processes [35]. An important mechanism of drought tolerance is higher and earlier production of dehydrins by the endophyte-colonized grasses, as compared to uninfected plants [51,52]. Quick restoration and regrowth of the endophyte-infected grasses after drought are very important for their persistence. It is considered even a more precious mechanism of drought tolerance than enhanced development during the periods of water deficit [53]. The most spectacular effect of endophyte presence in the host grass, the enhanced drought persistence, is the most desirable feature of the endophyte mediated associations. Climate change challenges being taken into account in the European Green Deal strategy and its increasing awareness may now provide a greater opportunity for the wider utilization of endophytes in sustainable grass production and landscaping in Europe. Therefore, the most advantageous grass-endophyte associations designed for regional conditions should be identified and/or constructed.

4. Mineral Nutrients from Soil Are More Efficiently Used by Grass–Endophyte Associations

Literature and data on the endophyte effect on the host plant response to mineral stress are much more scarce compared to those dealing with, e.g., alkaloid production or drought stress. Considerable amount of this evidence is related to nitrogen use efficiency and phosphorus metabolism [30]. As nitrogen is crucial for alkaloid synthesis and the production of metabolites involved in stress tolerance mechanisms, most of them proved the role of endophytes on the metabolism of this element [54–56]. Although the majority of studies indicate beneficial effects of endophyte on host grass growth under optimal N fertilization, the endophyte-related mechanism of N metabolism appears to be independent of N availability and involves increasing glutamine synthetase synthesis [56]. However, the greatest benefit of the endophyte presence for the host grass in environments poorer in minerals is their involvement in the regulation of root exudates released in the rhizosphere and their effect on transformations and the availability of minerals, e.g., phosphorus, aluminum, copper, and iron [57–62]. It has been proven that in soils with low availability of P, the endophyte-mediated increase in the uptake of P from insoluble sources may occur [59]. Root exudates are mainly phenolic compounds, and their quantity and quality are dependent on the endophyte strain [49,63,64]. Endophyte colonized grasses may also release root exudates possessing chelating properties. This feature may be used for soil remediation from metal pollutants (Al, Zn, Cd, Ni), helping in the restoration of degraded environments [58,65–68].

The above-mentioned evidence confirms that, although endophytes do not develop in roots, they do however have a relevant effect on the chemical transformations inside roots and on the rhizosphere. Due to the release of allelopathic compounds into the rhizosphere by the endophyte-infected grasses, these associations can inhibit the germination and growth of other plants, as well as weeds [29].

5. Presence of Epichloid Endophytes Protects Grasses against Pathogens

Many studies on epichloid endophytes address their role as providing the host plant with resistance to pathogens. Shimanuki and Sato in 1983 [69] first reported lower susceptibility of timothy (*Phleum pratense*) infected by the *E. typhina* endophyte against pathogenic fungus *Cladosporium phlei* in planta. Significantly lower infection of perennial ryegrass with endophyte by *Laetisaria fuciformis* (red thread) was reported by Vincelli and Powell [70], while Schmidt [71] found an inhibiting effect of the endophyte on *Drechslera sorokiniana*, *Microdochium nivale*, and *Rhizoctonia cerealis* infecting meadow fescue. Higher resistance of the endophyte-infected (E+) plants to the infection by *Sclerotinia homoeocarpa* (dollar spot disease), *Cercospora* (leaf spot disease), *Typhula ishikariensis* (grass snow mold disease), *Fusarium oxysporum* (damping-off of Arizona fescue seedlings), barley yellow dwarf virus, and spot diseases on perennial ryegrass was also observed [6,72–78]. Antagonistic effects of epichloid endophytes, ensured by the wide range of produced chemicals, towards the casual agents of many diseases in vitro, was also widely reported [79–81]. Endophytes from wild cereal form show high antagonistic activity towards many cereal pathogens as well [23]. However, the high activity in the production of secondary metabolites in vitro does not completely explain the mechanism of the inhibiting effect of endophytes on pathogens in planta. Antibiotic activity of microorganisms under natural conditions can be less successful [79,80]. There is also evidence available suggesting no endophyte effect on the development of the pathogens [82,83], and even greater susceptibility of the E+ plants to infection in some conditions was demonstrated [71,76,84]. This suggests that other factors, e.g., compatibility between symbionts and nutrients' availability can affect the phenotypic reaction of the association. High compatibility of the grass/endophyte symbiotic association can exhibit a very high level of resistance to pathogens. Pańka et al. [85] observed that tall fescue plants biologically modified with the novel endophyte isolate 'ArkPlus' were highly resistant to *Rhizoctonia zeae* infection, while endophyte-free (E−) clones were totally infected and died (Figure 2).

