The impact of microplastics on yield and economic losses in selected agricultural food commodities

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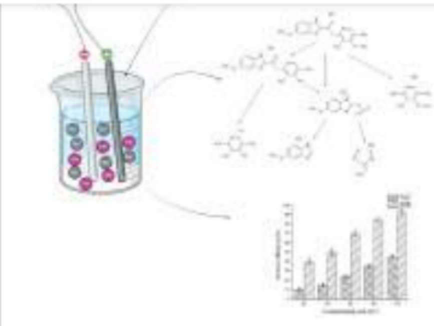

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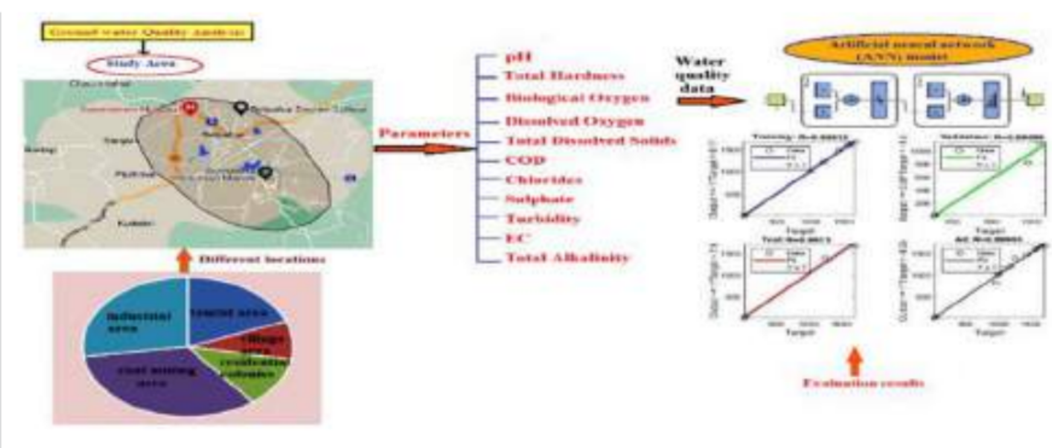

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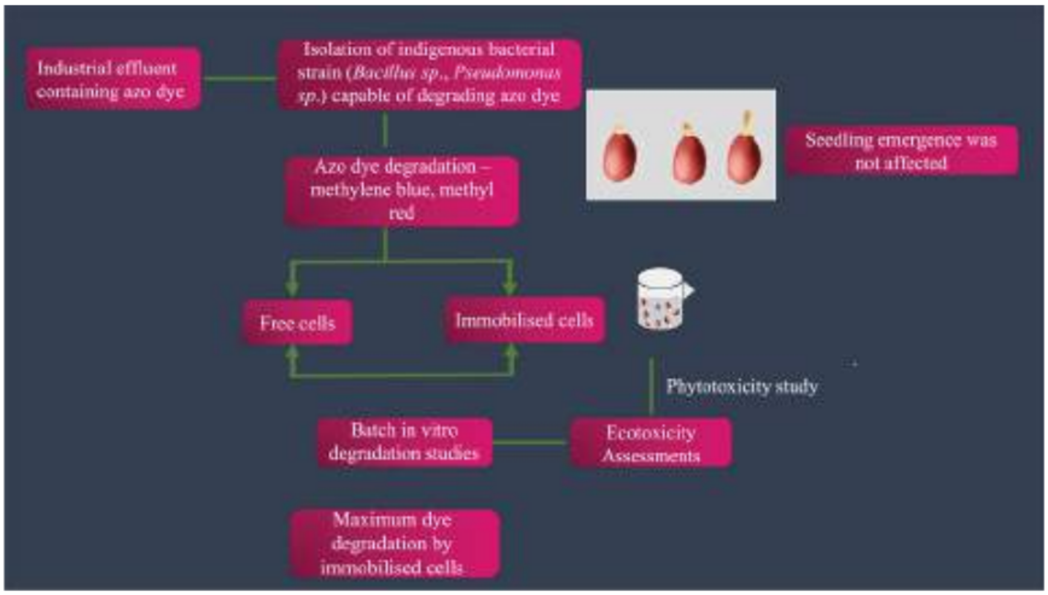

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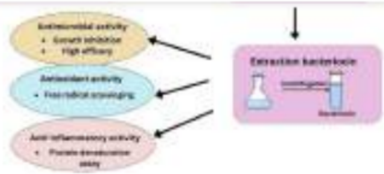

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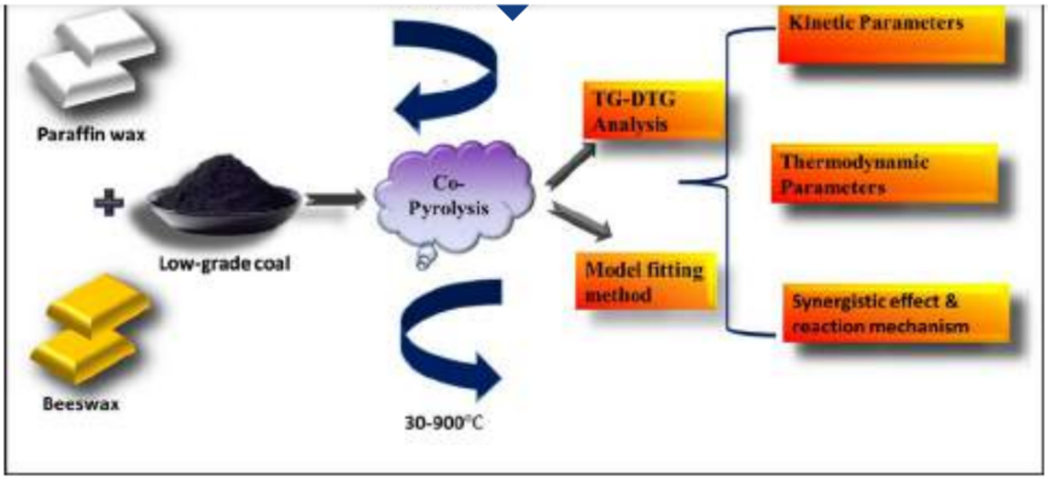

