

Review of the main diseases of *Centaurea cyanus* and *Echinacea purpurea* when grown in the organic farming system

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ABSTRACT

The aim of the study was to identify patterns and intensity of crop infection and to assess the influence of climatic and soil conditions under organic farming on the resistance of cornflower (*Centaurea cyanus*) and purple coneflower (*Echinacea purpurea*) to pathogens in leading producer countries. The study utilized comparative and structural analysis to evaluate pathogens, their optimal spread conditions, and organic management strategies. Agro-climatic factors significantly dictate the disease spectrum and severity. Powdery mildew and rust dominate moderately humid European regions, causing up to 20% yield reductions and decreasing essential oil and flavonoid contents. Root and white rots cause 20-25% yield losses under excessive moisture in North America. In Ukraine, *Alternaria* and *Fusarium* reduce yields by 15-25% and lower biologically active substances. In Southern Europe, leaf spots and bacterial blights reduce yields by 10-18%. Furthermore, nitrogen and potassium deficiencies intensify disease severity and diminish the pharmacological value of both crops. Optimised nutrient management, crop rotation, and mulching are essential to mitigate region-specific phytosanitary risks and stabilise organic medicinal crop productivity.

Keywords: Medicinal herbs, organic farming, plant diseases, soil fertility, yield loss.

INTRODUCTION

The absence of synthetic fungicides increases the importance of biological protection and agronomic practices. Cornflower (*Centaurea cyanus* L.) and echinacea (*Echinacea* spp.) are economically and pharmacologically significant medicinal crops, whose productivity under organic conditions depends largely on pathogen pressure, particularly under climatic fluctuations that favour disease development. Major diseases such as powdery mildew, rust, leaf spot, bacterial blight, and soil rots reduce yields and the content of biologically active compounds (Kuts *et al.*, 2025;

Havryliuk *et al.*, 2024). Limited control options in organic systems, combined with insufficient data on regional pathogen distribution, hinder the development of adapted cultivation technologies. Therefore, a systematic study of disease aetiology, development factors, and their impact on crop bioproductivity under organic conditions is required.

In previous studies, the links between the development of major cornflower and echinacea diseases and nutrient elements in organic systems, the role of natural entomophages, changes in bioactive substances under infection influence, the

impact of flower strips on disease incidence, the preservation of pharmacological raw material quality, and long-term variety resilience were insufficiently studied. The aim of the research was to determine the features of distribution and harmfulness of the main diseases of cornflower and echinacea in the organic farming system, considering nutrition, bioactive substances, and raw material quality.

Comparative analysis, structural analysis, and classification feature grouping were used for systematisation. Pathogens, biological development, optimal spread circumstances, and organic farming management strategies were evaluated. The National Centers for Environmental Information (2025) global climatic archives included cultivation region average annual temperature, precipitation, relative humidity (RH), and frost-free days. This enabled the study of climate and disease intensity. Official Food and Agriculture Organisation statistical compilations (2024) provided phytopathological factor effects on medicinal raw material production and quality. Quality was assessed by measuring flavonoids, essential oils, polysaccharides, and other physiologically active compounds in the lab (Jain *et al.*, 2024).

Influence of climatic and soil conditions on crop health

Organic cultivation of cornflower (*Centaurea cyanus*) and purple coneflower (*Echinacea purpurea*) relies on cereal-legume rotations, mulching, inter-row loosening, composting, and green manures to regulate soil nitrogen, suppress weeds, and reduce phytosanitary pressure. Optimal production occurs in moderately continental climates with mean annual temperatures of 7-11°C and precipitation of 450-700 mm, on light loamy, chernozem, or dark-grey forest soils with neutral to slightly alkaline pH ($\approx 6.5-7.5$) and sufficient humus content. The soils in the examined regions are typically agriculturally suitable. However, fertility metrics, physical structure, and moisture-

related variables vary. For example, chernozems and dark grey forest soils in Ukraine possess Corg of 1.8-2.4%, P_2O_5 of 55-70 mg/kg, a 30-35 cm arable layer depth, 25-28 cmol(+)/kg cation exchange capacity, and 28-32% vol field capacity, which causes vigorous growth and high phenolic and essential oil content in raw materials. In contrast, light to medium loams with 1.2-1.8% organic carbon dominate German agricultural soils, where high phosphorus levels (45-60 mg/kg), a 25-30 cm arable layer, and water permeability of 20-25 mm/hour indicate balanced nutrient retention and good penetration.

