IMPACT OF PERSONAL PROTECTIVE EQUIPMENT LEACHATES ON EARLY PLANT DEVELOPMENT

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Abstract

The increased disposal of personal protective equipment, such as face masks and gloves, during the global pandemic caused by the novel coronavirus (Covid-19) has led to a notable rise in plastic pollution, which represents a significant ecological threat. This study examines the impact of leachates from polypropylene masks and both latex and nitrile gloves on the early development of twelve plant species, utilising an *in vitro* semi-hydroponic system. The germination and root growth of the plants were assessed, and Fourier transform infrared spectroscopy was employed to analyse the ageing of the materials.

The findings revealed a range of effects of leachates on plant development. The root growth of species such as crimson clover, radish, and buckwheat was found to be inhibited, while other species, including rapeseed, white mustard, and cress, exhibited enhanced growth. The germination index, which integrates relative germination and root length, was utilised to evaluate plant responses. The Brassicaceae species exhibited distinctive responses, with radish displaying high sensitivity to glove leachates, while rapeseed, white mustard, and cress frequently demonstrated growth stimulation. At the family level, legumes exhibited the greatest sensitivity, while monocotyledons were minimally affected, and growth of the Brassicaceae family was generally enhanced. The least reduction in the germination index was observed in the case of mask leachates, in comparison to latex and nitrile gloves. Furthermore, a correlation was identified between root growth responses and material ageing, indicating that masks exhibiting minimal signs of ageing had a comparatively reduced impact on early root development in comparison to aged gloves.

The findings of this study emphasise the intricate relationships between plastic leachates from personal protective equipment and plant growth, underscoring the necessity for further investigation in this field.

Introduction

In addition to the conventional abiotic stresses that can impede plant root development, the impact of rising plastic pollution in the environment, including the vast quantity of personal protective equipment (PPE) utilized during the Covid-19 pandemic, represents a pressing yet under-researched topic in plant biology.

The rapid spread and high mortality rate of the SARS-CoV-2 pandemic caused considerable concern globally, leading to the introduction of various restrictions and prevention strategies to reduce the rate of virus transmission [1,2]. Face masks and disposable gloves became the most widely accepted tools for infection prevention, and thus the demand for gloves increased, leading to their excessive daily use. Consequently, the elevated volume of disposable protective equipment has imposed a significant burden on the disposal and management of plastic waste.

One estimate suggests that 1.5 billion units of personal protective equipment were produced globally between March 2020 and November 2021, with a total weight of 87 thousand tonnes [3]. Similarly, like other traditional plastics, protective equipment is not environmentally inert and can accumulate various harmful substances, including heavy metals and organic pollutants [4,5]. Such substances have the potential to adsorb, accumulate and, when transported by plastic, to pollute water and soil [6-8]. The gradual release of these pollutants has the potential to disrupt wildlife and ecosystem functioning.

Experimental

This study examined the impact of leachates from polypropylene (PP) masks, latex, and nitrile gloves on the early development of twelve plant species. An *in vitro* semi-hydroponic system was employed to assess the effects of these leachates.

Prior to the experiments, surgical mask, nitrile and latex glove pieces with an edge length of 1 cm were soaked in sterile distilled water at concentrations of 0.5% and 1% (w/v) in flasks for 72 h at room temperature with shaking at 100 rpm [9], and subsequently leachate free of plastic pieces was used.

The impact of the leachate was evaluated on the following plant species: *Trifolium pratense* L. (red clover, Rédei Kertimag Zrt., Altaswede), *Trifolium incarnatum* L. (crimson clover, Rédei Kertimag Zrt., Cantea), *Trifolium repens* L. (white clover, Rédei Kertimag Zrt., Romena), *Brassica napus* L. (rapeseed, GK Gabriella), *Medicago sativa* L. (medicago, Rédei Kertimag Zrt., Plato), *Sinapis alba* L. (white mustard, Rédei Kertimag Zrt., Marci), *Lepidium sativum* L. (garden cress, Rédei Kertimag Zrt., 539001), *Raphanus sativus* L. (radish, Rédei Kertimag Zrt, 629000), *Linum usitatissimum* L. (flax, GK Helga), *Oryza sativa* L. (rice, NAIK ÖVKI M-488), *Sorghum vulgare* L. (sorghum, GK Emese), *Fagopyrum esculentum* Moench (buckwheat, GK Oberon).

In the course of the experiments, 10 seeds were germinated in glass Petri dishes on two layers of sterile filter paper in 5 mL of leachate for a period of five days [10].

