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Evaluating the Safety of Imidacloprid FS Seed Treatment Use in Potato Production: A Case Study from China

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Abstract: This study evaluated the residue behavior and dissipation dynamics of a new imidacloprid FS 600 seed treatment in potato cultivation systems in Shandong and Jilin, China. Sensitive and accurate UPLC-MS/MS methods were established to quantify imidacloprid residues in potatoes, potato plants, and soil. Results showed that imidacloprid dissipation followed a first-order kinetic model, with half-lives ranging from 6.9 to 26.7 days in plants and 19.8 to 28.9 days in soil. At harvest, the highest average residues in potatoes and soil were 0.778 mg/kg and 0.149 mg/kg, respectively. The dietary risk assessment indicated a chronic risk quotient (CRQ) of 39.73% for adults, indicating minimal risk to human consumers, while the ecological risk quotient (ERQ) and ecotoxicity exposure ratio (TER) revealed low to moderate toxicity to earthworms, warranting caution in the use of this formulation. This research provides valuable data for assessing the safety of imidacloprid FS seed treatment in potato cultivation.

Keywords: imidacloprid FS; potato; soil; residue behavior; dietary risk; ecological risk

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1. Introduction

Modern agriculture has made extensive use of imidacloprid, a systemic neonicotinoid insecticide, to protect crops from pest infestations. It is a game-changer as an insecticide due to its low toxicity to mammals, excellent effectiveness, and versatility in use [1,2]. In the last 30 years, its non-repellent properties and high effectiveness have made it increasingly popular [3]. Despite its agricultural benefits, the extensive use of imidacloprid has raised concerns about its environmental impact, particularly on non-target organisms such as pollinators, aquatic life, and soil microorganisms [4,5]. For instance, it has been shown to affect pollinators such as bees, leading to reduced foraging efficiency, impaired navigation, and colony collapse [4]. These concerns have led to restrictions on the use of imidacloprid insecticides in some regions, highlighting the need for comprehensive risk assessments to evaluate the safety of their use in specific agricultural contexts [6]. Moreover, its relatively high water solubility (0.61 g/L at 20 °C) raises concerns about its potential to leach into groundwater, posing risks to aquatic ecosystems and drinking water sources [7]. Therefore, careful dosage management is crucial to prevent the subsurface from becoming a sink for this pesticide, ensuring both agricultural productivity and environmental protection. Therefore, recent years have seen a surge in its use as a direct seed treatment, showing promising results in controlling pests like jassids, thrips, and whiteflies in potatoes [8,9]. Moreover, its application as a seed treatment formulation (FS) has gained popularity due to its ability to protect crops against soil-borne pests during critical early growth stages [10].

The agricultural sector in China plays a critical role in ensuring food security and supporting the livelihoods of millions of farmers. Potatoes (Solanum tuberosum) are a significant crop, with China being the world's leading producer, accounting for over 25% of