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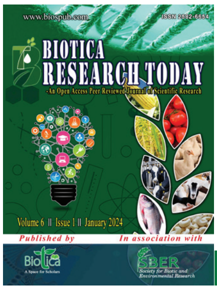

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Impact of Climate Change on Weed Flora Shift

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Abstract

Over the past few decades, climate change has spurred significant changes in the weed flora within the arable biosphere of India. This impact is not direct but rather indirect, as climate change compels adaptations in agronomic practices. For successful strategies in weed control while maximizing crop yield, it is crucial to possess a comprehensive understanding of these transformative processes. Growing concerns revolve around the potential impacts of global CO_2 enrichment in weeds and crop yields. Due to the impacts of climate change, there is a probable alteration in life cycles, phenology and infestation pressure. Certain weed species may be at risk of extinction, whereas others might exhibit increased aggressiveness as invaders. Comprehensive studies are of vital importance to assess the collective interactive effects of climate change factors. Such research will aid in predicting how weed-related challenges may evolve within the context of a changing climate scenario.

Keywords: Climate change, Crop-Weed competition, Weed flora, Weed shift

Introduction

Change in weather patterns involve prolonged alterations in weather patterns and temperatures which might results from common causes like fluctuations in solar activity or remarkable volcanic eruptions. Since 1800s, human activities develop into predominant catalyst for the change, primarily by the combustion of fuels like coal, gas, *etc*. leading to emission of various gases. Among these greenhouse gases carbon dioxide, methane and nitrous oxide are the primary culprits. Additionally, land clearance and deforestation contribute to carbon dioxide release, while agriculture and gas operations are prime sources of gaseous emissions. The factors accountable for release these gases include energy, deforestation, transportation, powering buildings, agriculture and manufacturing. When weed management practices fail to control an entire community of weed or population, weed shifts occur. Over recent decades, climate change has significantly impacted both natural and human ecosystems. The atmospheric concentration of CO_2 has surged from around 280 parts ppm in the pre-industrial era to about 390 ppm today. Projections indicate that if current emission trends persist, these levels could escalate to 600-700 ppm by the end of the 21st century (IPCC, 2000). Therefore, it is crucial to explore the competition between crops and weeds to formulate efficient weed management strategies tailored to emerging species within the changing climate landscape.

Climate Change and Weeds

Climate change has the capability to induce alterations of weed inhabitants and the biological phenomenon. Weed species extend their geographical radius spreading to new domain. Within a changing climate, invasive species could pose an increased threat due to their robust action to raised CO_2 levels compared to indigenous species. Weed species may also alter human wellness, exhibiting positive responses to changing climate conditions, particularly elevated CO_2 concentrations. This response may involve the production of higher plant biomass, increased pollen, or the synthesis of more potent poisonous compounds, leading to allergic reactions and internal poisoning. There is a need to formulate flexible integrated management practices on a solid foundation of knowledge regarding the biology and ecology of weeds. Fluctuations in atmospheric CO_2 levels, precipitation patterns, temperature and other key growing conditions have the potential to shape the distribution of weed species and impact their competitiveness within both weed populations and crops. Temperature variations may lead to shifts of existing plants which allow new plants (weeds) to replace native species, expanding into

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previously unoccupied areas. The dominant weed species may change with shifts in climate, with C_3 weeds prevailing under elevated CO_2 conditions and C_4 weeds may dominate under both elevated CO_2 and temperature. Understanding these dynamics is crucial for anticipating and addressing weed-related challenges within the settings of a changing weather conditions.