The germination and growth of the seeds were observed, and germination index (GI) was calculated from the germination data (expressed as a percentage in comparison to the control) and the relative root length (also expressed as a percentage in comparison to the control) [11].

Furthermore, in addition to measuring the pH and conductivity of the leachates, Fourier-transform infrared spectroscopy was utilised to examine the effects of ageing of the materials. The ageing of plastics was characterised by the ageing index (AI), which was calculated from Fourier transform infrared spectroscopy (FTIR) absorbance spectra. This value is calculated in a manner analogous to that employed in the characterisation of plastics, as represented by the carbonyl index, as outlined by Zhao et al. [12].

The results are presented as mean ± standard error. Pairwise comparisons were conducted using Student's t-test in Microsoft Excel 2016, with a significance level of $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$, respectively.

Results and discussion

The results demonstrated that leachate had a variable effect on plant development. Some species, including crimson clover, radish and buckwheat, exhibited inhibited root growth, while others, such as oilseed rape, white mustard and cress, demonstrated enhanced growth (Fig. 1-2).

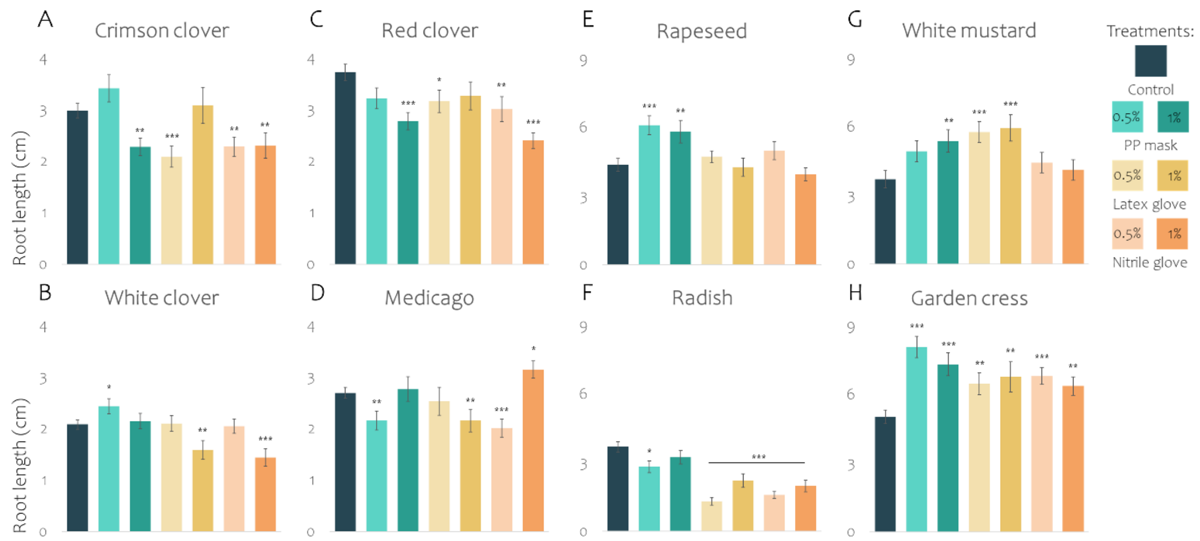

Figure 1. Primary root length of 5-day-old legume (A-D) and crucifer (E-H) seedlings grown on leachate from PP mask, latex and nitrile gloves. Results are expressed as mean ± standard error. Pairwise comparisons were performed using Student's t-test (*P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001).

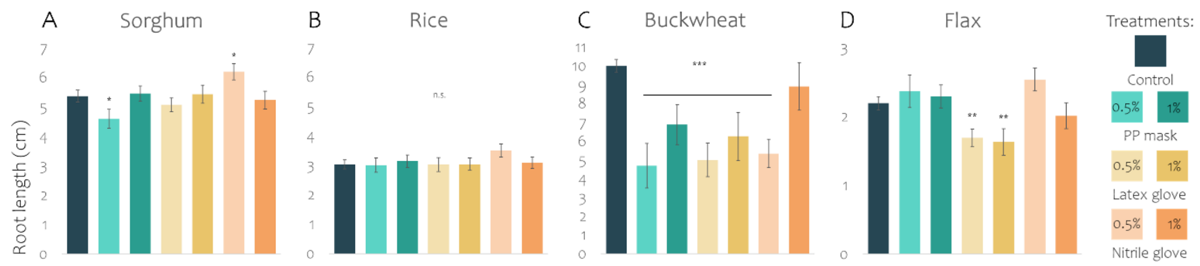

Figure 2. Primary root length of 5-day-old monocot (A-B), buckwheat (C) and flax (D) seedlings grown on leachate from PP mask, latex and nitrile gloves. Results are expressed as mean ± standard error. Pairwise comparisons were performed using Student's t-test (*P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001).

