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SEED ADULTERATION IN AGRICULTURE: CAUSES, IMPACTS AND MITIGATION STRATEGIES

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ABSTRACT

Seed purity is the key for successful crop production, maintenance of genetic purity and satisfaction of consumers. However, currently, seed adulteration with foreign matters, off types, weed seeds etc. is a common problem. Natural admixture or human activities unknowingly or knowingly such as high profit, fraudulent activity of the seller are some of the general reasons of the seed adulteration. Through morphological analysis, genetic testing, germination and quality analysis, seed adulteration can be identified. Seed adulteration undermines buyer-seller confidence and imperils agricultural productivity. Many nations have rules and guidelines, which may address issues like as certification processes, labelling requirements, and penalties for seed adulterators. Farmers and consumers may take precautionary action by purchasing seeds from reputable suppliers, verifying that the package and certification are accurate, and reporting any suspicions of adulteration to the relevant authorities. A comprehensive approach involving industry standards, regulation, stakeholder engagement and education is necessary to mitigate seed adulteration.

Key words : Agricultural productivity, foreign matters, rules and guidelines, seed adulteration, seed purity.

Introduction

The level of genetic consistency and a batch of seeds' absence of pollutants or other impurities are referred to as seed purity (Sundareswaran *et al.*, 2023). It is an important component of horticulture, agriculture and seed production since crop cultivation success frequently hinges on the quality and purity of the seeds utilized. Using seeds with high purity is essential for achieving consistent and desired crop performance. It helps in obtaining uniform plant stands, predictable crop characteristics and better yields. Farmers and gardeners often rely on reputable seed suppliers and certified seed varieties to ensure seed purity and quality. There are several variables that affect seed purity. Genetic purity guarantees that a batch of seeds accurately reflects the genetic traits of the parent plant or variety. Genetic impurities may arise via cross-pollination between distinct kinds. Physical purity involves the lack of inert materials, weed seeds and other crops'

seeds in a seed lot. To preserve physical purity, appropriate cleaning and processing techniques are required. The percentage of seeds in a batch that have the potential to germinate in the right circumstances is known as germination purity. Low germination rates can lead to poor crop establishment. The moisture level in seeds must be within acceptable limits to preserve viability and avoid fungal or bacterial development. The usual method for determining the purity of seeds is laboratory testing and analysis. Many nations have seed certification schemes in place to guarantee that farmers and growers have access to pure, high-quality seeds. High seed purity is crucial to achieve desired crop performance, optimum yield and marketing. It is the cornerstone of productive agriculture and is essential to maintaining food security, environmentally friendly farming methods and the agricultural industry's financial stability. However, admixture of crop seeds with off types, weed seeds, wild varieties, dirt, or other materials is a common problem

now-a-days (Dietiker *et al.*, 2011). This is sometimes natural due to no protection in the environment and mostly human induced. Farmers or any concerned person can make seed adulteration unknowingly or knowingly hampering the purity of the seeds. It reduces the confidence of the buyers or end-users. In many cases, it has been found that genetic purity of a crop is lost due to sowing adulterated seeds. Crop production and its quality is largely dependent on the seed purity. It sometimes, increases the cost of production and causes health issues if the seeds are consumable. There is a need to address this issue at this hour aiming the food security of the nation.

Seed adulteration

The deliberate mixing or replacing of seeds with other materials, often of inferior quality or other varieties, to mislead consumers or purchasers is known as 'seed adulteration'. This may happen in several sectors, such as gardening, agriculture and food production. Adulterating seeds can result in the inadvertent growing of undesirable plants or crops, which can have detrimental effects on yield, produce quality, or even cause crop failure.

Types of seed adulteration

- **Mixing with inert material:** To make seeds look more numerous than they actually are, adulterants, such as sand, dirt, or other inert materials, may be added to them to enhance their weight and volume.
- **Substitution with older or lower-quality seeds:** Vendors may swap out high-quality seeds for old or lower-quality ones, jeopardizing the possibility of healthy plant development and abundant crop production.
- **Combining different seed varieties:** One way that adulteration occurs is when seeds from one variety are combined with seeds from another. Sometimes, off-types or weed seeds of visual similarity gets admixed with actual crop seeds. When planting and nurturing seeds, this might result in unanticipated outcomes.
- **Coating/ colouring:** Seeds can be treated with adulterants to give the impression that they are healthier or more colourful than they are.
- Sellers may purposefully mislabel their seeds, giving incorrect information about the kind, origin, and quality of the seeds.