Invasiveness of Weeds and Climate Change

Under the influence of climate change, the outbreak of invasive weeds is expected to pose an increased risk. Certain species are projected to be 'winners' in the changing climate, while 'sleeper weeds' may expand their range and new exotic species may emerge. Historical events, such as floods in 1974 and 1988, brought an invasive weed, Athel pine (*Tamarix aphyla*), from Asia and Africa, displacing the riverbed germ (*Eucalyptus canaldulensis*) along 600 km of the Finke River. Disasters such as floods, cyclones, droughts and fires, are likely to expand the invasiveness of specific weeds. The rising levels of CO_2 are expected to alter the lifecycle of weeds by two basic ways: through climate instability and direct stimulation of plant growth. Cheat grass (*Bromus tectorum*), native to Central Asia, accidentally introduced into the Western United States in 1980, has overrun 100 million acres of western rangeland since then. Studies suggest that cheat grass's above-ground biomass increased 1.5-2.7 g plant^{-1} during 25-87 days after sowing. Elevated CO_2 levels may significantly contribute to cheat grass productivity and fuel load, subsequently affecting fire frequency and intensity. Research indicates that variations in temperature and CO_2 levels have a stimulating impact on the invasiveness of weed species which have indirect effects on their growth, biology, phenology, reproductive ability and colonizing capacity, regardless of whether these species have C_4 or C_3 photosynthetic pathways. Understanding these aspects is crucial for proper management of invasive weeds in the context of climate change scenario.

Crop-Weed Competition and Climatic Change

The distinct response of C_3 and C_4 plants to rising CO_2 levels is particularly pertinent for crop-weed competition in agro-ecosystems. Nevertheless, there is a scarcity of literature addressing competition outcomes between C_3 crops and C_4 weeds, or vice versa. The limited availability of research on this specific interaction underscores the importance of further investigations to fill these knowledge gaps. Generally, elevated CO_2 levels are expected to activate the growth of major crops worldwide, with a similar effect to expand the growth of both C_3 and C_4 weeds which could potentially lead to heightened crop competition, offsetting "fertilization" on C_3 crops. Scientific studies have assessed the competition outcomes between 'Round-up Ready' Soybean (*Glycine max* L.) and two weed species: a C_3 weed, lambsquarters (*Chenopodium album* L.) and a C_4 weed, redroot pigweed (*Amaranthus retroflexus*). These experiments were conducted under both ambient and enhanced CO_2 conditions (ambient + 250 µL L^{-1}). In a weed-free environment, the findings revealed that elevated CO_2 contributed to heightened soybean growth and increased yield when compared to conditions with ambient CO_2 levels. After all, both weed species significantly reduced soybean growth and yield under both CO_2 levels. Studies by Ziska *et al*. (1999) reported that rising atmospheric CO_2 concentrations notably lower the efficiency of Glyphosate. Variations in rainfall patterns and increased aridity consistent with a warming climate could also impact weed distribution and their effects on crop production and productivity. Anticipating future rainfall trends proves challenging, with expectations leaning towards increased unpredictability. More erratic rainfall patterns are on the horizon, leading to recurrent phenomena such as droughts and floods. The distribution and prevalence of weeds in crop ecosystems, particularly during summer drought rise to significant challenges for effective weed management. Prolonged drought spells may benefit C_4 weeds over C_3 weeds at the same time erratic rainfall patterns may favour hydromorphic weeds. Adapting weed management strategies to account for these climate-induced shifts is crucial for sustainable agriculture.

Shift in Weed Abundance and Distribution

The dynamic changes in climate variables may contribute to an expansion in the distribution range of weed species, driven by shifts in atmospheric temperature. Simultaneously, these changes may create conditions that favour certain non-patent weeds, leading to their increased dominance in weed abundance. The interactions between crops and weeds are expected to increasingly favour C_3 weeds. The anticipated impacts of climate change extend beyond weed dynamics, affecting the distribution, operation and productiveness of entire habitat. Notably, the elevated ampleness of woody shrubs due to higher volume of CO_2 is linked to higher mortality and diminished tree regeneration in forests globally. Moreover, the widespread presence of parasitic weeds represents a considerable menace to the yield of rice and sorghum crops in rainfed agriculture. Apart from agronomic weeds, the introduction of specific non-native weed species to new regions can give rise to ecological and environmental risks. Understanding the complex interplay between climate change and weed behaviour is crucial for developing sustainable agricultural practices.

Weed Species Shift

Climate change in agro-ecosystems leads to a noteworthy shift in weed species, influencing both weed management strategies and overall agricultural productivity. Confronted with anticipated climate change scenarios, plant species must either adapt in situ to the altering conditions or undergo distribution shifts toward more favourable environments. Within an arable ecosystem featuring a mixed stand of weeds and crops, the dynamics of weed populations are anticipated to gradually favour specific species over time (Das *et al.*, 2012). Peters *et al.* (2014) highlighted that climate change can manifest in three distinct types of shifts occurring at different scales. They are range shifts at the landscape scale, niche shifts at the community scale and trait shifts of individual species at the population scale.