		PP mask		Latex glove		Nitril glove	
	Control	0.5%	1%	0.5%	1%	0.5%	1%
Crimson clover	100	92	56	65	55	61	64
Red clover	100	72	67	85	79	73	64
White clover	100	113	107	90	79	98	61
Medicago	100	69	85	71	69	64	101
Rapeseed	100	134	108	104	87	110	74
White mustard	100	144	151	168	186	124	115
Radish	100	71	88	36	60	43	55
Garden cress	100	161	146	129	130	135	127
Rice	100	88	92	89	93	107	90
Sorghum	100	89	98	98	98	115	94
Buckwheat	100	23	48	27	47	35	58
Flax	100	89	101	77	61	112	85

Figure 3. Germination index of 5-day-old seedlings grown on leachate from PP mask, latex and nitrile gloves.

In addition to root length, the germination index, which combines relative germination and root length, was also used to characterize the response of the plant species.
The average GI of the different families (considering all three leachate types at both concentrations) indicates that the legumes were the most sensitive, while the monocots exhibited no significant inhibition, and the crucifers demonstrated the capacity to stimulate growth (Fig. 3). Upon examination of the impact of leachate from disparate protective devices, it was observed that the PP masks elicited the least pronounced reduction in GI values across all plant species and both concentrations. In contrast, the two types of gloves produced exhibited a greater reduction in GI, with an average reduction of 13% for latex glove leachate and 14% for nitrile.

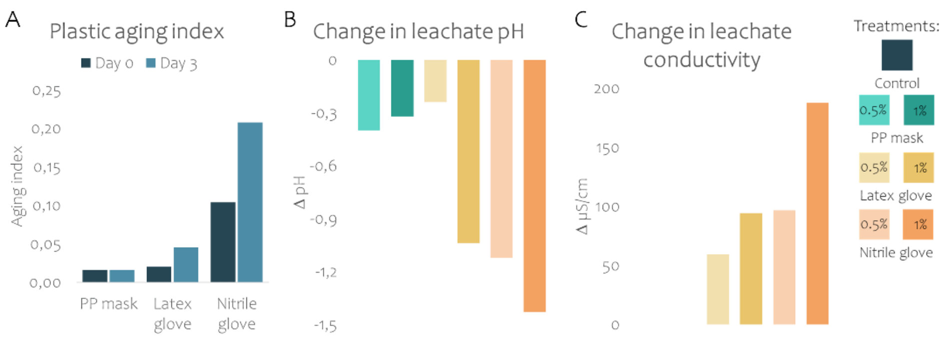

Figure 4. (A) Plastic aging index before and after leachate preparation. Changes in leachate parameters: pH (B) and conductivity (C), after 3 days of leachate preparation.

It is noteworthy that alterations in GI values are associated with fluctuations in the AI values of the test substances, as well as with the pH and conductivity of the leachates. (Fig. 4). The AI value of the PP mask remained unaltered throughout the three-day soaking period. The leachate, which exhibited a similar pH and conductivity after the 72-hour soaking duration, also demonstrated a negligible impact on the mean GI value of the plants. In contrast, the AI value of the two types of gloves approximately doubled after three days of soaking, resulting in a greater decrease in the GI values of the plants. It can also be seen that although the AI values of the nitrile glove pieces were an order of magnitude higher, this only caused a significant difference in the case of leachate from 1% of its concentration, i.e. a higher AI value of the plastic does not necessarily lead to a higher toxicity of the leachate from it.

Conclusion

Among the plant families, the species belonging to the Brassicaceae displayed distinct responses. The radish was observed to be highly sensitive to the leachates from gloves, while the rapeseed, white mustard, and cress often exhibited growth stimulation. The mean GI analysis demonstrated that legumes exhibited the greatest sensitivity, while monocotyledons demonstrated minimal inhibition, and growth in the Brassicaceae family was stimulated.
The least reduction in GI was observed in the case of mask leachates, in comparison to latex and nitrile gloves. The different levels of material ageing and the resultant varying leachate parameters may be responsible for the varying degrees of impact observed with different PPEs.

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