Role of heat shock protein in seed science and technology: A review

Neha Thakur
School of Agriculture, Lovely Professional University, Punjab, India

ABSTRACT

Plants have inbuilt mechanisms to protect itself from harsh environmental conditions. Due to tremendous change in the environmental conditions there are certain possibilities that one can think of. One of such mechanism is the Heat Shock Proteins (HSP) in side plant cell. These are molecular chaperons that allow plants to survive in the higher temperature regimes by binding with the protein molecules thus preventing their disintegration due to warm conditions. HSP have role in heat tolerance, desiccation tolerance, seed development, maturation, seed germination and seed longevity. It also regulates plant cell development and working mechanism

Keywords: Heat Shock Protein, seed germination, longevity, stress proteins

Introduction

Seeds, which is a fertilized mature ovule during its development gain exceptional defensive mechanisms that permit it to endure heat to amazingly low water content. It also allow it to keep up their germinability significantly. Heat shock proteins (HSPs) are molecular chaperones that are produced enormously when cells are brought to raised temperature and different pressure. They are associated with various plant cell forms like protein collapsing, transport of proteins across membranes, guideline of protein exercises and avoidance of irreversible protein grouping. Also conditions such as hormone balance, temperature, light condition, water status, or lead to adjusted quality characters in plants. At the sub-atomic level, a standout amongst other described ecological reactions is the reaction to high temperature. Therefore study of Heat Shock Protein is essential from point of view of studying plant as well as seed development (Liu et al., 2016).

The worldwide air temperature is anticipated to increase by 0.2 °C every decade, which will causes 1.8–4.0 °C higher temperatures than the present level by the year 2100. This forecast is making anxiety among researchers, as heat stress affects the existence of living beings, acting straightforwardly or through the change of encompassing environment. In plants, due to its immobility to progressively higher temperature conditions the development and other mechanisms are significantly influenced causing regular mortally, by high temperature (HT) stress. Plant species adjusted to calm conditions, which includes crop plants, for example, maize, wheat, soybean and pea that also start to incorporate HSPs when tissue temperatures is more than 32-33° C. HSP respond to higher temperature. (Vierling, 2003).

There are various classes of HSPs present in eukaryotes that includes plants. These HSP can be identified by their molecular weights in kDa such as as HSP60, HSP70, HSP90 and HSP110. HSP also appear in form of low molecular weight e.g., (LMW) HSPs (15-30 kDa) (121, 126) (Vierling, 2003). In presence of higher temperature outside the cell surface, protein function inside the cell also degrades as represented in Figure 1. Heat shock protein binds to the protein and prevents its degredation due to higher temperature. This is because HSPs have better hydrogen bonds, hydrophobic internal packing, better enhanced secondary structure and helix dipole stabilization. Therefore it prevents the plant from major effects of high temperature
viz., phenology and dry matter accumulation, loss of water, yield reduction. It also causes inhibition of seed germination, reduction of plant growth, improper development of plant as well as, alteration in photosynthesis and in crop quality and oxidative stress. The tolerance mechanism of HSP inside a plant cell is described in figure 2. (Hasanuzzaman et al., 2013)

Figure 1. Pictorial representation of the loss of protein function inside cell

There are various varieties in crop plants that have tolerance to heat viz., Wheat (JW-3020, JW-3173, JW-3211, JW-3288, JW-3336, JW-1202, JW-1203, Chirya-3), Chick pea (JG-14 (Yezin 6), Annigeri, ILC 482 and ICCV 10), Rice (NH219, Nagina 22 (remain at 40°C temp.), Dular, IR-64) and Maize (31Y45 (Monsanto) and DKC9108 (Pioneer). Research pertaining to heat shock proteins in seed science and technology is represented in the table 1.
Figure 2. The tolerance mechanism of HSP inside plant cell

Table 1. Research done in Seed Science and Technology in relation to Heat Shock Protein

<table>
<thead>
<tr>
<th>CROP</th>
<th>SCIENTIST</th>
<th>Inference</th>
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<tbody>
<tr>
<td>Sorghum bicolor and Pennisetum americanum</td>
<td>Howarth et al., 1989</td>
<td>HSPs is essential for development of thermotolerance in seeds</td>
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<tr>
<td>Wheat</td>
<td>Helm et al., 1989</td>
<td>weaker heat shock responses in low vigor seed lots as compared to their high vigor counterpart</td>
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<td>Brassica campestris(rapa) L.</td>
<td>Bettey, et al., 1998</td>
<td>post-harvest drying of seeds promoted HSP synthesis</td>
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<tr>
<td>Arabidopsis</td>
<td>Wehmeyer and Vierling, 2000</td>
<td>there exist correlation in reduction in the sHSPs 17.4 and desiccation intolerance in seed</td>
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<td>Pea</td>
<td>Stupnikova et al., 2006</td>
<td>HSP22 in seed mitochondria and lipid composition lead to heat tolerance in seed</td>
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<tr>
<td>Arabidopsis</td>
<td>Su and Li, 2008</td>
<td>Hsp70, promoted seed germination</td>
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<tr>
<td>Jatropha curcas</td>
<td>Omar et al., 2011</td>
<td>During maturation of seeds JcHSP-1 and JcHSP-2 heat shock proteins contributed for cell protection and seed development</td>
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<tr>
<td>Sunflower</td>
<td>Personat et al., 2014</td>
<td>transcriptional co-activation of a genetic program for longevity and desiccation tolerance in seeds by HSP HaHSFA4a and HaHSFA9 lead to</td>
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References


