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Alternate cotton-peanut intercropping: a new approach to increasing productivity and minimizing environmental impact

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Abstract

Recent publications have highlighted the development of an alternate cotton-peanut intercropping as a novel strategy to enhance agricultural productivity. In this article, we provide an overview of the progress made in the alternate cotton-peanut intercropping, specifically focusing on its yield benefits, environmental impacts, and the underlying mechanisms. In addition, we advocate for future investigations into the selection or development of appropriate crop varieties and agricultural equipment, pest management options, and the mechanisms of root-canopy interactions. This review is intended to provide a valuable reference for understanding and adopting an alternate intercropping system for sustainable cotton production.

Keywords Cotton, Peanut, Alternate intercropping, Productivity

Introduction

Intercropping, the simultaneous planting of at least two crops during the same period or season, and rotation, the alternating planting of different crops on the same field, has become crucial agricultural practices due to urbanization and changes in the planting industry. The escalating competition for land between cotton and oil crops has become increasingly intense, prompting the need for effective strategies to alleviate this conflict and enhance farmland productivity (Chi et al., 2021). One such strategy is the use of intercropping, with cotton-peanut intercropping serving as a significant method to achieve a double harvest of cotton and peanut within the same season (Xie et al., 2022). However, traditional intercropping practices still pose obstacles to continuous cropping, thereby limiting the realization of full yield and benefit of intercropping. To address this issue, recent developments have led to the emergence of a new intercropping pattern, known as the alternate intercropping of cotton-peanut, which integrates traditional intercropping and rotation of cotton and peanut (Chi et al., 2019; 2021; 2023). This innovative approach, characterized by wide strip intercropping with annual switching of planting positions on the same land, combines the advantages of both intercropping and rotation, resulting in a higher productivity than the monoculture and traditional intercropping. In this context, the alternate intercropping has garnered attention as a promising method to enhance agricultural productivity and to address the land competition challenges between cotton and oil crops.

Increased productivity through alternate intercropping

The measurement of productivity is the primary and essential metric for evaluating the effectiveness of crop intercropping and rotation patterns in agriculture (Lv

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et al., 2023). According to Xie et al. (2022), the traditional intercropping of cotton-peanut was observed to slightly decrease peanut pod yield but substantially increase seed cotton yield, thereby enhancing overall economic returns when compared with monoculture systems of peanut and cotton. Building on this observation, Chi et al. (2019) reported that the traditional intercropping increased seed cotton yield by 16.9% but decreased peanut yield by 5.6%. The alternate cotton-peanut intercropping is a new approach to increase productivity due to its higher productivity improvements than the traditional intercropping. Thus, the alternate cotton-peanut intercropping has emerged as a novel approach with the potential to significantly increase productivity compared with traditional intercropping methods (Chi et al., 2023). In a comparative analysis, Chi et al. (2023) found that the alternate intercropping resulted in a 3.9% increase in seed cotton yield, a 6.7% increase in peanut pod yield, and an overall productivity improvement of 10.6% when compared with traditional intercropping practices. These findings underscore the potential of the alternate intercropping to enhance agricultural productivity and warrant further exploration and adoption in agricultural systems.

Physiological attributes of the increased productivity

Alternate intercropping increased the uptake of nitrogen, phosphorus, and potassium in peanut by 6.3%, 11.5%, and 7.3%, respectively, compared with the traditional intercropping. It also increased the net photosynthetic rate, chlorophyll content, and maximum leaf area index of peanut by 7.2%, 8.9%, and 4.4%, respectively, relative to the traditional intercropping (Chi et al., 2019). The advantage of the alternate intercropping over the traditional intercropping in terms of peanut yield is likely attributed to the enhanced nutrient uptake and the alleviation of continuous cropping constraints (Xie et al., 2022). Further evidence from Chi et al. (2023) suggests that the alternate intercropping increased canopy photosynthesis and photoassimilate partitioning to reproductive organs, thus contributing to the increased cotton yield observed in the alternate intercropping system.

In addition to the direct physiological effects, the microbial community in the rhizosphere also plays a crucial role. Xie et al. (2022) observed that intercropping dramatically altered the soil bacterial abundance and composition in both peanut and cotton strips of the topsoil, whereas the bacterial diversity was barely affected compared with peanut and cotton monoculture. Plant growth-promoting rhizobacteria (PGPR) was found to be more abundant in the alternate intercropping, which is vital for enhancing nutrient uptake and canopy photosynthesis, as highlighted by Chi et al. (2023). These findings underscore the multifaceted impact of the alternate intercropping on plant physiological attributes and associated microbial communities, thereby contributing to increased productivity and the development of sustainable crop production systems.

Possible minimization of environmental impact

The potential for minimizing environmental impact in agricultural ecosystems lies in the enhancement of soil carbon storage, which has significant implications for sustainable development goals such as food security and climate change resilience (Rumpel et al., 2020). Carbon sequestration in agricultural soil, which involves the storage of atmospheric carbon (CO_2), depends on various factors such as climatic conditions, cropping systems, and nutrient inputs (Qasim et al., 2020; Gross et al., 2021). Notably, studies have demonstrated that intercropping systems, particularly the alternate intercropping of cotton-peanut, have led to increased carbon accumulation compared with sole cropping systems, while also resulting in higher yields for both cotton and peanut, as well as overall productivity. This is attributed to enhanced nutrient uptake facilitated by altered rhizosphere bacteria and increased canopy production (Chi et al., 2023). Furthermore, peanut possesses the unique trait of nitrogen fixation, leading to a rise in soil nitrogen content during harvest (Chi et al., 2019). This suggests that using peanut as an intercrop with cotton may allow for a reduction in the amount of nitrogen fertilizer needed for cotton planting in the following season. Ultimately, the alternate intercropping of cotton-peanut has the potential to enhance nitrogen sequestration and decrease greenhouse gas emissions.

