Pesticides and Health POSTnote Contribution

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I work as a leading researcher fellow in soft robotics (robots made of soft materials, and that may include mechanisms for changing their shape and rigidity) at the Soft Robotics Lab, in the Mechanical Engineering Department at UCL. I work in the INSTINCT (intuitive soft, stiffness-controllable haptic interface for soft tissue palpation during Robot-assisted Minimally Invasive Surgery (RMIS)) project. I am in charge of designing, developing and evaluating a haptic (touch sense) interface for the fingertips for RMIS. I also have a background in sustainable farming from my PhD research, where I received a scholarship from the Ecuadorian government to improve the mobility of robots to decrease the consumption of pesticides. Robotics can contribute to monitoring crops, controlling weeds continuously, reducing the use of pesticides and also optimising the dosing and application of soil nutrients, such as nitrogen, to reduce the impact of agriculture on the environment. Additionally, soft robots can adapt to the changing weather and soil conditions while avoiding damaging crops.

Background

Pesticides are commonly used in agriculture to control crop pests in fields and grain storage. Pesticides comprise substances such as fungicides, insecticides, rodenticides, and herbicides [1]. However, factors such as wind and the pollution of underground water increase the transmission of these chemicals from farms to neighbouring ecosystems and rural residential areas. Urban residents are not immune from the effects of pesticides, as they are commonly found in products such as pet shampoos/treatments for flea control [2] and used to control pests in non-agricultural areas such as playgrounds, sports fields, pavement [3], and gardens. Additionally, agrochemical residues on agricultural products (i.e. fruits and vegetables) cannot be completely removed by washing and peeling [4], resulting in continuous, low-level exposure to several types of pesticides through daily food consumption [5].

Feedback on the scope of this POSTnote

The scope of this POSTnote covers four crucial points related to the effects of pesticides on human health. These points can be further enhanced by including the link to the list of approved pesticides in the UK [6] in the Background section. This knowledge will contextualise the subsequent discussion.

Main risks to human health from pesticide use

Humans are exposed to pesticides through inhalation, ingestion, and contact with the skin. These pesticides are subsequently excreted, metabolised, and accumulated as fat or stored; their implication on human health depends on the health status of the person, length and type of exposure, and type of pesticide [1].

Several studies have investigated the effect of pesticides on human health [7–14]. For example, there is a possible correlation between pesticides exposure and illnesses such as Alzheimer's, Parkinson's, kidney failure, diabetes [7], modern diseases such as gluten intolerance [8] and reproductive issues [9]. Herbicides such as glyphosate have also been declared as possibly carcinogenic by the World Health Organisation's International Agency for Research on Cancer [10]. Additionally, long-term pesticide exposure has been linked to conditions such as depression and anxiety [11], attention deficit and hyperactivity disorder (ADHD) [12, 13], and asthma [14].

Technologies and strategies that could be used by farmers as alternatives to pesticide use

Weeds have a significant impact on food production [15]. Crops must compete with weeds for water, sunlight, and nutrients from the soil, which reduces crop yields [16]. Therefore, technological alternatives to pesticides should be able to operate continuously while moving easily through fields, be lightweight to avoid compaction, include a mechanical weeding system, and gather field data (soil health, amount of pests, etc.), and be affordable. These can even be complemented with bio-controllers to manage pests insects.

Current alternatives and research needs

In the last years, commercially available farming robots [17–20] are used to counteract the scarcity of hand-labour, control weeds, monitoring crops, and decrease the impact of herbicides in the environment. In addition, research in artificial intelligence (i.e. deep learning) has proven to be successful in detecting weeds *in situ* [21]. However, further research is needed regarding the following considerations:

Physical considerations

The size and weight of these farming robots still cause soil compaction [17–19], which disrupts nutrients and water cycles due to the creation of impermeable layers in the soil. Robot's dimensions also affect which crops it can be used with and crop density (number of plants per unit area of ground). For example, OZ from Naïo Technologies [20] requires crops to be spaced at more than 47 cm, while AVO from ecoRobotix [19] requires crop spacing between 35-70 cm to facilitate the robot's navigation.

The topography (inclination of the terrain) and texture of the soil (i.e. the amount of clay, sand, or rocks in the soil) can make mobility difficult for wheeled mechanisms. Consequently, legs [22] or hybrid wheel-legs [23] can be used to improve the adaptability and mobility of the robots. To avoid damaging desired crops while performing inter- and intra-row weed-control, soft robotics tools that can adapt their body rigidity [24–27] (i.e. the tool can become soft near desired crops and rigid near weeds) are beneficial.

Bio-diversity considerations

Robots in farming will facilitate crop diversity and land management while decreasing the exposure of humans to hazards. Intensive use (or misuse) of herbicides can lead to herbicide-resistance in weeds [28, 29], necessitating the greater use of mechanical weeding mechanisms. Using robotics for continuous monitoring of the farm can eliminate or minimise the need for herbicides, facilitate the early detection of pests, and optimise the application of nutrients to the soil to avoid contaminating neighbouring ecosystems.

Complementing robotic technologies – Bio-control of pest insects

Bio-control uses living organisms, often referred to as 'natural enemies', to decrease the population and impact of plant pathogens [30, 31]. In crops, this implies that pathogens compete with non-pathogens for nutrients. For example, social wasps are successful natural predators of resilient crop pests in sugar cane and maise [32]. Certain species of ladybirds and spiders are effective at combating pests that affect wheat [33] and soybean crops [34]. Additionally, native bio-controllers are even more sustainable than those that are introduced because less management infrastructure is required for their deployment [32].

Other points of interest to Parliamentarians in the scope of this note

It is important to discuss the following points about organic farming sustainability and pesticides regulation, respectively:

- The increased concentration of pesticides in the air due to long-range air transportation, and subsequent deposition on organic products, should also be discussed. Long-range air transportation of approved pesticides, such as glyphosate, prosulfocarb, and pendimethalin, can make it difficult for organic farmers to avoid exceeding the permissible amount of these pesticides in their products [35]. Consequently, farmers cannot sell their products as organic, impacting them financially/economically, as well as the overall sustainability of the organic farming sector.

- It is also important to continuously re-evaluate the toxicity of approved organophosphorus pesticides (including glyphosate, malathion, carbamate, atrazine and simazine) to factors in new evidence as it emerges. This re-evaluation is important due to their effects on the environment and human health, such as the possible correlation with several illnesses such as cancer [10] and kidney failure [3].

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