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Correction to “Analysis of Brazilian consumers’ perceptions of cosmetics packaging from a circular economy perspective ”

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Ana Cecília Cavalcante da Silva,Patricia Guarnieri,Bárbara de O. Vieira, Thaíssa V. Castelo-Branco

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Encapsulation and application of cell-free extracts produced by *Penicillium chrysogenum* R1 in tomato plants for the control of *Fusarium oxysporum*

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RESEARCH ARTICLE

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The impact of microplastics on yield and economic losses in selected agricultural food commodities

Adi Sutanto[1] | Wahyu Widodo[1] | Imbang Dwi Rahayu[1] | Sustiyana Sustiyana[2] | Fitrotin Nazizah[2] | Iswahyudi Iswahyudi[3,4] | Ary Bakhtiar[1]

[1]Faculty of Agriculture and Animal Science, University of Muhammadiyah Malang, Malang, East Java, Indonesia

[2]Department of Agribusiness, Universitas Islam Madura, Pamekasan, East Java, Indonesia

[3]Department of Agriculture Science, University of Muhammadiyah Malang, Malang, East Java, Indonesia

[4]Department of Agrotechnology, Universitas Islam Madura, Pamekasan, East Java, Indonesia

Correspondence
Adi Sutanto, Faculty of Agriculture and Animal Science, University of Muhammadiyah Malang, 65144 Malang, East Java, Indonesia.
Email: sutanto@umm.ac.id

Iswahyudi Iswahyudi, Department of Agriculture Science, University of Muhammadiyah Malang, Malang, East Java, Indonesia.
Email: iswahyudi@uim.ac.id

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Abstract

In the realm of the global economy, agriculture holds a prominent status, acting as a vital source of employment and revenue for nations. Despite its crucial role, the agricultural sector contends with recurrent annual losses attributable to market fluctuations. One noteworthy contributor to the decline in agricultural productivity is the adverse impact of microplastics (MPs). This study aims to estimate the production losses suffered by key crops—rice, wheat, maize, tomato, and peas—due to MPs, along with the resulting economic consequences arising from the direct damage inflicted by MPs. To assess production losses caused by MPs, secondary data from diverse sources were employed for five plant varieties. The economic losses resulting from MPs were calculated for the period spanning 2017–2023, with cumulative data aggregated from all states. The study's findings indicate that the presence of MPs corresponds to an annual global output decline ranging from 0.4% to 34.7%. This decline translates to a reduction of approximately 0.01 million to 66.97 million tons per year in the production of food, fiber, and biofuels. The aggregate yearly economic losses are estimated at around USD 46.5 billion. These findings carry substantial implications for governmental policy in the agricultural domain, underscoring the necessity for current statistics on global losses incurred due to MPs. Moreover, they emphasize the importance of implementing a systematic surveillance system to monitor such losses effectively.

KEYWORDS
economic loses, microplastics, toxicity effects

1 | INTRODUCTION

Microplastics (MPs) exert a substantial economic impact (Van der Meulen et al., 2014). Concerns about potential yield and economic losses, as well as the transfer of MPs into the food chain, arise due to their toxicity on crops such as Cucurbita pepo (Colzi et al., 2022). Bivalves, crucial to the fishing industry, face adverse effects from MPs, prompting concerns regarding their role in ecosystem services and economic losses (Khanjani et al., 2023). MPs also influence the bioaccumulation of heavy metals in vegetables, with implications for economic losses in agricultural production (Jia et al., 2022). The Mediterranean coastal environments, economically reliant on tourism, experience depreciation of high touristic attractions due to MPs pollution (Chatziparaskeva et al., 2022). Overall, the economic impact of MPs extends across sectors, impacting agriculture. The use of very large MPs negatively affects the growth and yield of rice plants by 43.81% (Ma et al., 2022), while corn plant productivity is reduced by about 36.90% (Uzamurera et al., 2023), underscoring the significant role of MPs in agricultural production and economic losses.

Many studies have addressed economic losses in the agricultural production sector globally. In Brazil, research focuses on mitigating economic losses caused by insect pests, responsible for an average annual loss of 7.7%, equating to a significant decrease of around 25 million tons of food, fiber, and biofuels (Oliveira et al., 2014). In India, economic losses due to weeds in rice amount to USD 4420 million, with wheat and soybean following closely at USD 3376 million and USD 1559 million, respectively (Gharde et al., 2018). Despite the substantial threat posed by insects, which can result in potential economic losses of up to USD 470 billion (Shehzad et al., 2023), no research has been conducted on the potential economic losses attributable to MPs.

Several investigations have detected MPs in soil and plant (Zhang et al., 2022). MPs in soil have the potential to be assimilated and accumulated in plants, leading to adverse physiological, biochemical, and genetic effects (Jiang et al., 2019). These effects include the inhibition of plant growth, suppression of photosynthesis, excessive production of reactive oxygen species (ROS), oxidative damage to lipid membranes, and modifications in enzymatic activities, among others (Dong et al., 2020). The inhibitory mechanisms can be categorized into direct processes, such as pore obstruction or light interference, physical harm to roots, gene expression inhibition, and additive release (Li et al., 2022). Additionally, MPs can affect plant growth during vegetation and reproduction growth stages, causing significant changes in biomass, reducing root length, bud length, and fresh weight (Qiang et al., 2023). The presence of MPs in the agricultural and food domain raises consumer concerns about food safety, potentially impacting the economic sustainability of the agricultural sector (Ghosh et al., 2023). The economic impacts of MPs on farm businesses, including the agricultural sector, underscore the need for a thorough and proactive approach. However, a comprehensive assessment of the precise quantification of agricultural losses attributable to MPs has been lacking.