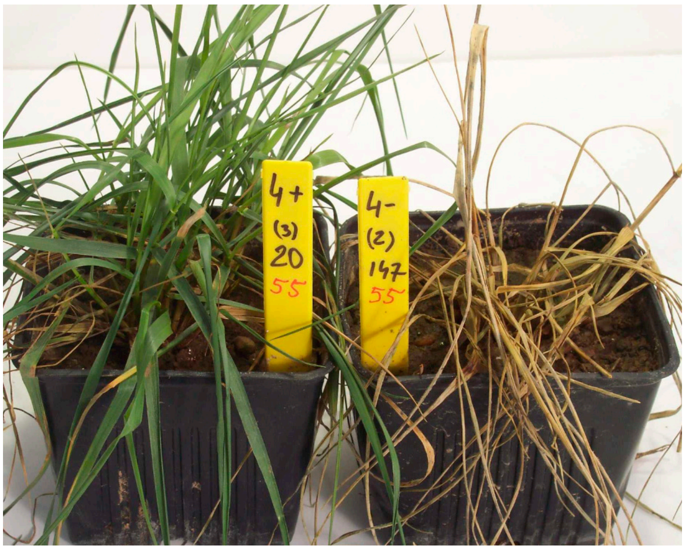

Figure 2. Tall fescue ecotype containing (**left**) and not-containing (**right**) by *Epichloë coenophiala* after 10 days from inoculation with *Rhizoctonia zeae* (Phot. by D. Pańka).

The protective effect of the endophyte is a result of its complex influence on the host plant. Moy et al. [86] observed the presence of endophyte hyphae on the leaf surface which probably inhibited the penetration and the development of the mycelium of pathogens, whereas Panka et al. [85] did not observe the competitive effect of the endophytes towards *R. zeae*. Numerous chemicals produced by endophytes also play an essential role in increased resistance of the host. Moy et al. [87] identified the presence of the enzyme β-1,6-glucanase, produced by the endophyte, which can decompose the cell wall of pathogens. Similarly, in E+ plants Pańka et al. [85] observed a higher total content of phenolic compounds which may have been responsible for significantly lower infection of those plants with *Fusarium poae*. The authors also observed a more intensive release of volatile compounds such as linalool and methyl salicylate by E+ plants, as compared with E−. Methyl salicylate, the ester of salicylic acid, is considered to be taking part in transmission of information about infection within plant tissue and to other plants [88]. It initiates the synthesis of defense compounds against pathogenic microorganisms in plant cells. Malinowski and Belesky [29] suggested that endophytes induce a weak resistance response in the host plant. A similar reaction has been shown for endomycorrhizal fungi [89]. This confirms the fact that E+ plants can initiate a defense reaction quicker than E− plants in response to infection by pathogens. The provided evidence proves that epichloid endophytes can play a crucial role in the plant defense against pathogens and it indicates the potential of the endophyte as an efficient tool in sustainable management of grass diseases.