Causes of seed adulteration

Many causes, many of which have their roots in market dynamics and economic incentives, might lead to

the adulteration of seeds. Adulterating seeds is frequently done primarily for financial gain. To provide reduced pricing and obtain a competitive advantage in a highly competitive market, merchants may turn to adulterating seeds. Sellers might boost their profit margins by combining cheaper or lower-quality seeds with higher-quality ones. To complete orders and stay in the market, merchants, who are experiencing a scarcity of authentic, premium seeds may resort to mixing or substituting seeds. Vendors may replace pricey or inaccessible seed kinds with more accessible or reasonably priced options. When there is a limited supply of a certain seed and a great demand for it, adulteration may happen. To satisfy consumer demand, sellers may have to mix or substitute seeds. Seed vendors can minimize manufacturing costs and boost profit margins by adulterating seeds with inferior or less expensive ingredients. Adulteration can be employed as a temporary tactic to preserve or increase market share, particularly in situations, when rivals are providing comparable goods at a reduced cost. There may be a greater chance of seed adulteration in areas with loose or ineffective laws governing seed quality. It's possible that some vendors are ignorant of the required handling and distribution procedures for seeds or are not completely aware of the repercussions of adulterating seeds. Farmers and consumers may unintentionally buy contaminated seeds, if they are unaware of seed quality requirements. Variations in the price or state of the market for seeds may force suppliers to economize and sacrifice seed quality in order to stay profitable. During planting seasons, suppliers may face pressure to fulfil requests, which might result in adulteration and shortcuts. Sometimes, seed adulteration can be natural or without the knowledge of the farmers. Mixing of mustard seeds with *Argemone mexicana* weed seeds is a great example which has created dropsy disease (Times of India, 2022).

Techniques for detection of seed adulteration

- **Morphological analysis:** To find any abnormalities, seeds can be inspected for size, shape, color, and other morphological traits.
- **Genetic testing:** To confirm the genetic purity of seeds and detect any alien genetic material, sophisticated genetic procedures can be used, such as DNA analysis (Wu *et al.*, 2023).
- **Germination tests:** By measuring the vigour and rate of germination, seeds may be tested to check if they satisfy the necessary requirements.
- **Quality testing:** Seed quality should be tested to find out the authenticity of a seed type (Orhan *et al.*, 2022).

Impact of seed adulteration on agriculture, environment and living organisms

The effects of seed adulteration on agriculture, the environment, and farmers' livelihoods can be profound and far-reaching. Among the major effects are:

1. **Decreased crop yields** : Poor germination rates and hampered plant development caused by adulterated seeds can lead to decreased crop yields. This has a direct impact on agricultural output and may cost farmers money.
2. **Problems with produce quality** : Crops grown from adulterated seeds may have lower-than-average quality, influencing attributes including size, color, flavor and nutritional value. The harvested produce's marketability and economic worth may be negatively impacted as a result. Farmers that unintentionally sow tainted seeds may suffer financial losses as a result of reduced yields and subpar crops. Their income may be impacted by this.
3. **Crop failure risk** : During the process of adulteration, crops may acquire undesirable characteristics or weaknesses that leave them more vulnerable to pests, diseases, and unfavourable weather. This makes crop failure more likely, which worsens the financial blow to farmers.
4. **Undermining the seed industry's trust** : Farmers and seed suppliers lose trust as a result of seed adulteration. Farmers may become more circumspect and doubtful about the quality of seeds on the market as a result of this mistrust, which might have long-term implications for the seed industry.
5. **Genetic contamination** : Through adulteration, genetic material from undesirable plants may unintentionally spread. The genetic purity of crops may be impacted by this genetic contamination, especially in the case of genetically modified (GM) seeds, which might have unforeseen effects on the environment.
6. **Environmental impact**: There can be an impact on the environment if adulteration uses invasive or non-native species. These species might threaten biodiversity, upset ecosystems and outcompete native plants.
7. **Legal repercussions** : Farmers that inadvertently sow tampered seeds may find themselves in hot water legally, particularly if the resulting crops violate intellectual property rights or other laws. Farmers may face increased financial strain as a result of legal actions.
8. **Market distortion** : By bringing in inferior goods, adulterated seeds have the potential to change the dynamics of the market. This may result in unfair competition and compromise the agriculture market's general integrity.
9. **Food security concerns** : Lower crop yields and lower-quality produce can be a factor in food security issues, especially in areas where agriculture plays a major role in the economy. Food supply and cost may be impacted by decreased agricultural output.
10. **Farmer confidence loss** : Farmers may lose faith in the whole agricultural input supply chain if they get subpar outcomes as a result of seed adulteration. This lack of faith can prevent the adoption of new kinds or technology, which would further impede the advancement of agriculture.
11. **Growing reliance on fertilizer and pesticide use** : Plants that have been exposed to contaminated seeds may be weaker and more susceptible to pests and diseases. To make up for poor plant health, farmers may turn to applying larger doses of fertilizer and pesticides, which might pose health hazards and pollute the environment.
12. **Economic and social divides** : The consequences of seed adulteration may be disproportionately felt by small-scale farmers, who frequently have little resources. The financial losses can exacerbate already-existing social and economic divides, which makes it more difficult for smaller farms to prosper and compete.
13. **Long-term effects on soil health** : Using tainted seeds repeatedly can have long-term effects on the condition of the soil. Overall agricultural sustainability in the impacted regions may be impacted by soil deterioration brought on by lower crop yields and a greater reliance on agrochemicals.
14. **Effects on genetic resources and seed banks** : The genetic diversity of seeds can be jeopardized by adulteration, especially if the adulterants add genetic material that is not local to the area. This puts seed banks and gene banks at risk, which are essential for retaining a variety

of genetic resources for agricultural requirements in the future.

- 15. Trade restrictions :** Adulteration of seeds can result in hurdles and disagreements in commerce. If there are doubts about the integrity and quality of their seed products, exporting nations may be subject to limitations that might harm their trading ties with other countries.
- 16. Setbacks in research and development :** Research and development in agriculture may suffer if tainted seeds are used. The development of superior crop varieties may be impeded if the findings of field experiments are tainted by adulterated seeds, as breeders and researchers depend on reliable data.
- 17. Increasing government financial burden :** To counteract the effects of seed adulteration, governments may need to set aside more money for oversight and regulation of the seed business, investigations and the implementation of educational initiatives. Public resources are subject to an increased financial strain as a result.
- 18. Consumer health issues :** Produce of poor quality as a consequence of tampered seeds might be harmful to consumers' health. The safety and nutritional content of the food supply may be impacted by nutrient shortages and the possible inclusion of dangerous chemicals.
- 19. Stagnation in innovation :** Adulteration of seeds can stifle innovation in the seed sector. Concerns about theft of intellectual property or unlawful use of genetic material that is unique to the company may make them extra cautious when creating and distributing new seed kinds.
- 20. Genetic pollution :** Genetic contamination can result via adulteration, which introduces undesirable genetic material into crops. This can have long-term effects for biodiversity and the genetic integrity of crops.
- 21. Volatility in the market :** Because seed adulteration can create doubts in the minds of buyers and sellers about the dependability and quality of seed goods, it can cause market instability. Price fluctuations and market imbalances may arise from this.
- 22. Supply chain upheaval :** The seed supply chain may be upset by adulteration, making it more difficult to satisfy the demand for seeds during planting seasons. The timely availability of seeds

for farmers may be impacted by this disturbance.

