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Role of Chemical Hybridizing Agents in Seed Production

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Effective pollination is a crucial step in optimal seed germination and it is affected by a wide range of variables, including the type of plant (self or cross pollination), the nature of the plant and the type of pollination (monoecious or dioecious). The transmission of desirable pollens is must in hybrid seeds production. The manual emasculation of bisexual flowers or monoecious plants—or their 50% population—is required, which raises the price of hybrids. Chemical hybridising chemicals are utilised as an alternative to such hand emasculation methods. The chemical hybridizing agents used as a pollen suppressor which induce femaleness without destroying the plants. CHAs are male sterility-inducing agents that prevent the production of viable pollen in the female plant, allowing for controlled pollination with pollen from a male plant of a different variety. The use of CHAs in seed production offers advantages such as increased yields, improved crop uniformity, and the ability to produce hybrid seeds in crops that are difficult to hybridize naturally.

Introduction

Chemical hybridizing agents (CHAs) are compounds that are used to induce male sterility in plants, allowing for the production of hybrid seeds through controlled pollination. CHAs have been widely used in plant breeding programs to develop crop varieties with improved yield, disease resistance and other desirable traits. This article will review the role of CHAs in seed production and discuss their advantages and disadvantages.

CHAs in Seed Production

CHAs work by disrupting the normal process of pollen production in one parent plant, resulting in male sterility. The other parent plant is left fertile, allowing for controlled pollination to produce hybrid seeds with desirable traits. CHAs have been used in a variety of crop plants, including maize, sorghum, pearl millet and rice. In maize, for example, CHAs have been used to produce hybrids with high yield, disease resistance and drought tolerance. In sorghum, CHAs have been used to develop hybrids with improved grain quality, disease resistance and higher biomass production. In pearl millet, CHAs have been used to produce hybrids with increased yield and improved nutritional quality. In rice, CHAs have been used to produce hybrids with higher grain yield and better milling quality.

Key feature of CHAs

1. **Induction of male sterility**: CHAs can induce male sterility in plants, which is a useful tool for plant breeding because it eliminates the need for labor-intensive hand pollination.
2. **Specificity**: CHAs can be designed to induce male sterility in one parent plant while leaving the other parent plant fertile, allowing for controlled pollination and the production of desired hybrids.
3. **Efficiency**: CHAs can produce a higher percentage of hybrid seeds compared to traditional breeding methods, which can be more labor-intensive and time-consuming.

4. **Versatility**: CHAs can be used in a variety of crop plants, including maize, sorghum, pearl millet, rice and others.
5. **Safety**: CHAs are generally safe for humans and the environment when used in accordance with recommended guidelines.
6. **Cost-effective**: CHAs are often more cost-effective than other methods of producing hybrid seeds, such as manual pollination or the use of male-sterile lines.
7. **Improved crop performance**: CHAs can be used to develop crops with improved performance characteristics, such as higher yield, better disease resistance and improved nutritional quality.
8. **Residual effect**: CHAs have no residual effect left on harvested seeds.
9. These are easy to use and effectively control the male parent without affecting female parents.

Types of CHAs

There are several types of chemical hybridizing agents (CHAs) used in seed production, each with a different mechanism of action. Here are some of the most common types of CHAs:

1. **Cytoplasmic male sterility (CMS) inducer**s: CMS-inducing CHAs work by inducing male sterility in plants through the disruption of mitochondrial function. This type of CHA is widely used in hybrid seed production for crops such as maize, sorghum and brassicas.
2. **Gametocides**: Gametocidal CHAs work by selectively killing male gametes in plants, leaving the female gametes intact. This type of CHA is commonly used in hybrid seed production for crops such as rice and wheat
3. **Hormonal agents**: Hormonal CHAs work by disrupting the balance of plant hormones, leading to male sterility in one parent plant. This type of CHA is commonly used in hybrid seed production for crops such as sunflower and maize.
4. **Inhibitors of nucleic acid synthesis**: These CHAs work by inhibiting the synthesis of nucleic acids in plants, leading to male sterility in one parent plant. This type of CHA is commonly used in hybrid seed production for crops such as tomato and peppers.
5. **Protein synthesis inhibitors**: These CHAs work by inhibiting protein synthesis in plants, leading to male sterility in one parent plant. This type of CHA is commonly used in hybrid seed production for crops such as soybean and cotton.