6. Grasses with Epichloid Endophytes Are More Resistant to Pest Infestation

Plants infected by endophytes contain antiherbivore and deterrent fungal alkaloids, and as a result they show an increased resistance to numerous species of insects and nematodes [7,90–96]. Such detrimental effect for invertebrates is conditioned by the production of pyrrolizidine (peramine) and loline (N-acetylloline, N-formylloline) alkaloids [97,98]. Some ergot alkaloids (ergovaline, agroclavine) also exhibit antimicrobial and insect deterrent activity [99–102]. Lolines are produced by tall fescue and meadow fescue colonized by epichloid endophytes [8,103,104] and endophyte-infected perennial ryegrass at elevated temperatures [105]. Usually, their concentration in plant tissues is higher than that of vertebrate-toxic alkaloids [4]. Their mode of action as insecticides is similar to that of nicotine [106]. Lolines and peramine are the most toxic to insects [107,108]. However, insect species may differ in their response to particular alkaloids produced by the grass–endophyte association. Such differentiation is observed often among aphid species [103,109]. Other insects are very sensitive to particular alkaloids, e.g., Argentine stem weevil (*Listronotus bonariensis*), one of the most dangerous pests of pastures in New Zealand, is strongly affected by peramine [107]. The type of produced alkaloids found in plants and their concentration depends on many factors, as follows: On the species and genotype of fungus, grass, and also environmental conditions [97,98]. As an example, the concentration of peramine is closely associated with the endophyte genotype, especially the genetic distances among *Epichloë* isolates [110]. Lehtonen et al. 2005 [111] found decreased performance of bird cherry aphid (*Rhopalosiphum padi*) on endophyte-infected perennial ryegrass when the mineral nutrients availability in soil increased. This suggests the dependence of the alkaloid production on nutrients content in the soil. However, presence of the endophyte affected alkaloid production to a higher extent. Epoxy-janthitrems belonging to the indole diterpene alkaloids [112] are also suggested to likely be associated with observed effects on pasture insect pests and also livestock [113]. This group of alkaloids was suggested to likely be responsible for the protection of endophyte infected perennial ryegrass from larvae of Argentine stem weevil (*Listronotus bonariensis*), adult African black beetle (*Heteronychus arator*), Porina larvae (*Wiseana* spp.), and root aphid (*Aploneura lentisci*) [114–117]. Epoxy-janthitrems are responsible for bioprotective properties such as insect herbivory deterrence of perennial ryegrass colonized by novel endophytes AR37 and NEA12 [112,118].

7. Forage Quality Can Be Negatively Affected by Endophytes

High competitiveness of endophyte-infected grasses in the environment is due to the production of a wide range of alkaloids. Some of them confer higher resistance of the association to pests and pathogens (see Sections 5 and 6); others protect the host grass from grazing vertebrates such as cattle, sheep, and horses, decreasing forage quality. However, those antiquality factors lead to higher competitiveness and persistence of endophyte-infected grasses in the natural environment compared to endophyte-free, more often grazed counterparts. The most harmful toxins to mammals are diterpene alkaloids (lolitrems) and ergot alkaloids including ergopeptines (ergovaline, ergonovine, and ergotamine), clavines, lysergic acid, and its amides. Lolitrems, produced by endophyte-infected perennial ryegrass [119], are responsible for ryegrass staggers in livestock, the neuromuscular disorder that occurs mainly in late spring, summer, and autumn [120]. Lolitrem-based toxicoses have a great importance in New Zealand and Southern Australia as the perennial ryegrass is the basis for forage production in these countries. Ergot alkaloids may cause toxicoses of grazing animals, e.g., fescue toxicosis (summer syndrome), fescue foot, and bovine fat necrosis [99–101,121,122]. Fescue toxicosis has the greatest economic importance in the USA and can be manifested through hyperthermia, agalactia and reduced reproduction. It occurs during hot weather periods. In contrast, the fescue foot, manifested through dry gangrene of limbs and extremities, occurs during cold weather conditions. There is scant literature evidence related to diterpene or ergot alkaloids in planta, as well as their toxic effect on grazing livestock in Europe [120,123–127]. Although concentrations of toxic alkaloids are sometimes reported high enough to exhibit symptoms of toxicosis in livestock their incidence is low in Europe. Such a situation is due to the following factors: (i) Commercial cultivars have no or low levels of endophyte, (ii) old permanent pastures are botanically diverse which may dilute endophyte toxins, (iii) in highly intensive production and indoor feeding systems, high energy supplements with relatively low contribution of grass in animal diet are used, and (iv) periods with high temperatures favorable for high level production of toxic alkaloids occur only occasionally.

The type and concentration of alkaloids found in plant-endophyte associations depend on many factors. The most important are: Species and genotype of grass and endophyte [97]. However, environmental conditions, plant age, or the endophyte colonization level may also affect alkaloid production to a large extent [128–131]. As an example, the content of ergovaline in plant-endophyte association is more influenced by environmental factors [110]. Variation in toxic alkaloids production may be considered as an opportunity for the best endophyte strains to be selected and commercialized. Low or no production of toxic alkaloids, high fresh matter yield, and high resistance to stress factors ensuring more sustainable production are desirable for European farmers in the context of the European Green Deal expectations. Endophyte strains producing alkaloids toxic to livestock (to some extent) and other protective chemicals in the host grass bear high potential for lawn turf, sports amenities, and landscape purposes. Such types of grass-endophyte associations may also be used for successful, persistent, and low-maintenance-demanding restoration of degraded ecosystems in Europe.