The presence of MPs in the agricultural and food domain raises consumer concerns about food safety, potentially impacting the economic sustainability of the agricultural sector

Previous studies have neglected the economic implications of crop yield reductions caused by MPs interference. Therefore, it is imperative to conduct research examining the economic impacts arising from the influence of MPs on food crop production. This study aims to estimate economic losses resulting from the interference of MPs in the production of specific crops, offering a novel perspective by identifying production losses and economic impacts caused by MPs on certain agricultural commodities.

2 | MATERIALS AND METHODS

2.1 | Data collection

The secondary data sources provided yield loss data, serving as input for a numerical simulation process. To evaluate the reliability of the impact of MPs on yield losses, experimental data on rice yield losses in China were examined from sources such as Guo et al. (2023), Wu et al. (2020), Chen et al. (2023), Zheng et al. (2023), wheat in Netherlands collected by Qi et al. (2018), tomato in Spain collected by Hernández-Arenas et al. (2021), pea plants in South Korea collected by Kim et al. (2022) and maize in China collected by Chen et al. (2022) were reviewed to assess the reliability of the effect of MPs on yield losses (Exhibit 1). This thorough review of experimental data aimed to establish the credibility and accuracy of the observed effects of MPs on yield losses in various agricultural contexts.

2.2 | Calculation of economic losses

The calculation of economic losses resulting from MPs included the use of standard estimations pertaining to the production of various crops across different geographical regions, spanning from 2017 to 2023. Additionally, the minimum support price for the crops year 2022–2023 was considered. The determination of the MSP for the fiscal year 2022–2023 included the use of present value as the basis for estimating. The calculation included the use of average yield losses data for a specific crop in several locations (states). The Equation (1) proposed by Oliveira et al. (2014) was applied to each state in order to get the results. In overall, the cumulative economic losses were derived by aggregating the data from all states.

$$EL = NEP \times \left(\frac{\%YL}{100}\right) \times MSP \quad (1)$$

where EL is the economic losses due to MPs (USD), NEP is the normal production estimation (ton), $\%YL$ is the percentage yield losses due to MPs, and MSP is the minimum support price (USD).

3 | RESULTS AND DISCUSSION

3.1 | Actual yield losses due to MPs

Potential yield losses attributed to MPs were derived from a literature review, as outlined in Exhibit 2. The findings indicated substantial yield reductions, particularly in maize, which experienced a significant 34.7% decrease, followed by rice with recorded yield losses ranging from 9.36% to 32.9% due to the presence of MPs. Additionally, potential

EXHIBIT 1 Map of world depicting the locations (rice in China, wheat in Netherland, pea plants in South Korea, maize in China, and tomato in Spain) of which data were considered for calculation of yield losses due to MPs. [Color figure can be viewed at wileyonlinelibrary.com]

EXHIBIT 2 Potential effect of MPs to agriculture yield losses.

Commodity	Polymer type	Size	Concentration	Losses	References
Rice (*Oryza sativa* L.)	LDPE	2 mm	1% (w/w)	32.1%	(Guo et al., 2023)
	PLA			32.9%	
	PS	8.5–30.7 μm	–	25.9%	(Wu et al., 2020)
	Hight-density polyethylene (HDPE)	–	5 mg/kg	9.36%	(Chen et al., 2023)
	PET				
	PE and polyacrylonitrile (PAN)	2 mm	–	19%	(Zheng et al., 2023)
Wheat (*Triticum aestivum*)	LDPE	Mixed 50 μm–1 mm	1% (w/w)	0.96%	(Qi et al., 2018)
Pea plants (*Pisum sativum*)	PS	20 μm	20–40 mg/kg	34%	(Kim et al., 2022)
Tomato (*Solanum lycopersicum* L.)	Sewage sludge containing MPs	–	30.940 ± 8589 items/kg	0.4%	(Hernández-Arenas et al., 2021)
Maize	Polymeric films	–	720 kg/ha	34.7%	(Chen et al., 2022)

EXHIBIT 3 Impact of MPs on economic losses per agriculture area.

Commodity	Polymer	Losses (%)[a]	Production ton/ha[b]	Production million ton/years[c]	Production losses ton/ha	Production losses million ton/years	Economic losses/ha[d]
Rice (*Oryza sativa* L.)	LDPE	32.1%	9	54.75	2.89	17.57	$ 1.271,16
	PLA	32.9%	9	54.75	2.96	18.01	$ 1.302,84
	PS	25.9%	9	54.75	2.33	14.18	$ 1.025,64
	Hight-density polyethylene (HDPE)	9.36%	9	54.75	0.84	5.12	$ 370,66
	PET, PE and polyacrylonitrile (PAN)	19%	9	54.75	1.71	10.40	$ 752,40
Wheat (*Triticum aestivum*)	LDPE	0.96%	9	213.80	0.09	2.05	$ 310,18
Pea plants (*Pisum sativum*)	PS	0.34%	3	25.5	0.01	0.09	$ 16,63
Tomato (*Solanum lycopersicum* L.)	Sewage sludge containing MPs	0.4%	65	3.7	0.26	0.01	$ 101,40
Maize	Polymeric Films	34.7%	9	193	3.12	66.97	$ 593,37

