INTEGRATED WEEDS CONTROL IN SUGARCANE RATOON MANAGEMENT WITH BIOTECHNOLOGICAL AND MOLECULAR APPROACHES

Salma Niaz*, Abdul Khaliq*, M. Shahzad Afzal*, Naveed Akhtar**, Waqas Raza Arshad***
*Sugarcane Research Institute, Faisalabad **Agronomic Research Institute (V&O), Faisalabad
***Sugarcane Research and Development Board, AARI, Faisalabad

ABSTRACT

Sugarcane crop is a cash and industrial crop contributing 0.7% in Pakistan's GDP. It is providing raw material for sugar mills operating in the country. The average cane yield in Punjab is 742mounds per acre. The progressive cane farmers is achieving more than 1500 mound per acre yield by growing latest varieties like CPF-249, HSF-240, CPF-234, CPF-250, CPF-251, CPF-252 and CPF-253 released by Sugarcane Research Institute, AARI, Faisalabad. Each variety has different features and needs different inputs and management requirements for plant and ratoon crop. Weeds management especially of narrow leaves is a difficult agronomic approach being faced in sugarcane. In most agriculture farmlands of sugarcane, weed management is predominantly reliant on herbicide application. Other agronomic methods and agro-technological manipulations were also being practiced for improving the productivity of sugarcane ratoons. It includes dismantling of ridges, stubble shaving, sub-soiling within rows, inter-culturing within rows and earthing up end of May. But these manipulations were adopted at small scale in farm area of sugar mills and few progressive farmers in Punjab. The weeds control is mainly done with use of weedicides of pre-emergence and post-emergence groups. However, the overuse and misuse of herbicides has resulted in the uptrend of herbicide-resistant weeds. Many biotechnological and molecular strategies can be focused on alterations of plant architecture, increased drought adaptation capabilities, increased salt tolerance, and increased pest and disease resistance and to reduce herbicide-resistant weeds. It is concluded that modern molecular approaches like Gene discovery, "omics," and genome editing technologies as a tool for current and future weeds management strategies in sugarcane plant and ratoon crop.

Keywords: Sugarcane, Weeds, Molecular, Biotechnological, Pakistan, Ratoon

INTRODUCTION

The world population is projected to increase from the current average of 7.6 billion people in 2020 to 8.6 billion people in 2030. The food security for increasing population is a great challenge for agriculture research and meet the demand of sugar of world population. One of the most significant challenges facing crop improvement programs globally is the capacity to adequately match crop production with demand, thereby ensuring food security. Global crop production is affected by various abiotic and biotic stresses which are further worsened by climate change.

Ratooning is ways of growing full cane crop from new growth of underground stubbles left in the field after reap of the plant crop (Singh *et al*., 2013). Ratoon crop is cost-effective for the farming communities of Pakistan because making cost is 30% less than plant crop with saving of seed material as an extra benefit.

It saves the cost of seedbed preparation, seed material, irrigation and planting labour due reduced crop period. In Punjab, half of total sugarcane area is engaged as ratoon (Naeem *et al*., 2019) but it contributes 30% to total cane production (Srivastava *et al*., 2012) due to improper attention of the farmers towards ratoons. Low yield of ratoon crop is primarily because of peculiarity ratooning potential of cultivated varieties (Rafiq *et al.,* 2006) and pitiable ratoon management Techniques (Junejo *et al*., 2010).

Good ratoon management practices and inherent ratoon potential of a variety is of prime importance for sustaining high cane and sugar productivity (Cheong and Teeluck, 2015). Vast acceptance of a variety depends very much on its ratooning potential (Verma, 2002). The sugarcane varieties will show good performance in ratoon crop only if accompanied with best management techniques (Hemwong *et al*., 2009). Otherwise, the variety will flop to perform in field (Singh and Singh, 2004).

In world, sugarcane growing countries are taking two to five ratoons (Sundara *et al*., 2006). Good improvement of ratoon crop be determined by high sprouting of underground buds after harvesting of plant crop (Bashir *et al*., 2013). In multi-ratooning system, yield declined in successive ratoons can be enhanced by following good ratoon-management practices viz. loosening of inter-rows soil through chiseling, sub-soiling and earthing up to diminish soil compaction for root growth and preservation of trash to augment soil organic matter for resourceful utilization of water and nutrients (Hobbs *et al*., 2008).

Furthermore, in ratoon sugarcane, the mortality of facultative tillers usually happens, especially in case those sprout from the above-ground uneven portions of canes left after harvest. Therefore, stubble shaving are recommended within a week of harvest of sugarcane (Ahmed and Giridharan 2000).

