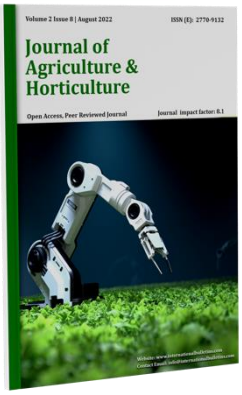

TECHNOLOGY FOR APPLYING HERBICIDES AGAINST WEEDS

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Abstract: In the ever-evolving landscape of modern agriculture, the battle against weeds has become a paramount concern for farmers and land managers worldwide. Weeds, those unwanted and often tenacious plants that compete with crops for essential resources, pose a significant threat to agricultural productivity and ecosystem balance. To combat this persistent challenge, the development and refinement of technology for applying herbicides have become a crucial aspect of integrated weed management strategies. Herbicides, chemical compounds designed to selectively target and eliminate unwanted vegetation, have long been a cornerstone of modern agricultural practices. However, the mere existence of these potent compounds is not enough; the efficient and targeted application of herbicides is essential to ensure their effectiveness, minimize environmental impact, and maximize the return on investment for farmers and land managers.

Keywords: science and technology, new methods, earth quality, weather, herbicides, weeds, chemical substances, research

Introduction: Improvement of cost efficiency in herbicide application can often be achieved by increasing application efficacy so that the same or better weed control is provided at a lower cost. This can be contrasted to increasing application efficiency, which is concerned with the rate at which an herbicide is applied and has no effect on total herbicide cost. One way to improve application efficacy is to ensure that herbicides are applied at a time when they are most effective at controlling a target weed species. This might involve the application of a specific herbicide at a different rate to control different weed species that are present in a crop at the same time. An example would be the use of a reduced rate of a broad-spectrum herbicide to control a less susceptible weed species so that a more susceptible weed species can be controlled with the same herbicide at a later application. Time of application can also be improved by accurately predicting when weed species are emerging and developing ways to assess this in the field.

In recent years, the expense of herbicide application has increased due to rising costs of herbicides and competitive costs of hired application. Hence, it is essential to consider developing technology that will make herbicide application more cost efficient. Development of new herbicide application technology is not only concerned with the engineering of new herbicide formulations but also with the aim of developing better ways to apply herbicides that will result in improved weed control at a lower cost. This paper will review the status of mechanical and spray technologies in use today and explore some new technologies that have the potential for improving cost efficiency of herbicide application.

The cost efficiency of every weed control method must be considered in the search for profitable weed control in industrialized agriculture. An herbicide is considered cost efficient

when it provides acceptable levels of crop damage and consistent control of the weed species at an expense that is less than the resulting increased crop value.

Overview of Herbicide Application

Broadcast treatments are used when the goal is to treat an entire area, such as a corn field, with the objective of killing all vegetation or killing a certain weed species that is interfering with the crop. Methods of broadcast treatments include spraying from ground-based equipment or aircraft, applying granular formulations, and various methods for treating aquatic weeds. Droplet or particle drift from the target area can be a concern with broadcast treatments and damage to non-target vegetation can occur. Advances in technology are aimed at reducing herbicide use and employing more targeted techniques even in situations where the objective is to treat an entire area.

Herbicides are chemical substances used to control or kill undesirable plants. The goal of herbicide application is to provide maximum efficacy on the target species while minimizing damage to the crop or environment. Herbicides are applied on a variety of crops and for a variety of purposes, as well as to control vegetation on rights of way, forests, and aquatic environments. The objective of herbicide treatments in these various situations can be quite different and a wide array of techniques are used to apply the material. In general, herbicide application techniques can be divided into two main categories: broadcast and spot treatments.

Importance of Effective Weed Control

It is extremely important that herbicides be applied in an effective manner. This requires that sprays reach the target site, be it soil, crop canopy or weed, and do so in a form that is not only active on the weed of interest, but also has minimal impact on crop safety, the environment, or non-target organisms. This is to ensure that herbicides are both economically and environmentally viable. There are a number of reasons why herbicides require effective application. The global reason is to ensure food security for the ever-increasing global population. Available arable land is decreasing due to urban expansion and land degradation. Loss of arable land has to be compensated by increased crop production in less land. Also, intensive land production is increasingly demanded in developed countries where rising costs have to be offset by increased efficiencies. In broadacre cropping, the biggest land users are herbicides as they are universally used in all tillage systems to control weeds.

Weeds are controlled by herbicides to prevent yield loss in a crop. It has been estimated that in the absence of weed control, yield losses can be up to 70% of the potential yield, i.e. crop failure. This is due to competition for water, light and nutrients between crop and weeds. Weeds which are aggressive and fast growing often outcompete crop for these essential resources. Herbicides are the most efficient and cost-effective means to target weeds and try to avoid yield loss in a crop. Weeds can also act as alternate hosts and carriers for pests and diseases of a crop. By preventing weed infestations, incidences of these pests and diseases can be reduced. An example is barley grass being an alternate host for cereal cyst nematode which is a devastating pest of cereal crops in Australia. By controlling weeds with herbicides, it is hoped that the nematode can be eradicated in a costly biological control program.