[a] Percentage of losses caused by MPs based on Exhibit 3.
[b,c] *Source* BPS (2023c); DGFC (2023); and FAO (2023).
[d] Based on the average price paid to the farmer per kilogram or liter, source: BPS (2023a); Darmawan (2023); (BPS, 2023b); and BPS (2023d).

yield losses of 34% for pea plants, 0.96% for wheat, and 0.4% for tomatoes were observed. The impact of polylactic acid (PLA) MPs on rice yields was notably more significant compared to other types such as low-density polyethylene (LDPE), high-density polyethylene (HDPE), polystyrene (PS), polyethylene terephthalate (PET), polyethylene (PE), and polyacrylonitrile (PAN). Subsequent studies revealed that LDPE MPs affected wheat yields, PS significantly reduced pea plant yields, sewage sludge containing MPs had a notable impact on tomato fruit, and polymeric films significantly decreased maize yields.

MPs-induced pollution significantly amplifies economic losses for plant products. The presence of MPs in agricultural environments impedes water and nutrient uptake by crop plants, resulting in reduced photosynthesis and cell growth (Ullah et al., 2021). MPs have been shown to alter metabolic processes and induce oxidative damage to crops, hence exerting a negative impact on their overall production (Gan et al., 2023). Additionally, MPs alter both abiotic and biotic soil conditions, influencing the accessibility of water and nutrients to agricultural crops (Iqbal et al., 2023). The combined toxicity of MPs and other common pollutants in agricultural soil exacerbates negative impacts on crops, posing significant concerns for agroecosystems and food security (Rillig et al., 2019). Comprehending the economic impacts of MPs on plant life is crucial for assessing ecological hazards and formulating effective approaches to mitigate MP contamination in agricultural environments (Yu et al., 2021).

3.2 | Economic losses due to MPs

Actual economic losses per hectare were most pronounced for rice (USD 1302.84), followed by maize (USD 593.37), wheat (USD 310.18), tomato (USD 101.40), and pea plants (USD 16.63), respectively (see Exhibit 3). In terms of annual economic losses, maize ranked highest (USD 12,724.49 million), followed by rice (USD 7925.61 million), wheat (USD 7368.48 million), pea plants (USD 141.32 million), and tomato (USD 5.77 million), as illustrated in Exhibit 4. Maize, experiencing an average yield loss of 34.7%, emerged as the crop with the most substantial economic impact due to its global standing as the second-largest producer, distinguishing it from rice, tomato, wheat, and pea plants discussed in this context. The collective economic losses across these five key global crops resulting from microplastics (MPs) were estimated at approximately USD 46.5 billion.

The assessment of economic impacts associated with MPs contamination extended beyond agriculture, encompassing marine pollution and its diverse repercussions in terms of type and magnitude of loss. This broader evaluation included the economic valuation of damages to marine ecosystems (Chaudhry & Sachdeva, 2021; Ofiara & Seneca, 2001). Additionally, research investigations focused on injuries provided estimations of quality-adjusted life years (QALY) linked to these injuries, offering a comprehensive perspective on the economic effects associated with such losses (Gabrielle et al., 2022; Pérez-Reverón et al., 2022). However, a complete analysis specially focused on the calculation of economic losses due to contamination caused by MPs was not available during that period.

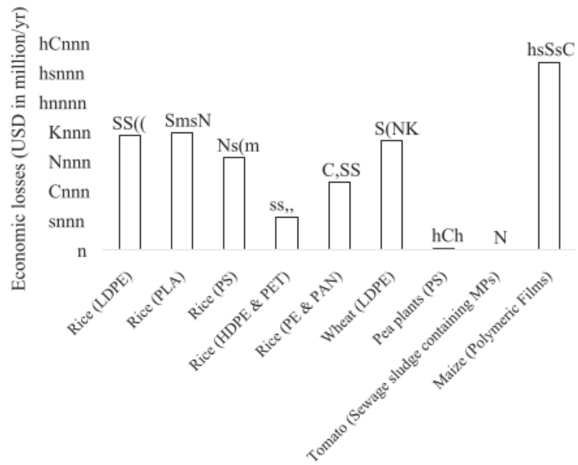

EXHIBIT 4 Economic losses (USD in million/year) due to MPs.

3.3 | Comparison of economic losses by MPs and other factors

Exhibit 5 provides a comparative analysis with previous research endeavors. The economic losses attributable to microplastics (MPs), measured in million dollars per year, were found to range from USD 5.77 to 12,724.49 million across various studies involving rice, wheat, maize, tomato, and pea plants. Notably, the study by Oliveira et al. (2014) in Brazil observed economic losses of USD 17,700 million due to the impact of insect pests, while in India Gharde et al. (2018) reported economic losses of USD 11,000 million resulting from the effects of weeds. In contrast, Chen et al. (2016) identified the economic losses attributed to climate change in China as USD 820 million.

The financial implications of MPs on agriculture were predominantly indirect, imposing costs typically borne by farmers and polluters. MPs were identified as agents damaging soil quality, leading to diminished plant biomass and subsequent yield losses. The persistence and potential escalation of these pollutants were anticipated, as their complete elimination was deemed unfeasible. Mitigating the adverse effects of MPs necessitates active involvement from various stakeholders, including the public, socio-economic sectors, farmers, governmental entities responsible for policy and regulation, and waste management firms (Chaudhry & Sachdeva, 2021).