8. Symbiotically Modified Grasses

The research results of epichloid endophytes on grasses have practical applications in agriculture. The wide range of competitive advantages of their associations with grasses, as well as often exhibited tolerance to abiotic and biotic stresses, led to the selection of the best strains from nature. Such new endophytes are called "novel endophytes" and they are introduced into commercial grass cultivars. A key feature of the new association has to be marginal or zero production of alkaloids, which are toxic to grazing livestock. However, in turf-type associations it is not a primary criterion of endophyte selection. Thus, novel endophytes can be used to improve and develop cultivars beyond plant breeding and selection, and can additionally be incorporated into breeding programs. The efficient seed transmission of epichloid endophytes allows for the mass production of cultivars infected by particular endophytes. The symbiont can be inoculated into plants either into the breeding material or into the highly qualified seed material. Then, infected plants are propagated to obtain a sufficient amount of E+ seeds for farmers. Due to high specialization of the endophytes, there is no need for continuous application. The specificity of development allows the endophyte to reproduce within the host seeds. After sowing, it develops within the new plant. The need for continuous applications and the decrease in the effectiveness of the symbiotic association, compared to standard BCAs (Biological Control Agents), are overcome. Gundel at al. [132] proposed the term, symbiotically modified organisms (SMOs), for such not genetically but naturally made, grass-novel endophyte associations. However, the genetic compatibility of those elements of the association and the effect of specific environmental conditions determine the final beneficial outcome of the plant-symbiont association. The technology is still being developed and new novel endophytes are being adopted for the improvement of forage and turf grass cultivars. There are grass cultivars enhanced with endophytes that do not produce toxic alkaloids, and improve the productivity, persistence, pest resistance, and adaptation to marginal areas of important forage grasses (*L. perenne*, *L. arundinaceum*) [133]. In the case of sports and turf grasses, there are cultivars that have been improved with endophyte strains providing better persistence and resistance to pests and diseases [62,134]. These novel associations have mainly been operating on the market in the United States, New Zealand, and Australia (Table 1).

Table 1. Examples of commercially available grass cultivars containing novel endophytes.

Grass Cultivar	Novel Endophyte	Reference
"Estancia" [1], "Teton II" [1]	Ark Shield	[135]
"Jesup" [1]	MaxQ (AR542)	[136]
"Jesup" [1], "Lacefield" [1], "Texoma" [1]	MaxQ II (AR584)	[136]
"Shogun" [2]	NEA	[137]
"Bealey" [2], "Rohan" [2], "Trojan" [2], "Impact 2" [2], "Kidman" [2]	NEA2	[137,138]
"Maxsyn" [2], "Viscount" [2]	NEA4	[137,138]
"Tyson" [2], "Governor" [2]	AR1	[137]
"Base" [2], "Excess" [2], "Governor" [2], "Rely" [2], "Platform" [2], "Lush" [3]	AR37	[137,139]

[1] Tall fescue cultivar, [2] perennial ryegrass cultivar, [3] Italian ryegrass cultivar.

9. Conclusions

Droughts have been observed more often in recent years, which has greatly impacted the agricultural growth production [140]. Irregular rainfall distribution during the cropping season and climate change have played a part in disturbing the proper development of plants, resulting in lower yields and reduced income from the agricultural industry. The profitability can be further decreased due to the necessity of covering additional costs (e.g., mineral fertilization and watering) related to the need of plant regeneration. This may lead to an increase in environmental pollution and problems with water management. Moreover, the weakening of plants due to abiotic stress lowers the efficiency of the organism's natural defense mechanisms. This, in turn, increases the plant's susceptibility to numerous biotic stress factors and carries the need to apply synthetic pesticides. The solution to this problem is to use symbiotic microorganisms to support plants in difficult growth periods. The epichloid endophyte potential described above in the chapters of this article confirms this explicitly. The presence of novel endophytes guarantees (i) high persistence and improved growth of grass in environment, (ii) resistance to water shortages, (iii) higher tolerance to soil salinization, (iv) better use of nutrients, (v) higher resistance to attacks by pathogenic microorganisms, and (vi) lower susceptibility to damage caused by insects and nematodes. This, in turn, enables a producer to have more flexibility and comfort if the optimal conditions for plant growth are lacking. Using grass modified symbiotically with novel endophytes (i) increases yield even under conditions of irregular rainfall distribution and water shortage, (ii) increases the efficiency of water management thanks to the plant's association, (iii) allows for better use of environmental potential to provide higher yield, (iv) prevents soil environment degradation due to better persistence of the association and extended root system, (v) improves soil fertility, and (vi) reduces the input of fertilizers and pesticides. Therefore, this solution provides a more sustainable management and meets the offset by the European Green Deal, thus providing a very reasonable chance for a very good "deal" for fungal endophytes. However, despite the enormous potential of these endosymbionts, there are currently no registered endophyte-enhanced grass cultivars in Europe. There are several reasons as to why, the major one being the lack of clear standards for the intentional introduction of novel endophytes onto the market. It is also necessary to clearly define the standards for testing endophyte-enhanced grasses in the registration process in order to assess the traits that determine distinctness, uniformity, and stability (DSU) [141]. That is because the final expression of the association depends on environmental factors which may have an essential impact on the DSU. This suggests the need for decisive steps to be taken by the European regulatory agencies and testing bodies so that endophyte-enhanced grasses can soon appear on the European market. What should also be considered in the process is the support of breeders and seed producers who have a wealth of experience and expertise in this area [141].