While cornflower and echinacea cultivation demonstrate broadly consistent agroecological patterns across temperate regions, long-term climatic differentiation among producing regions explains variations in productivity, disease prevalence, and management intensity. To ensure stable yields and high-quality medicinal raw materials, region-specific practical implementations of organic technologies are required (Mukhametov *et al.*, 2022). In Southern Europe, regions facing significant moisture deficits and high temperatures rely on active water management as the primary organic intervention (Aliyeva *et al.*, 2024; Huseynli *et al.*, 2024). Summer irrigation is necessary for chernozems in Bulgaria, which have poor moisture reserves, and likewise in southern France, where plants grown on chestnut soils with high water permeability experience severe stress without supplemental summer irrigation. Ultimately, combining these suitable climatic and soil conditions with targeted organic technologies, such as irrigation in Southern Europe, mulching in North America, and biofungicides in humid Central European zones, ensures stable yields, high-quality medicinal raw materials, reduced phytosanitary risks, and improved agroecosystem resilience.

Pathogen distribution and intensity by region

Agro-climatic and geographic factors affected the medicinal crop disease spectrum and severity, where powdery mildew and rust ruled moderate climates with enough moisture; leaf spots and bacterial infections dominated high temperatures and moisture deficits; and root and white rots dominated excessive wetness. Cornflower (*Centaurea cyanus L.*) and echinacea (*Echinacea spp.*) phytosanitary conditions vary significantly due to these factors.

In Germany, Poland, and the Czech Republic, cultivation predominantly occurs on light and medium loams, where higher humidity makes powdery mildew and rusts the main diseases. Germany's humid climate and average air temperature of 18-22°C made powdery mildew (*Erysiphe cichoracearum*) and rust the main diseases of both crops, as light and medium loams above 70% RH enhanced pathogen development. With optimal development around 18-22°C and RH above 70%, *Erysiphe cichoracearum*-caused powdery mildew affects both crops in Germany routinely, largely reducing leaf photosynthetic area (Sukhina and Novytska, 2025; Shuvar and Korpita, 2023). Pathogens thrive around 18-22°C and 65-80% RH (Devi and Kumar, 2024). Similarly, most Polish cornflower and echinacea have powdery mildew and rust, where heat and humidity following summer rains promoted rust growth in cornflower budding at optimal developments around 20-26°C and 70-85% humidity. Powdery mildew grows in Poland lowering raw material ornamental quality, while under comparable warm and wet conditions, *Puccinia spp.* rust infections cause early leaf senescence and productivity loss. Powdery mildew and rust also afflicted both crops in Czechia, spreading best at 19-24°C and 70-85% humidity, but summer wetness specifically exacerbated rust, diminishing leaf assimilating surface and yield. In warmer and more humid environments, mulching and biological agents, including *Trichoderma harzianum*, effectively reduce pathogen pressure and support yields up to

2.2 t/ha, whereas in cooler or more stress-prone regions, reliance on mechanical weed control and green manures results in lower yields (up to 1.4 t/ha less).

Regional differences are common in Ukraine, where *Alternaria alternata* affected echinacea and cornflower most in the Forest-Steppe at 20-27°C and RH over 60%, causing cornflower leaf necrosis. Conversely, *Fusarium* root rot (*Fusarium spp.*) impacted both crops more in the Steppe during drought and temperatures above 28°C (specifically exceeding 26°C and soil moisture above 70%), reducing production. Notably, the highest productivity of purple coneflower is recorded in the Forest-Steppe and northern Steppe zones on soils with a humus content of 3-4.5%. In a comparison between conventional 'control technology' and organic farming variants, viral disease incidence reached 15-40% in the control group, whereas the organic variant showed no symptoms and yielded negative ELISA results. Marked differences in soil organic matter content (humus 5.7% vs. 2.6%) align with the hypothesis that soil condition and nutrition strongly influence the susceptibility and epidemiology of viral diseases, alongside other agroecosystem factors like vectors and reservoirs (Mishchenko et al., 2018).