Challenges in weed management

Despite the usefulness of integrated weeds management (IWM), such strategies need to be heavily researched to determine the appropriate cultural, physical, and chemical methods that would be the most beneficial for the agro-ecological zone. Additionally, the change in the global climate has rendered some tried and true practices ineffective, leaving the door open to innovation in IWM. Climate change has raised complications in a number of different agricultural systems, and many of the challenges with weed management.

Firstly, with the expected reduction in rainfall in already dry regions, the resilience of crops will be suffered. In this scenario, weeds have mechanisms to allow them to combat such stressors and out-compete the struggling crops, while also having extended periods of growth beyond their usual growing season (Ramesh *et al*., 2017).

Weeds have ability to quickly accumulate mutations to be better adapted to rapidly changing climate scenarios, in contrast to many crops which rely on breeding programs to introgression desired traits in a relatively slow manner. Focusing more on the management side, climate change is expected to result in the need for new weed management strategies that will need to be rapidly implemented to be an effective combatant to the rapid climate variance. The change in climate will also result in the increased instability of current herbicides.

Herbicide resistance in weeds

Continuous and non-judicious use of herbicides with the same mode of action creates herbicide resistance in weeds. From 1957 to 2020, the global reported number of unique cases of herbicide-resistant weeds has increased from 2 to 507 (Heap, 2022). In general, herbicide resistance mechanisms can be categorized into two broad types: (1) target-site resistance, and (2) non-target site resistance. Target-site resistance typically involves specific site mutations in the target enzyme, which prevents herbicide from binding to the target enzyme. Mutations could occur in the binding sites within the enzyme.

Other forms of target-site resistance include target gene amplification (the increase in target gene copies) and the increase in target gene expression.

These resistance mechanisms aim to increase the production capacity and abundance of the target enzyme, in which higher doses of a herbicide would be required to fully inhibit the target enzyme. Non-target site resistance stems from the physiological characteristics of the plant and how it absorbs, metabolizes, and/or sequesters the herbicide (Jugulam and Shyam, 2019).

Another example of non-target site resistance is through reducing translocation of the herbicide, so once the herbicide enters the source leaves they are prevented from reaching the growing and meristematic tissues *via* the phloem and/or xylem. Reduced translocation can be due to sequestration, which traps the herbicide molecules within the source tissues, or altered activity of transporter proteins, which either prevent or limit the entrance of the herbicide molecules into the phloem and/or xylem.

Weed seed bank persistence

Most weed species are known to be hardy and persistent in nature, producing thousands of seeds that can withstand various adverse environmental conditions, while staying dormant in the soil for long periods (Chauhan and Manalil, 2022). When optimal germination conditions are met, the seeds will germinate and compete with the crops sown on the same area of land. This makes weed management challenging.

Seed dormancy is the main contributor to a persistent weed seed bank globally. It is a heritable genetic trait. Recent genetic and molecular studies on seed dormancy have provided important genomic information to aid the understanding of seed dormancy in weeds.

Biotechnological and molecular approaches in weed management

Weeds are a detrimental threat to global crop production in both developing and developed countries (Chauhan, 2020). Overall, among the biotic factors causing crop losses, weeds contribute to the highest potential yield loss to crops. Some molecular approaches have been implemented in conjunction with herbicide application to reduce the proliferation of weeds in agricultural lands. Many molecular strategies for crop improvements have been largely focused on alterations of plant architecture, increased drought adaptation capabilities, increased salt tolerance, and increased pest and disease resistance. The development of glyphosate-resistant crops enables the application of glyphosate, a non-selective herbicide, to eliminate unwanted weeds in the field at various application timings, thus enhancing the level of weed control (Massel*et al*., 2021).

Gene discovery, “omics,” and genome editing technologies currently applied in crop research can be potentially applied to weeds as tools for weed management. Aside from GM methods, transient technologies relying on the non-transformative applications of RNA interference (RNAi) mechanism are also potential molecular approaches to control weeds instead of heavy reliance on herbicides.

These approaches could potentially manipulate expression of key genes in weeds to reduce its fitness and competitiveness, or, by altering the crop to improve its competitiveness or herbicide tolerance, by the molecular technologies in weed management**.** Genome editing may be used to improve crop resilience and adaptability to various environments, improve yields in suboptimal conditions. One such approach is the development of herbicide-resistant crops, such as the well-known Roundup Ready resistant crops (Barry *et al*., 1997).

CONCLUSION

It is concluded from above discussion that Biotechnological and Molecular techniques, like, genome editing, CRISPR/Cas9, gene drives, OMICS and RNAi technology, may be used for future molecular research on weed management as a tool for integrated weeds management in ratoon and plant sugarcane crop along with agronomical manipulation approaches. It will improve level of weeds control, higher cane and sugar yield.

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