Summary and future prospects

The new alternate intercropping system not only allows farmers to harvest two crops in a year, but also increases economic returns through enhanced crop productivity relative to the traditional intercropping. In particular, the crop output value under the alternate intercropping was higher than that under the traditional intercropping, while the input value remained the same, resulting in a 10% higher net return under the alternate intercropping system. This substantial increase in net return is attributed to the considerable growth in crop productivity without the need for additional inputs. Based on these findings and conclusions, the new alternate intercropping system shows promise as an alternative cropping method in cotton and peanut planting areas.

Future research should focus on several key aspects.

Firstly, the development of compatible crop varieties and mechanized equipment is vital for further enhancing crop yield and reducing labor costs. This involves

screening cotton and peanut varieties that are well-suited for alternate intercropping patterns, as well as identifying agricultural machinery that aligns effectively with agronomic practices.

Secondly, the impact of the new alternate intercropping patterns on the microenvironment and the occurrence of pests and diseases warrant thorough investigation. These include studying alternate intercropping patterns for cotton that can effectively control pests and diseases, thereby reducing the pesticide applications.

Thirdly, further investigation of carbon sequestration and greenhouse gas emissions are needed. Future research should prioritize long-term field experiments aimed at evaluating the impact of the alternate intercropping on carbon sequestration and greenhouse gas emissions. This thorough examination is essential for gaining valuable insights into the potential environmental benefits of these agricultural practices. These findings highlight the capacity of such practices to improve carbon sequestration and crop productivity on less arable land, while concurrently mitigating greenhouse gas emissions.

Finally, exploration of underlying mechanisms is critical. Previous studies have revealed that the alternate intercropping leads to an increase in the relative abundance of PGPR, with significant correlations observed between canopy photosynthesis and biological yield, ^{13}C partitioning, and harvest index, as well as the relative abundance of PGPR and uptake of major nutrients (Chi et al., 2023). The elevated crop productivity observed in the alternate cotton-peanut intercropping is possibly linked to the heightened canopy photosynthesis, and nutrient uptake associated with shifts in rhizosphere bacterial communities. Therefore, future research efforts should center on investigating the root-canopy interaction of alternate crops and delving into the role of rhizosphere bacteria in shoot–root interactions.

In conclusion, the alternate cotton-peanut intercropping represents a novel approach to bolster agricultural productivity. Future research focusing on root-canopy interaction of alternate crops and the involvement of rhizosphere bacteria in shoot–root interactions would improve our understanding of how alternate intercropping enhances system productivity.

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References

Chi BJ, Zhang YJ, Zhang DM, et al. Wide-strip intercropping of cotton and peanut combined with strip rotation increases crop productivity and economic returns. Field Crop Res. 2019;243:107617. https://doi.org/10.1016/j.fcr.2019.107617.

Chi BJ, Zhang DM, Dong HZ. Control of cotton pests and diseases by intercropping: A review. J Integr Agric. 2021;20(12):3089–3100. https://doi.org/10.1016/S2095-3119(20)63318-4.

Chi BJ, Liu J, Dai JL, et al. Alternate intercropping of cotton and peanut increases productivity by increasing canopy photosynthesis and nutrient uptake under the influence of rhizobacteria. Field Crop Res. 2023;302:109059. https://doi.org/10.1016/j.fcr.2023.109059.

Cong WF, Hoffland E, Li L, et al. Intercropping enhances soil carbon and nitrogen. Glob Change Biol. 2015;21(4):1715–26. https://doi.org/10.1111/gcb.12738.

Gross A, Glaser B. Meta-analysis on how manure application changes soil organic carbon storage. Sci Rep. 2021;11:5516. https://doi.org/10.1038/s41598-021-82739-7.

Lv QQ, Chi BJ, He N, et al. Cotton-based rotation, intercropping, and alternate intercropping increase yields by improving root–shoot relations. Agronomy. 2023;13(2):413. https://doi.org/10.3390/agronomy13020413.

Qasim W, Xia LL, Lin S, et al. Global greenhouse vegetable production systems are hotspots of soil N_2O emissions and nitrogen leaching: a meta-analysis. Environ Pollut. 2020;272:116372. https://doi.org/10.1016/j.envpol.2020.116372.

Rumpel C, Amiraslani F, Chenu C, et al. The 4p1000 initiative: Opportunities, limitations and challenges for implementing soil organic carbon sequestration as a sustainable development strategy. Ambio. 2020;49:350–60. https://doi.org/10.1007/s13280-019-01165-2.

Xie W, Zhang K, Wang XY, et al. Peanut and cotton intercropping increases productivity and economic returns through regulating plant nutrient accumulation and soil microbial communities. BMC Plant Biol. 2022;22:121. https://doi.org/10.1186/s12870-022-03506-y.