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Seed Recalcitrance in *Pisumsativum* (Pea Crops): Challenges and Solutions

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Abstract
Pea plants are an ideal crop to perform experiments relating to seed relcalcitrance and orthodoxy, because they are a stable source of nutrients in many communities. However, like with pineapple, strawberry and even calabash plants, there are several challenges that arise with *Pisumsativum.* The present contribution aims to widen our understanding of seed recalcitrance in pea crops. In this article, the causes, consequences and solutions to various issues pertaining to seed recalcitrance in Pisumsativum will be discussed. In addition, mentioned will be made on storage conditions ideal to pea crops and that are contrasting to orthodox seed behaviour.

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INTRODUCTION

Seed recalcitrance is a term that describes dessication tolerant seeds (Berjak and Pammenter, 1997). These seeds are also able to maintain their viability under conventional storage conditions (Singh, 2019; Berjak and Pammenter, 1997). Pea plants are a popular choice of study under the term seed recalcitrance because they are cultivated widely, and possess a sustained nutritional value (Singh, 2023). However, 3 main challenges exist with pea seed recalcitrance. These challenges are: seed preservation, overall crop management, and breeding program issues.

UNDERSTANDING SEED RECALCITRANCE

The nature of seed recalcitrance- Seed recalcitrance in pea crops is a term that requires further clarification, and this understanding can only occur by understanding the nature of seed recalcitrance (Singh, 2023). A recalcitrant seed is one that has inherent high moisture content, and this means that they are able to remain in a hydrated state (Roberts, 1973; Singh, 2023). This condition is opposite in orthodox seeds, which can tolerate low moisture content levels (read Singh, 2017b); and thus survive desiccation (read Sakai *et al*., 1968). Therefore, pea seeds are prone to damage during drying and are thus sensitive to drying (Singh, 2016).

Pea seed biochemistry- Pea seeds have a biochemical composition that distinguishes them from other type of seeds. In comparison with orthodox seeds, in pea seeds, it can be found that the levels of polyunsaturated fatty acids - a type of lipid - are in a much higher concentration (adapted, Singh, 2023). These lipids are very susceptible to oxidation, which is harmful, since this process produces harmful reactive oxygen species (Chaitanya and Naithani, 1994; Singh, 2017a). Reactive oxygen species are detrimental and affects pea seed viability during storage read Normah and Chin, 1991).

Storage proteins and complex carbohydrates- Within pea seeds there are complex carbohydrates and storage proteins. Maillard reaction products are produced within peas when the seeds are exposed to high temperature and moisture conditions (Singh, 2023). Once again, here too, the viability and longevity of the seeds are compromised, but in this case the Maillard reaction products cause structural changes and chemical alterations to the seeds (Singh, 2023), causing them to lose their longevity (Singh, 2017a).

Temperature sensitivity- Pea seeds react differently to high and low temperatures. It has been found that these seeds are sensitive to low temperatures (Singh, 2023). At low temperatures, pea seeds are susceptible to chilling injury, unlike, in orthodox seeds where the seeds can be stored at low temperatures for longer periods and not undergo viability loss (Singh, 2019). When the temperatures move below the critical threshold, pea seeds can accumulate irreversible damage Fu *et al*., 1993; Chaitanya and Naithani, 1994). This includes cellular death arising from membrane disruptions (Singh, 2017a).

CONSEQUENCES OF SEED RECALCITRANCE IN PEA CROPS

There are 3 main consequences of seed recalcitrance in pea crops. These are listed below:

Crop management challenges- The nature of recalcitrant seeds, as we've witnessed, is very fragile. As a result, farmers face many difficulties in managing pea crops (Singh, 2023). One of the biggest challenges is ensuring optimal storage conditions of the seeds, as well as, ensuring that the seeds are never exposed to chilling temperatures (read Fu *et al*., 1993).

Genetic variability challenges- One of the greatest challenges handling pea seeds is that their genetic variability can easily be reduced (Singh, 2023). This is a major setback in breeding programs that prioritizes these seeds, because the lack of genetic variability restricts the ability to breed new pea cultivars with good traits like improved yield, nutritional value and disease and pest resistance (read Bewley and Black, 1994).

Shelf life challenges- When pea seeds are compared with orthodox seeds, it can be said that they have a limited shelf-life (adapted; Normah and Chin, 1991). This is because pea seeds have high moisture content and are susceptible to drying (Singh, 2019). This is a limiting factor for seed banks and genebanks, since this challenge makes it difficult to preserve the genetic diversity of pea seed varieties (Singh, 2023).

ADDRESSING SEED RECALCITRANCE IN PEA CROPS

As seen, there are many challenges and concerns regard pea crop seed recalcitrance. However, several strategies have been developed to deal with these. These strategies are listed below:

Better storage methods- By having better storage methods, pea seeds can be contained in a controlled atmosphere that has an optimum temperature coupled with good humidity levels. This is essential to slow down the deterioration of recalcitrant seeds (Singh, 2019). However, it's difficult to obtain these conditions are it resource-intensive and is only a short- to medium-term solution.

Genetic techniques- There are several approaches used to identify genetic markers that can improve seed longevity in pea crops. The idea here is to able to develop pea cultivars with reduced recalcitrant traits by incorporating the markers into breeding programs (Bain and Mercer, 1966). In order for the seeds to be housed at enhanced conditions, the genetic approaches must ensure that selective breeding occurs for seeds that possess a lower lipid content and enhanced antioxidant system (Chaitanya and Naithani, 1994; Tomassi*et al*., 1999; Singh, 2017a).

Biotechnology approaches- There are two main techniques that have been found to be very promising in addressing seed recalcitrance. These techniques are genetic engineering and genome editing. In order to develop pea seed varieties with improved viability, scientists can target specific genes that are involved in lipid metabolism and oxidative stress responses (read Tomassi*et al*., 1999).

Conservation strategies- As mentioned, in order to preserve the genetic diversity of pea crops, genebanks and conservation institutes are crucial. In order to ensure long-term availability of genetic resources, there are many initiatives that are being explored to cryopreserve genetic resources in seed banks (read Poulsen, 1992).

CONCLUSION AND PERSPECTIVE

Pea seeds are a source of food in many communities and societies worldwide. There are many challenges with the recalcitrance of pea seeds, and these have far-reaching implications for agriculture and food security (Singh, 2023). During storage, pea seeds have a reduced viability. This is particularly ascribed to them having high moisture content, a different biochemical composition to orthodox seeds, as well as a low temperature sensitivity (Singh, 2023). In order to mitigate through these challenges, it has been discovered that improved methods of cryopreserving the seeds are an essential in seed and genebanks (Singh, 2023). This is the only way to improve breeding programs for pea seeds, and to ensure that pea crops are available for food production and sustained nutrients in communities (Singh, 2023).

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