Challenges in Herbicide Application

It is at this point that the development and studying the various new technologies for applying herbicides to targeted weeds across the US will be critical. This will range from

equipment that can optimize the efficacy of the current herbicide tools to the testing of entirely new weed control tactics enabled by a given technology. The success of each will depend on its ability to provide a higher level of precision and/or better results than the current standards at a cost that is justified by the added benefits.

Simply changing the selective spectrum or increasing the price per acre of a given weed control tactic may not substantially affect its long-term profitability or sustainability compared to the previous practice. This is especially true for any tactic that requires a total system change to ensure it is used effectively. There are also inherent inefficiencies in merely trying to improve the effectiveness of the same weed control program. Alternatives to the current practice must be developed and thoroughly evaluated for their potential impact on the cropping systems and the targeted weed species in terms of economic viability and long-term sustainability.

Facing a more competitive business environment, burgeoning environmental constraints, and global demand to produce more food, fiber, and fuel on less land, the increasing technical skills and knowledge of the latest weed control practices by producers are essential. The current model of weed control using broadcast applications of soil residual herbicides is no longer sustainable, especially as commodity prices remain relatively low. The move by producers to place a greater emphasis on postemergence weed control to maximize the profitability of the crop has resulted in further questioning by farmers for the need to optimize the timing and placement of herbicides for increased efficiency and cost-effectiveness.

One of the primary advancements in herbicide application technology has been the emergence of precision spraying systems. These sophisticated systems, often integrated with GPS and advanced sensors, allow for the precise targeting of weeds, reducing the amount of herbicide required and minimizing the risk of off-target application. By precisely mapping weed infestations and adjusting the herbicide delivery accordingly, these systems enable a more judicious and environmentally responsible use of chemical control measures.

Furthermore, the development of intelligent spraying technologies, such as computer-controlled nozzle systems and variable-rate application, has revolutionized the way herbicides are applied. These systems can dynamically adjust the herbicide output based on factors like weed density, crop canopy, and environmental conditions, ensuring that the right amount of herbicide is applied in the right place at the right time. This level of precision not only enhances the efficacy of weed control but also reduces the potential for herbicide drift and minimizes the risk of non-target impacts.

Here are some key technologies for applying herbicides to control weeds:

Sprayers:

Boom sprayers - Mounted on tractors or self-propelled, apply herbicides uniformly over a wide area.

Handheld sprayers - Backpack or pump-based sprayers for spot treatments or small-scale applications.

Weed wipers - Wipe herbicide directly onto weed foliage, minimizing off-target application.

Precision application:

GPS-guided sprayers - Use GPS to precisely target weed infestations, reducing overall herbicide use.

Sensor-based sprayers - Detect weeds and only apply herbicide where needed, improving efficiency.

Robotic/autonomous sprayers - Self-driving units that can navigate fields and spray weeds autonomously.

Adjuvants and surfactants:

Adjuvants - Substances added to improve herbicide performance, such as wetting agents, emulsifiers, etc.

Surfactants - Reduce surface tension, improving herbicide coverage and penetration into weed foliage.

Herbicide application timing:

Pre-emergent - Applied before weeds germinate, preventing their emergence.

Post-emergent - Applied after weeds have emerged, targeting actively growing plants.

Selective - Target specific weed species while minimizing damage to desired crops or plants.

Specialized application methods:

Granular herbicides - Applied as solid particles, useful for soil-applied pre-emergent treatments.

Weed wipers - Wipe herbicide directly onto weed foliage, minimizing off-target application.

Injection systems - Inject herbicides directly into the soil or plant tissue for targeted control.

The choice of technology depends on factors like weed type, crop, field conditions, and the desired level of precision and efficiency in herbicide application.

In addition to precision spraying, the integration of unmanned aerial vehicles (UAVs), commonly known as drones, has become a game-changer in herbicide application. These aerial platforms, equipped with specialized spraying equipment, can access hard-to-reach areas, navigate complex terrain, and cover large swaths of land efficiently. By leveraging the unique vantage point and maneuverability of drones, land managers can target weeds in remote or inaccessible locations, ensuring a more comprehensive and effective weed control strategy.

The advancement of herbicide application technology has also led to the development of innovative delivery systems, such as controlled-release formulations and encapsulated herbicides. These technologies allow for the gradual and sustained release of the active ingredients, reducing the need for multiple applications and minimizing the risk of environmental contamination. Additionally, the emergence of precision application equipment, such as targeted spot sprayers and weed-sensing technologies, enables the selective application of herbicides, further reducing the overall chemical load on the environment.

Beyond the technological advancements, the integration of herbicide application technology with other weed management practices, such as cover cropping, crop rotation, and mechanical control, has become a hallmark of modern integrated weed management (IWM) strategies. By combining these complementary approaches, land managers can achieve a more holistic and sustainable solution to the weed problem, reducing reliance on herbicides and promoting the long-term health and resilience of agricultural ecosystems.

Conclusion

In conclusion, the advancement of technology for applying herbicides against weeds has been a crucial development in the field of modern agriculture. From precision spraying systems and intelligent application technologies to the integration of UAVs and innovative delivery methods, these technological innovations have significantly improved the efficiency, effectiveness, and environmental stewardship of weed control practices. As the challenges posed by weeds continue to evolve, the ongoing refinement and integration of herbicide application technology will undoubtedly play a pivotal role in ensuring the long-term sustainability and productivity of agricultural systems worldwide.

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