3.4 | Impact of yield losses on food security

Yield losses exerted significant repercussions on food security, manifesting in both postharvest activities and field-related yield reductions, which emerged as a prominent concern impacting food security (Gomiero, 2019). Ahmed et al. (2023) highlighted that agricultural pollution and climate change posed substantial challenges to food security in Turkey, primarily due to their adverse effects on agriculture, heightened dependence on food imports, and subsequent price

EXHIBIT 5 Comparison of economic losses effected by MPs and other factors.

Commodity	Case	Yields losses (%)	Economic losses (million USD)	Reference
Rice, wheat, maize, tomato, and pea plants	MPs	0.4–34.7	5,77–12.724,49	Present study
Crops grown in Brazil	Exotic insect pests	2–30	12.000	(Oliveira et al., 2013)
Major crops in Brazil	Insect pests	7.7	17.700	(Oliveira et al., 2014)
Corn and soybean	Climate change	3–19	820	(Chen et al., 2016)
Major crops in India	Weeds	45–76	11.000	(Gharde et al., 2018)

increases. A substantial portion of global food production, exceeding one-third, was lost, or wasted, resulting in a reduction in the quantity of food available for human consumption (Ishangulyyev et al., 2019). In Ethiopia, postharvest losses of important food and cash crops resulted in a volume of crops that could have fed over 23 million citizens being wasted, with an economic cost of 1.2 billion USD per annum (Teferra, 2022). With a rising global population and concerns about food insecurity, reducing crop losses was crucial for achieving sustainable food and nutrition security (Sawaya, 2017). Weather-related disasters, particularly drought, contributed to large-scale crop losses, further exacerbating food security challenges (Kogan, 2019). Therefore, addressing crop losses was essential for ensuring an adequate food supply and reducing food insecurity.

MPs impacted food security by contaminating terrestrial domestic animals and the food chain, compromising food productivity and safety (Prata & Dias-Pereira, 2023). Animal products might have already shown MPs contamination, which could have occurred during their lifetime and during processing (Briassoulis, 2023). Additionally, the release of MPs in animal feces led to the contamination of agricultural fields, potentially affecting plants (Nair & Perumal, 2022). In urban environments, companion animals might have acted as sentinels for human exposure to MPs, particularly through airborne exposure (Saeedi, 2023). The use of agricultural plastics (AP) in farming practices also contributed to soil pollution and the potential generation of micro- and nanoparticles, which could have impacted food security (Usman et al., 2020). MPs and nano plastics posed a risk to the ecological environment and could have accumulated in the food chain, including human food webs (Nelis et al., 2023). Long-term exposure to MPs might have posed a serious threat to human health. Therefore, it was important to identify and reduce sources of MPs contamination to ensure food security.

3.5 | MPs can affect economic loses in food commodities

MPs could affect economic losses in food commodities through various mechanisms. Improper disposal methods and the use of synthetic plastic materials for food packaging could lead to contamination of the food chain by MPs, posing health hazards (Jayasinghe et al., 2023). Coastal seafood, which was a valuable food commodity, was found to contain MPs, raising concerns about potential economic impacts and risks of dietary exposure (Hantoro et al., 2019). Plastics used for food packaging, when degraded, could release MPs and additives that could negatively affect human and animal health (Kadac-Czapska et al., 2023). MPs contamination in agroecosystems could reduce food yields and impact the food chain components, leading to economic losses and affecting food security (Okeke et al., 2022). Human exposure to MPs through the ingestion of contaminated food posed a risk to food security and human health (De-la-Torre, 2020). Therefore, addressing MPs contamination in the food chain was crucial to mitigate economic losses in food commodities.

4 | CONCLUSION

This study found that presence of MPs resulted in an average annual decline in global output ranging from 0.4% to 34.7%. This translates to a reduction of approximately 0.01 million to 66.97 million tons per year, with total annual economic losses reaching around USD 46.5 billion. The study focused on data pertaining to five crop commodities from specific countries. However, expanding the scope to include more commodities and locations could potentially lead to even greater losses than those anticipated based on existing data.

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CONFLICT OF INTEREST STATEMENT

The authors reported no declarations of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Adi Sutanto https://orcid.org/0000-0002-6561-4420
Iswahyudi Iswahyudi https://orcid.org/0000-0002-3576-7418

REFERENCES

Ahmed, N., Areche, F. O., Cabello, G. G. C., Trujillo, P. D. C., Sheikh, A. A., & Abiad, M. G. (2023). Intensifying effects of climate change in food loss: A

22
threat to food security in Turkey. *Sustainability (Switzerland)*, *15*(1), 350. https://doi.org/10.3390/su15010350

BPS. (2023a). Average monthly unhulled prices by quality, quality components and HPP at farmer level 2023. Retrieved from https://www.bps.go.id/indicator/36/1034/1/rata-rata-harga-gabah-bulanan-menurut-kualitas-komponen-mutu-dan-hpp-di-tingkat-petani.html

BPS. (2023b). Food group rural consumer price statistics 2022. Retrieved from https://www.bps.go.id/publication/2023/05/08/17384fd90a768797bca41439/statistik-harga-konsumen-perdesaan-kelompok-makanan-2022.html

BPS.. (2023c). Harvest area and rice production in Indonesia 2022. Retrieved from https://www.bps.go.id/publication/2023/08/03/a78164ccd3ad09bdc88e70a2/luas-panen-dan-produksi-padi-di-indonesia-2022.html

BPS.. (2023d). Price wheat. Retrieved from https://www.bps.go.id/statictable/2019/02/14/2016/impor-biji-gandum-dan-meslin-menurut-negara-asal-utama-2017-2022.html

Briassoulis, D. (2023). Agricultural plastics as a potential threat to food security, health, and environment through soil pollution by microplastics: Problem definition. *Science of the Total Environment*, *892*, 164533. https://doi.org/10.1016/j.scitotenv.2023.164533