Mitigation strategies of seed adulteration

A comprehensive strategy combining the cooperation of farmers, seed providers, regulators and researchers is necessary to lessen these effects. This entails fortifying laws, encouraging environmentally friendly farming methods, and cultivating an open and accountable culture within the seed sector. Seed adulteration mitigation calls for a comprehensive strategy that includes industry standards, legislation, stakeholder participation and education. The following are some essential tactics to deal with and lessen seed adulteration:

- 1. Enhancing regulatory structures :** It is needed to implement and strengthen current laws pertaining to seed production, sales and labelling. Severe punishments are to be enacted for adulterating seeds, such as fines, license suspension, and legal repercussions for offenders.
- 2. Programs for seed certification :** It is required to create and support comprehensive seed certification processes to guarantee the authenticity and quality of seeds. It also helps farmers to buy certified seeds from reliable vendors that follow certification guidelines.
- 3. Testing and quality assurance :** Before seed batches are released into the market, thorough and frequent quality control testing on them is compulsory. To identify adulteration, testing standards are put in place for germination rates, genetic purity and other pertinent factors.
- 4. Openness throughout the supply chain :** To track the origin and treatment of seeds from manufacturing to distribution, traceability and transparency in the seed supply chain are to be promoted. Besides, it is also needed to promote the use of technology, such as blockchain, to increase traceability and decrease the danger of adulteration.
- 5. Public education and awareness :** It is highly essential to educate farmers, seed traders and other stakeholders about the dangers and repercussions of adulterating seeds by holding educational sessions. They should be given advice on how to spot real, high-quality seeds and report alleged instances of adulteration.
- 6. Assistance with research and development :** Through research and development, it is needed to create new technologies and techniques for authenticity and seed testing. It is required also

to encourage the creation of seed cultivars that possess inherent resistance against manipulation or adulteration.

7. **Working together with foreign organizations** : Collaborative work to embrace global standards and exchange best practices with international organizations like the International Seed Testing Association (ISTA) and the Food and Agriculture Organization (FAO) is highly recommended.
8. **Encouraging authorized seed distributors** : The farmers should be advised to get seeds from vetted, trustworthy vendors that follow quality requirements. To encourage compliance, incentives should be provided to certified seed merchants.
9. **Whistleblower safety measures** : It is needed to provide safeguards for informants, who expose cases of seed adulteration and promote a reporting culture in the industry for any questionable activity.
10. **Constant observation and monitoring** : Routine surveillance and monitoring systems to find and stop cases of adulterated seed should be established. It is essential to utilize technologies to keep an eye on seed producing regions and distribution networks, such as satellite photography and data analytics.
11. **Building capacity** : To improve agricultural extension officers' and other relevant personnel's ability to recognize and handle seed adulteration, training programs should be conducted.
12. **Technological remedies** : It is needed to examine how to authenticate seeds using contemporary technology including DNA fingerprinting, molecular markers and other cutting-edge genetic methods. Use of mobile apps and digital technologies that give farmers quick and simple ways to confirm the validity of seeds can be made.
13. **Multi-partnership cooperation** : To address the issue of seed adulteration, cooperation between governments, industry groups, non-governmental organizations (NGOs) and research institutes must be encouraged.
14. **Random sampling and testing** : To deter efforts at adulteration, randomly and covertly sampling seed batches from the market for testing reasons is needed. Further, frequently revealing of seed testing findings to foster openness and discourage possible miscreants can help.

15. Encourage the use of sustainable agricultural practices : It is essential to promote the use of sustainable farming methods that lessen the crop's need on outside inputs and protect it from the harmful effects of tainted seeds. Encouragement to the use of agroecological techniques that increase biodiversity and resilience is also required.

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Conclusion

Adulteration of seeds jeopardizes agricultural output and erodes buyer-seller confidence. Many nations have laws and standards for seed quality management in order to address this problem. These rules could cover things like certification procedures, standards for labelling and sanctions for anybody found guilty of adulterating seeds. By buying seeds from reliable vendors, ensuring that the packaging and certification are correct and reporting any suspicions of adulteration to the appropriate authorities, farmers and consumers may take preventative measures. Furthermore, protecting the integrity of the seed sector may be facilitated by supporting and upholding regional, national and worldwide standards for seed quality.

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