Weed Management

The success of weed management operations, especially in the face of emerging water crises, is anticipated to be influenced indirectly by the impacts of climate change. This challenge is notably recognized in irrigated rice, where looming water scarcity has become a pressing issue. In response, aerobic rice systems have been proposed as potential water-efficient production systems. However, the sustainability of these systems is threatened by high weed infestation, leading to up to 90% yield reduction. Within rainfed rice systems, fluctuations in rainfall patterns, like insufficient early-season precipitation, could prompt farmers to modify their land preparation and planting schedules. These modifications may affect the synchronization of rice growth stages with the emergence and vigorous growth phases of problematic weeds. Alterations in the physical environment, such as drought spells or extended rainy seasons, could impose constraints on field conditions required for herbicide implementation. These circumstances can have diverse implications for different facets of chemical weed management, encompassing aspects like the timing of application, spray drift, herbicide persistence in the environment, herbicide metabolism and overall effectiveness. Addressing these challenges requires a holistic approach to ensure sustainable and productive agriculture in the face of evolving climatic conditions.

Adapting Mechanisms to Climatic Change

The influence of climate change and global warming on both crops as well as weeds is apparent and within the competitive field environment, the species that emerge as overall winners are likely to be those with superior adaptations and broad ecological amplitudes characteristics that facilitate colonization. Building latest networks and strengthening the capacity for timely detection with prompt response techniques will be integral components of an effective strategy. Enhanced information gathering is imperative, necessitating localized and regional surveys to evaluate the diffusion and abundance of promising invaders. Disseminating these facts among nations and implementing bolstered barrier measures, including rigorous quarantine procedures, will act as a crucial role for preventing the spread of invasive species. Adopting an ideal standard in weed management is crucial, with a perspective that emphasizes doing existing practices better, recognizing that the stakes are now much higher and collaborative approach is imperative to safeguard agricultural ecosystems against the adverse effects of global heating and alien breeds.

Weed Management Principles to Reduce Weed Shifts

Effective weed management practices hinge on the accurate identification of weed species, which serves multiple purposes. Firstly, it allows for the assessment of the competitiveness of the weeds present in a given area. Understanding the specific characteristics and behaviour of different weed species is crucial in devising targeted and efficient control strategies. Secondly, proper identification is essential when selecting the appropriate herbicide, if chemical control is deemed necessary. Identification process is particularly significant when dealing with young seedlings. Early detection and control of weed seedlings are more manageable and effective, helping to prevent the establishment and spread of undesirable plants. Recognizing and addressing weeds at the seedling stage can significantly contribute to the overall success of weed management efforts.

1. Frequent monitoring for escapes;
2. Herbicide rate and timing;
3. Crop rotation;
4. Agronomic practices;
5. Rotation of herbicides.

Conclusion

Shifts in arable ecosystems due to climate change represent a significant outcome and research is crucial to understand the potential impacts and adaptive strategies. The concept of "CO_2 fertilization" concept, wherein elevated carbon dioxide levels contribute to enhanced plant growth, requires thorough scrutiny to ascertain its potential effectiveness in counteracting adverse impacts of climate change on the competition between crops and weeds. This involves investigating how elevated CO_2 levels may influence the dynamics in changing environmental conditions between crops and weeds. Initiatives are essential to investigate adaptive techniques that can support crop production in response to evolving climatic exceptions. It is crucial to formulate strategies aimed at bolstering the resilience of crops to climate change, as this plays a vital role in securing global food supplies. Moreover, studying the diverse association of plant-weed carbon fixation cycle is complex which involves examining the interactions between C_3 and C_4 crops. These pathways have different photosynthetic mechanisms and understanding their responses to climate change is vital for predicting competitive interactions in arable ecosystems. With the unfolding of climate change, numerous weeds are expected to intensify pressure on crop-weed competition. Considering this, comprehensive research endeavours become imperative to inform agricultural practices and policies, offering insights that can effectively mitigate the influence of climate change on arable ecosystems.

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