Chatziparaskeva, G., Papamichael, I., & Zorpas, A. A. (2022). Microplastics in the coastal environment of Mediterranean and the impact on sustainability level. *Sustainable Chemistry and Pharmacy*, *29*, 100768. https://doi.org/10.1016/j.scp.2022.100768

Chaudhry, A. K., & Sachdeva, P. (2021). Microplastics' origin, distribution, and rising hazard to aquatic organisms and human health: Socio-economic insinuations and management solutions. *Regional Studies in Marine Science*, *48*, 102018. https://doi.org/10.1016/j.rsma.2021.102018

Chen, F., Aqeel, M., Khalid, N., Irshad, M. K., Farhat, F., Nazir, A., Ma, J., Akhtar, M. S., Eldesoky, G. E., Aljuwayid, A. M., & Noman, A. (2023). Glutathione treatment suppresses the adverse effects of microplastics in rice. *Chemosphere*, *322*, 138079. https://doi.org/10.1016/j.chemosphere.2023.138079

Chen, P., Gu, X., Li, Y., Qiao, L., Li, Y., Fang, H., Yin, M., & Zhou, C. (2022). Effects of residual film on maize root distribution, yield and water use efficiency in Northwest China. *Agricultural Water Management*, *260*, 107289. https://doi.org/10.1016/j.agwat.2021.107289

Chen, S., Chen, X., & Xu, J. (2016). Impacts of climate change on agriculture: Evidence from China. *Journal of Environmental Economics and Management*, *76*, 105–124. https://doi.org/10.1016/j.jeem.2015.01.005

Colzi, I., Renna, L., Bianchi, E., Castellani, M. B., Coppi, A., Pignattelli, S., Loppi, S., & Gonnelli, C. (2022). Impact of microplastics on growth, photosynthesis and essential elements in Cucurbita pepo L. *Journal of Hazardous Materials*, *423*, 127238. https://doi.org/10.1016/j.jhazmat.2021.127238

Darmawan, A. D.. (2023). The price of corn on the international market. Retrieved from https://databoks.katadata.co.id/datapublish/2023/08/07/harga-jagung-di-pasar-internasional-rp-2-976-9-per-kg-senin-07-agustus-2023-

De-la-Torre, G. E. (2020). Microplastics: an emerging threat to food security and human health. *Journal of Food Science and Technology*, *57*(5), 1601–1608. https://doi.org/10.1007/s13197-019-04138-1

DGFC. (2023). National Rice Production. Retrieved from https://tanamanpangan.pertanian.go.id/detil-konten/iptek/52#:~:text=Hasil%20Penelitian%20Badan%20Penelitian%20dan,sangat%20lebar%20sebesar%202.8%20ton

Dong, Y., Gao, M., Song, Z., & Qiu, W. (2020). Microplastic particles increase arsenic toxicity to rice seedlings. *Environmental Pollution*, *259*, 113892. https://doi.org/10.1016/j.envpol.2019.113892

FAO.. (2023). Crop water information. In *F. A. A. Organization* (Ed.). Food and Agriculture Organization.

Gabrielle, F. M., Curtis, F., Sarah Beth, B., Cora, P., Bruce, A. L., & Ted, R. M. (2022). Monetised estimated quality-adjusted life year (QALY) losses for non-fatal injuries. *Injury Prevention*, *28*(5), 405. https://doi.org/10.1136/injuryprev-2021-044416

Gan, Q., Cui, J., & Jin, B. (2023). Environmental microplastics: Classification, sources, fates, and effects on plants. *Chemosphere*, *313*, 137559. https://doi.org/10.1016/j.chemosphere.2022.137559

Gharde, Y., Singh, P. K., Dubey, R. P., & Gupta, P. K. (2018). Assessment of yield and economic losses in agriculture due to weeds in India. *Crop Protection*, *107*, 12–18. https://doi.org/10.1016/j.cropro.2018.01.007

Ghosh, S., Sinha, J. K., Ghosh, S., Vashisth, K., Han, S., & Bhaskar, R. (2023). Microplastics as an emerging threat to the global environment and human health. *Sustainability (Switzerland)*, *15*(14), 10821. https://doi.org/10.3390/su151410821

Gomiero, T. (2019). Soil and crop management to save food and enhance food security. In C. M. Galanakis (Ed.), *Saving food* (pp. 33–87): Academic Press. https://doi.org/10.1016/B978-0-12-815357-4.00002-X

Guo, S., Mu, L., Sun, S., Hou, X., Yao, M., & Hu, X. (2023). Concurrence of microplastics and heat waves reduces rice yields and disturbs the agroecosystem nitrogen cycle. *Journal of Hazardous Materials*, *452*, 131340. https://doi.org/10.1016/j.jhazmat.2023.131340

Hantoro, I., Löhr, A. J., Van Belleghem, F. G. A. J., Widianarko, B., & Ragas, A. M. J. (2019). Microplastics in coastal areas and seafood: implications for food safety. *Food Additives & Contaminants: Part A*, *36*(5), 674–711. https://doi.org/10.1080/19440049.2019.1585581

Hernández-Arenas, R., Beltrán-Sanahuja, A., Navarro-Quirant, P., & Sanz-Lazaro, C. (2021). The effect of sewage sludge containing microplastics on growth and fruit development of tomato plants. *Environmental Pollution*, *268*, 115779. https://doi.org/10.1016/j.envpol.2020.115779

Iqbal, B., Zhao, T., Yin, W., Zhao, X., Xie, Q., Khan, K. Y., Zhao, X., Nazar, M., Li, G., & Du, D. (2023). Impacts of soil microplastics on crops: A review. *Applied Soil Ecology*, *181*, 104680. https://doi.org/10.1016/j.apsoil.2022.104680

