ABSTRACT

The rapid increase in the world's population and consumption growth has triggered the global demand for food, so enhancing food security and environmental sustainability is one of the most significant challenges. It was estimated that half of the global population relies on food grown by applying chemical fertilisers, of which N fertiliser contributes the most. However, the misuse of N fertilisers has led to environmental pollution and soil quality decline. Plant pathogens have led to a20% yield reduction globally, with the majority lost to fungal diseases. Synthetic fertilisers and fungicides are the primary agrochemical inputs for crop production worldwide. However, the effects of fertilisation and fungicide (and their interactions) on yield and fungal diseases have not been systematically analysed. This research investigated answering the question of the effect of N fertilisation and fungicide application on crop yield and fungal diseases. What are the possible interactions and trade-offs? How do other key factors, such as aridity, rainfall, and temperature, affect the effects of N fertilisation and fungicide? How do these effects differ among crops and continents? The objectives of this study are to identify and review relevant studies and quantify the effect of N fertilisation and fungicide application, and their possible interactions on yield and fungal disease of major crops, and evaluate the impact of aridity, temperature, and rainfall on the effects of N fertilisation and fungicide. Investigate differences in the effects of N fertilisation and fungicide among major crops (wheat, maize, oats, rice, and soybeans) and across continents. Data was collected through a literature search that yielded 2501 observations from 57 articles. The statistical analysis was conducted by using a mixed-effect model in R.

(1) The result showed that the general application of N input significantly increased yield by an average of 50% ($P < 0.05$), compared with no N input, but had no significant effect on the fungal diseases of these crops ($P > 0.05$). Medium N fertilisation significantly reduced fungal disease by 12%, whereas high and low N fertilisation had no significant effect on the fungal diseases of these crops. The result showed that aridity had a significant effect on influencing N to decrease the disease. Precipitation and temperature did not significantly affect the disease. The interaction that shows the interdependence of N being influenced to affect the disease was all negative, except for aridity. Variations in disease occurrence and yield were significant among crops and across continents.

(2) The main effect of applying fungicide on fungal diseases and the yield of grain crops showed that fungicide significantly decreased disease at all levels (high, medium, low, and overall). The main effect of fungicide application on the yield of grain crops showed no significant effect. The insignificant effect of fungicide on yield showed that fungicides don't have the total capacity to increase yield; they can only increase yield in the presence of N fertilisation, or maybe due to the alteration that occurs during photosynthesis when the fungicide is applied.

(3) The effect of the interaction between N and fungicide showed that at low N and fungicide input levels, an increase in N and fungicide significantly decreased disease. And at high N and fungicide input levels, a decrease in N and fungicide input significantly increased yield. At different N and fungicide interaction levels, N and fungicide decreased diseases. They increased yield significantly when the input levels were at the medium level than at a high or low level. In

this study, the significant effects on fungal diseases were only found at the medium N input level, suggesting that N input can be optimised to affect fungal diseases significantly. In conclusion, N fertilisation and fungicides can significantly affect crop yield and fungal disease. However, the inputs of N and fungicide need to be optimised to achieve the best performance. Notably, the optimisation must be crop- and site-specific, considering the interactions and trade-offs. The findings of this study provide essential guidelines for exploring sustainable measures for ensuring food security and agricultural sustainability worldwide.
Keywords: nitrogen, fungicide, fungal disease, yield.