The use of chemical hybridizing agents (CHAs) and their doses can vary depending on the plant species, purpose of their use, environmental conditions and the specific CHA being used. It is recommended to follow the instructions provided by the manufacturer and consult with agricultural experts before using CHAs in crop production. Here are a few examples:

- In rice: A commonly used CHA in rice is sodium azide (NaN_3) which is applied at a dose of 0.2-0.3% (w/v) solution at the booting stage of the plant.
- In maize: Ethephon is a widely used CHA in maize. It is applied as a spray at a concentration of 250-1000 ppm at the pre-tassel stage of the plant.
- In sunflower: Ethrel (ethephon) is used as a CHA in sunflower. It is applied as a spray at a concentration of 100-200 ppm at the stage when the disc flowers are at the anthesis stage.

Each type of CHA has its own advantages and disadvantages and the choice of which type to use will depend on the specific crop and breeding program. It is important to use CHAs responsibly and in accordance with recommended guidelines to minimize their potential impact on the environment and to ensure the long-term sustainability of seed production.

Advantages of CHAs

The use of CHAs in seed production offers several advantages over traditional breeding methods.

- It eliminates the need for labor-intensive hand pollination, which can be time-consuming and costly.
- It can produce a higher percentage of hybrid seeds compared to traditional methods.
- It allows breeders to produce hybrids between plant varieties that are normally difficult to cross.

Disadvantages of CHAs

- One of the main concerns associated with the use of CHAs is the potential environmental impact. CHAs can be harmful to non-target organisms such as pollinators and their use can also result in the buildup of chemical residues in the soil. To minimize the environmental impact of CHAs, it is important to use them according to recommended guidelines and to implement appropriate management practices.
- Another disadvantage of CHAs is the risk of unintended pollination between the male-sterile and fertile plants. If unintended pollination occurs, it can result in the production of non-hybrid seeds, which can reduce the effectiveness of the breeding program. To prevent unintended pollination, CHAs are usually applied at a specific time during the growth and development of the plants.

Future thrust related to CHAs

There is need to focus on the development of new CHAs that are more effective, safe and environmentally friendly. Here are some potential areas of research and development:

- **Development of novel CHAs**: Researchers are exploring new chemical compounds that can induce male sterility in plants with high efficiency and specificity. This includes the use of plant growth regulators, such as gibberellins and auxins, as well as other chemicals that can disrupt specific metabolic pathways in plants.
- **Optimization of CHA application**: The optimization of CHA application methods and doses can help to maximize their effectiveness and reduce their negative impacts on the environment. Researchers are exploring different application techniques, such as foliar spray, seed treatment and soil application, as well as the use of different doses and timing of application.
- **Evaluation of CHA safety**: The safety of CHAs for human health and the environment is an important consideration in their use in seed production. Future research may focus on the development of CHAs that are less toxic or harmful, as well as the evaluation of their long-term impacts on soil health, biodiversity and ecosystem services.
- **Integration with other breeding methods**: The integration of CHAs with other breeding methods, such as marker-assisted selection, genetic engineering and genomic selection, can help to accelerate the development of new crop varieties with desirable traits. Researchers are exploring the potential synergies between these different approaches and developing new breeding strategies that combine their strengths.

Conclusion

In conclusion, chemical hybridizing agents play an important role in seed production by allowing breeders to produce hybrid seeds with desirable traits. While the use of CHAs offers several advantages over traditional breeding methods, it is important to use them responsibly to minimize the environmental impact and to ensure the long-term sustainability of seed production. Further research is needed to develop new CHAs that are safer and more effective, as well as to identify new applications for CHAs in plant breeding.

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