Ishangulyyev, R., Kim, S., & Lee, S. H. (2019). Understanding food loss and waste—Why are we losing and wasting food? *Foods*, *8*(8), 297. https://doi.org/10.3390/foods8080297

Jayasinghe, C. V. L., Jayatilake, S., Rajapakse, H. U. K. D. Z., Kithmini, N. K. S., & Kulathunga, K. M. P. M. (2023). Microplastics in the food chain. In *Microplastics in the ecosphere* (pp. 339–355). https://doi.org/10.1002/9781119879534.ch20

Jia, H., Wu, D., Yu, Y., Han, S., Sun, L., & Li, M. (2022). Impact of microplastics on bioaccumulation of heavy metals in rape (Brassica napus L.). *Chemosphere*, *288*, 132576. https://doi.org/10.1016/j.chemosphere.2021.132576

Jiang, X., Chen, H., Liao, Y., Ye, Z., Li, M., & Klobučar, G. (2019). Ecotoxicity and genotoxicity of polystyrene microplastics on higher plant Vicia faba. *Environmental Pollution*, *250*, 831–838. https://doi.org/10.1016/j.envpol.2019.04.055

Kadac-Czapska, K., Knez, E., Gierszewska, M., Olewnik-Kruszkowska, E., & Grembecka, M. (2023). Microplastics derived from food packaging waste—Their origin and health risks. *Materials*, *16*(2), 674. https://doi.org/10.3390/ma16020674

Khanjani, M. H., Sharifinia, M., & Mohammadi, A. R. (2023). The impact of microplastics on bivalve mollusks: A bibliometric and scientific review. *Marine Pollution Bulletin*, *194*, 115271. https://doi.org/10.1016/j.marpolbul.2023.115271

Kim, D., An, S., Kim, L., Byeon, Y. M., Lee, J., Choi, M.-J., & An, Y.-J. (2022). Translocation and chronic effects of microplastics on pea plants (Pisum sativum) in copper-contaminated soil. *Journal of Hazardous Materials*, *436*, 129194. https://doi.org/10.1016/j.jhazmat.2022.129194

Kogan, F. (2019). Vegetation Health-Based Modeling Crop Yield and Food Security Prediction. In F. Kogan (Ed.), *Remote sensing for food security* (pp. 115–162). Springer International Publishing. https://www.doi.org/10.1007/978-3-319-96256-6_6

Li, J., Yu, S., Yu, Y., & Xu, M. (2022). Effects of microplastics on higher plants: A review. *Bulletin of Environmental Contamination and Toxicology*, *109*(2), 241–265. https://doi.org/10.1007/s00128-022-03566-8

Ma, J., Aqeel, M., Khalid, N., Nazir, A., Alzuaibr, F. M., Al-Mushhin, A. A. M., Hakami, O., Iqbal, M. F., Chen, F., Alamri, S., Hashem, M., & Noman, A. (2022). Effects of microplastics on growth and metabolism of rice (Oryza sativa L.). *Chemosphere*, *307*, 135749. https://doi.org/10.1016/j.chemosphere.2022.135749

Nair, H. T., & Perumal, S. (2022). Trophic transfer and accumulation of microplastics in freshwater ecosystem: Risk to food security and human health. *International Journal of Ecology*, *2022*, 1234078. https://doi.org/10.1155/2022/1234078

Nelis, J. L. D., Schacht, V. J., Dawson, A. L., Bose, U., Tsagkaris, A. S., Dvorakova, D., Beale, D. J., Can, A., Elliott, C. T., Thomas, K. V., & Broadbent, J. A. (2023). The measurement of food safety and security risks associated with micro- and nanoplastic pollution. *TrAC Trends in Analytical Chemistry*, *161*, 116993. https://doi.org/10.1016/j.trac.2023.116993

Ofiara, D. D., & Seneca, J. (2001). *Economic losses from marine pollution: a handbook for assessment*: Island Press. Retrieved from https://www.google.com/books?hl=idamp;lr=amp;id=LK_ZecmoxhUCamp;oi=fndamp;pg=PR13amp;dq=Economic+Losses+from+Marine+Pollution:+A+Handbook+For+Assessment+Douglas+D.+and+Joseph+J.+Seneca+Ofiara+01+May+2001-amp;ots=CoJJR5P1M9amp;sig=IfwLCa831D2Q8ZAduMJ9el9sX0Q

Okeke, E. S., Okoye, C. O., Atakpa, E. O., Ita, R. E., Nyaruaba, R., Mgbechidinma, C. L., & Akan, O. D. (2022). Microplastics in agroecosystems-impacts on ecosystem functions and food chain. *Resources, Conservation and Recycling*, *177*, 105961. https://doi.org/10.1016/j.resconrec.2021.105961

Oliveira, C. M., Auad, A. M., Mendes, S. M., & Frizzas, M. R. (2013). Economic impact of exotic insect pests in Brazilian agriculture. *Journal of Applied Entomology*, *137*(1-2), 1–15. https://doi.org/10.1111/jen.12018

Oliveira, C. M., Auad, A. M., Mendes, S. M., & Frizzas, M. R. (2014). Crop losses and the economic impact of insect pests on Brazilian agriculture. *Crop Protection*, *56*, 50–54. https://doi.org/10.1016/j.cropro.2013.10.022

Pérez-Reverón, R., Álvarez-Méndez, S. J., Kropp, R. M., Perdomo-González, A., Hernández-Borges, J., & Díaz-Peña, F. J. (2022). Microplastics in agricultural systems: Analytical methodologies and effects on soil quality and crop yield. *Agriculture*, *12*(8), 1162. https://doi.org/10.3390/agriculture12081162