This is also confirmed by that articulated above, rapidly growing demand for non-chemical, and environmentally friendly solutions. It is related to the process of reducing the use of plant protection products in the coming decade, arising from the principles of the European Green Deal. This imposes certain limitations on agricultural producers. Under such conditions, the opportunity for agriculture lies in applying existing cutting-edge science and support science to business (S2B) cooperation, so as to implement new innovative solutions, supporting sustainable agricultural production in line with the European Green Deal as soon as possible [142,143]. In order to support such activities, dedicated financial resources are allocated, both at the level of the European Union programs and individual member countries, which are also co-funded with EU funds [142]. This need was perfectly captured by Stella Kyriakides, the EU's Commissioner for Health and Food Safety—"We know that investment will be necessary to encourage innovation and create sustainable food systems. We have made €10 billion available for research and innovation, to support and accelerate this transition, to develop biological pesticides, natural resources as well as the use of digital and nature-based solutions for food production" [143]. In Poland, a very good example of such activities is Action M16 "Cooperation", managed by the

Agency for Restructuring and Modernisation of Agriculture (ARMA) and implemented under the Rural Development Program for 2014–2020. The aim of this action is "to support the creation and operation of task forces for innovations (EPI), as well as to support the running projects to develop and implement innovation" in the wide agricultural sector and in the sector of food production and distribution for sustainable development of rural areas and agricultural production. One of the projects that qualified for financing within the framework of this action is the project "Launching innovative variety of perennial ryegrass colonised by the symbiotic endophytic fungi". The activities within the project are carried out by the EPI consortium under the name NOVA TRAWA, led by UTP University of Science and Technology in Bydgoszcz. Apart from the university, the consortium includes: The Plant Breeding Company Grunwald Ltd., Group IHAR based in Bartążek, the Plant Breeding and Acclimatization Institute—National Research Institute in Radzików, the Kuyavian–Pomeranian Agricultural Advisory Centre in Minikowo, and an individual agricultural producer. The expected result of the project is product, technological, and marketing innovation for sustainable agriculture. The cooperation within the above-mentioned section proves the fact that scientists based at universities and research institutes acknowledge the problems and challenges facing modern agriculture, as well as the need to promptly transfer knowledge and technology into practice. The involvement of both the Plant Breeding Company Grunwald, an innovative producer using the latest techniques in growing grass seeds, and an advisory institution ensures the sustainable development of Polish (and in the long term also European) agriculture. Due to the combined efforts of scientists, businesses, and farm advisory bodies, the transfer of innovative solutions that are tailored to meet the needs of agricultural producers is achieved quickly and effectively. A key advantage of this type of consortia is their ability to operate promptly, using their combined expertise in agriculture. The described example allows us look optimistically forward to the next decade, which, in view of the aims of the European Green Deal, will bring an important transformation for EU agriculture.

Author Contributions: Conceptualization, D.P., M.J., A.Ł. and P.P.; methodology, D.P.; validation, D.P.; formal analysis, D.P.; data curation, D.P. and J.d.D.M.; writing—original draft preparation, D.P.; writing—review and editing, D.P., M.J., A.Ł., K.S. and J.d.D.M.; visualization, D.P.; supervision, D.P.; project administration, D.P.; funding acquisition, K.S. and P.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data sharing not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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