Echinacea root rots from *Rhizoctonia solani* and *Pythium spp.* are common in Kansas and Nebraska, damaging crops in heavy soils under significant rainfall at 18-24°C. High soil wetness and inadequate drainage in Canada similarly cause these root rots, lowering echinacea stand density. After significant rainfall at 15-20°C with humidity above 85%, white mould (*Sclerotinia sclerotiorum*) damaged both crops, destroying plants and decreasing crop output in cool, humid conditions (National Centers for Environmental Information, 2025).

Hot summers (25-30°C) with high humidity and morning dew cause premature leaf dieback in Bulgaria due to *Cercospora* and *Phoma* leaf spot diseases. *Pseudomonas*

syringae caused bacterial blights above 28°C and with humidity changes, leading plants to lose biomass and leaves. Finally, 24-29°C, 70-85% RH, and frequent dew formation enhance *Cercospora* and *Phoma* leaf spot infections in southern France, reducing raw-material quality, while severe humidity swings spread bacterial blights that damage leaves and decrease output.

Disease harmfulness: Impact on yield and raw material quality

The statistics show that medical crop diseases reduce raw material productivity and quality in most nations, with the USA and Ukraine (Steppe) experiencing the highest yield losses (25%) and Bulgaria the lowest (14%). In Germany, powdery mildew and rust infection of cornflower (12-18% of leaf area, depending on vegetative phase) reduced output by 15% and quality indices, especially essential oil content, by 12%. In Poland, rust infection of cornflower (*Centaurea cyanus*) at the budding stage sometimes caused total cornflower yield losses of 10-15%, worsening production economic efficiency, while also reducing flavonoid content by 12% (Baran, 2025). In Czechia, extreme moisture intensified rust damage in cornflower, reducing cornflower yield by 15% and flower petal colouration by 8% (Food and Agriculture Organisation, 2024).

Foliar infections significantly affected biosynthetic activity in moderately humid circumstances. *Alternaria* infection of echinacea in Ukraine (Forest-Steppe) reduced yield by 15% and phenolic content by 10%. For *Alternaria* leaf spots in Echinacea (*Alternaria rudbeckia*), long-term observations show that spread ranged from 44-80%, while severity varied from 12-53% across years, though the application of biological preparations effectively reduced these figures to approximately 18-33% and 5-18%, respectively. These parameters serve as an external baseline for interpreting incidence and severity values, helping determine whether the observed disease

pressure is “low”, “moderate” or “high” within organically compatible systems (Shvydchenko and Gentosh, 2023). Conversely, soil infections, moisture shortage, and high temperatures enhance plant death risk. *Fusarium* root rot in Ukraine (Steppe) reduced yields by 25% and biologically active compounds by 12%.

Root rots (*Rhizoctonia solani*, *Pythium spp.*) and white rot reduced *Echinacea purpurea* yield by 25% and glycoside content by 15% in the US (Shahini *et al.*, 2023; Zhao *et al.*, 2025). In Canada, white rot reduced *Echinacea purpurea* yield by 20% and the content of biologically active compounds in Echinacea roots by 10% in wet years (Jain *et al.*, 2024). In France, similar diseases reduced cornflower (*Centaurea cyanus*) floral raw-material yield by 15% and the content of biologically active compounds by 9%. Such findings showed that even minor yield losses can significantly reduce the final product's pharmacological potency.

The role of mineral nutrition and organic management

Mineral nutrition is a key modifier of host susceptibility and pathogen development (Dordas, 2008; Tripathi *et al.*, 2022). Nitrogen (N) supply can differentially affect diseases depending on pathogen lifestyle: excess N often favours obligate biotrophic foliar pathogens such as powdery mildews and rusts by increasing crop vigour and the proportion of young susceptible tissues, whereas N deficiency reduces plant vigour and defence capacity and may aggravate yield losses caused by foliar necrotrophs and root pathogens (Eurostat, 2025). Potassium (K) is central to osmotic regulation, stomatal function, and activation of many enzymes. K deficiency is widely associated with higher incidence and severity of diseases, and adequate K frequently mitigates disease development by strengthening tissues and supporting defence metabolism (Wang *et al.*, 2013; Tripathi *et al.*, 2022).