Prata, J. C., & Dias-Pereira, P. (2023). Microplastics in terrestrial domestic animals and human health: Implications for food security and food safety and their role as sentinels. *Animals*, 13(4). https://doi.org/10.3390/ani13040661

Qi, Y., Yang, X., Pelaez, A. M., Huerta Lwanga, E., Beriot, N., Gertsen, H., Garbeva, P., & Geissen, V. (2018). Macro- and micro- plastics in soil-plant system: Effects of plastic mulch film residues on wheat (Triticum aestivum) growth. *Science of the Total Environment*, *645*, 1048–1056. https://doi.org/10.1016/j.scitotenv.2018.07.229

Qiang, L., Hu, H., Li, G., Xu, J., Cheng, J., Wang, J., & Zhang, R. (2023). Plastic mulching, and occurrence, incorporation, degradation, and impacts of polyethylene microplastics in agroecosystems. *Ecotoxicology and Environmental Safety*, *263*, 115274. https://doi.org/10.1016/j.ecoenv.2023.115274

Rillig, M. C., Lehmann, A., de Souza Machado, A. A., & Yang, G. (2019). Microplastic effects on plants. *New Phytologist*, *223*(3), 1066–1070. https://doi.org/10.1111/nph.15794

Saeedi, M. (2023). How microplastics interact with food chain: a short overview of fate and impacts. *Journal of Food Science and Technology*, *60*(3), 1209. https://doi.org/10.1007/s13197-023-05720-4

Sawaya, W. N. (2017). Impact of food losses and waste on food security. In S. Murad, E. Baydoun, N. Daghir, & A. Badran (Eds.), *Water, energy & food sustainability in the middle east: The sustainability triangle* (pp. 361–388). Springer International Publishing. https://www.doi.org/10.1007/978-3-319-48920-9_16

Shehzad, M., Bodlah, I., Siddiqui, J. A., Bodlah, M. A., Fareen, A. G. E., & Islam, W. (2023). Recent insights into pesticide resistance mechanisms in Plutella xylostella and possible management strategies. *Environmental Science and Pollution Research*, *30*, 95296–95311. https://doi.org/10.1007/s11356-023-29271-5

Teferra, T. F. (2022). The cost of postharvest losses in Ethiopia: economic and food security implications. *Heliyon*, *8*(3), 1–8. https://doi.org/10.1016/j.heliyon.2022.e09077

Ullah, R., Tsui, M. T.-K., Chen, H., Chow, A., Williams, C., & Ligaba-Osena, A. (2021). Microplastics interaction with terrestrial plants and their impacts on agriculture. *Journal of Environmental Quality*, *50*(5), 1024–1041. https://doi.org/10.1002/jeq2.20264

Usman, S., Abdull Razis, A. F., Shaari, K., Amal, M. N. A., Saad, M. Z., Mat Isa, N., Nazarudin, M. F., Zulkifli, S. Z., Sutra, J., & Ibrahim, M. A. (2020). Microplastics pollution as an invisible potential threat to food safety and security, policy challenges and the way forward. *International Journal of Environmental Research and Public Health*, *17*(24), 9591. https://doi.org/10.3390/ijerph17249591

Uzamurera, A. G., Wang, P.-Y., Zhao, Z.-Y., Tao, X.-P., Zhou, R., Wang, W.-Y., Xiong, X.-B., Wang, S., Wesly, K., Tao, H.-Y., & Xiong, Y.-C. (2023). Thickness-dependent release of microplastics and phthalic acid esters from polythene and biodegradable residual films in agricultural soils and its related productivity effects. *Journal of Hazardous Materials*, *448*, 130897. https://doi.org/10.1016/j.jhazmat.2023.130897

Van der Meulen, M., De Vriese, L., Lee, J., Maes, T., Van Dalfsen, J., Huvet, A., Soudant, P., Robbens, J., & Vethaak, A. (2014). Socio-economic impact of microplastics in the 2 Seas, Channel and France Manche Region. An initial risk assessment. Retrieved from https://archimer.ifremer.fr/doc/00287/39834/

Wu, X., Liu, Y., Yin, S., Xiao, K., Xiong, Q., Bian, S., Liang, S., Hou, H., Hu, J., & Yang, J. (2020). Metabolomics revealing the response of rice (Oryza sativa L.) exposed to polystyrene microplastics. *Environmental Pollution*, *266*, 115159. https://doi.org/10.1016/j.envpol.2020.115159

Yu, Z.-f., Song, S., Xu, X.-l., Ma, Q., & Lu, Y. (2021). Sources, migration, accumulation and influence of microplastics in terrestrial plant communities. *Environmental and Experimental Botany*, *192*, 104635. https://doi.org/10.1016/j.envexpbot.2021.104635

Zhang, Z., Cui, Q., Chen, L., Zhu, X., Zhao, S., Duan, C., Zhang, X., Song, D., & Fang, L. (2022). A critical review of microplastics in the soil-plant system: Distribution, uptake, phytotoxicity and prevention. *Journal of Hazardous Materials*, *424*, 127750. https://doi.org/10.1016/j.jhazmat.2021.127750

Zheng, X., Song, W., Ding, S., Han, L., Dong, J., Feng, Y., & Feng, Y. (2023). Environmental risk of microplastics after field aging: Reduced rice yield without mitigating yield-scale ammonia volatilization from paddy soils. *Environmental Pollution*, *318*, 120823. https://doi.org/10.1016/j.envpol.2022.120823

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The impact of microplastics on yield and economic losses in selected agricultural food commodities

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