For cornflower (*Centaurea cyanus L.*), the key foliar diseases in temperate humid regions are powdery mildew (*Erysiphe/Golovinomyces cichoracearum*) and cornflower rust (*Puccinia cyani*) (O'Neill et al., 2003; PNW Handbooks, 2025). Given the biotrophic lifestyle of these pathogens, nutrient management that avoids excessive, rapidly available N while maintaining adequate K and a balanced N:K ratio is especially important under organic production (Dordas, 2008). Gradual N supply via organic amendments (e.g., composts and green manures) combined with regular soil and tissue diagnostics can reduce predisposition. Evidence from other host-powdery mildew systems shows that foliar potassium salts can suppress powdery mildew by reducing spore germination (Kettlewell et al., 2000), illustrating a plausible mechanism by which adequate K may contribute to lower mildew pressure.

For purple coneflower (*Echinacea purpurea (L.) Moench*), foliar diseases include *Alternaria* leaf spot (*Alternaria alternata*) and powdery mildew (Garibaldi et al., 2018), whereas soil-borne pathogens (e.g., *Fusarium spp.*) cause root and crown rots that reduce stand density (PNW Handbooks, 2025). Nutrient sufficiency is essential for compensatory growth and for the accumulation of caffeic acid derivatives, phenolics and flavonoids in rhizomes/roots, and nitrogen supply has been shown to increase both growth and phytochemical quality traits in *E. purpurea* (Ahmadi et al., 2020). Therefore, disease management should integrate soil fertility building practices with balanced N and K nutrition rather than relying on national mineral fertiliser consumption statistics.

In the Ukrainian Forest-Steppe, *Echinacea purpurea* yield fell by 14% and *Echinacea* raw-frial quality by 10%, with nitrogen and potassium deficits intensifying *Alternaria* damage and reducing biomass and phenolic content. In the Steppe, losses reached 19% in yield and 12% in quality, while *Fusarium* eliminated up to one-third of

plants under arid, low-fertility conditions. Comparable declines were recorded in *Echinacea purpurea* in the USA (21% yield loss) and Canada (15%), and in cornflower in Bulgaria (12%) and France (11%), where macroelement deficiencies increased fungal pressure (Kazakova et al., 2024; Krychkovska et al., 2025). Nitrogen and potassium shortages lowered the content of bioactive compounds in cornflower inflorescences and *Echinacea purpurea* roots, thereby reducing the pharmacological value of both crops. Optimised nutrient management, along with mulching and crop rotation, mitigated disease, stabilised soils, and improved productivity under region-specific climatic conditions (Jakhwal et al., 2025; Dimitrov et al., 2024).

CONCLUSION

The study identified region-specific phytosanitary patterns of cornflower and echinacea under organic farming and quantified pathogen-induced yield and quality losses. In moderately humid European countries (Germany, Poland, Czechia), powdery mildew (*Erysiphe cichoracearum*) and rust (*Puccinia spp.*) were predominant. In Germany, infection by powdery mildew and rust affected 12-18% of the leaf area, which caused a 15% reduction in yield and decreased essential oil content by 12%. In Poland, the intensive development of rust at the budding stage led to a 20% reduction in yield and a 12% decrease in flavonoid content. In Czechia, excessive summer humidity intensified rust development, resulting in a 15% yield decline and an 8% reduction in petal colour intensity. In North America (USA, Canada), root rots (*Rhizoctonia solani*, *Pythium spp.*) and white rot (*Sclerotinia sclerotiorum*) caused 20-25% yield losses under excessive soil moisture. In Ukraine, *Alternaria* blight in the Forest-Steppe reduced yield by 15% and phenolic content by 10%, whereas *Fusarium* root rot in the Steppe led to losses of up to 25% and a 12% decrease in biologically active substances. In southern Europe

(Bulgaria, France), leaf spots and bacterial blights resulted in 10-18% yield reductions.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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