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ACCLIMATIZATION OF RICE (*Oryza sativa*) UNDER WATERSTRESS

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Abstract

Oryza sativa commonly known as Asian Rice is one of the principal food Crop in the world. But the water related stress causes severe menace to Rice plants and is major limiting and most challenging factor for its production. Small root system, thin cuticular wax, swift stomatal closure is some major morphological and physiological reason that makes rice plant more drought susceptible. Water stress affects rice plant at every level i.e. Morphological (reduced plant height, biomass, germination and tillers number), Physiological (reduced transpiration, photosynthesis, water use efficiency, chlorophyll content, stomatal conductance), Biochemical (accumulation of prolines, polyamines and antioxidants) as well as at molecular level (alteration in gene expression and mutation). Genes in rice plant and its genetic variations that is responsible for drought tolerance have been divulged via screening and study of germplasm and many studies are under process like installation of C4 photosynthetic pathway into rice gene as it is more efficient than C3 pathway in terms of water use efficiency. Many drought resistant varieties are already there like Hardinath 1, BRRIdhan 56 etc. (Indian drought tolerant varieties of Rice). It may be plausible to neutralize drought stress in rice in future by developing drought tolerant varieties. This article is mainly focused on effect of drought on rice plant, its response, adaptation, recent work on stress tolerant varieties, future possibilities which leads to acclimatization of Oryza sativa with high yield and less water.

Keywords:*Acclimatization, Oryza sativa, drought tolerant, C4 pathway, Genetic level.*

1. Introduction

Oryza sativa, commonly known as Asian rice is one of the most widely grown tropical cereal. It is cultivated in Europe, tropical and temperate Asia, Africa, Australia and America. Around 400 million tone of milled rice is produced every year. It is also a model organism for cereal biology as it can be genetically modified easily. Water stress is one of the major causes behind yield loss and economic loss of rice production across globe. The cause of water stress is traditional, biological as well as morphological. Water stress on rice crop can be easily identified by observing and studying its morphological changes. Drought stress not only effect at morphological level, it can affect at physiological, molecular, biochemical level which leads to severe damage to crop production. Rice plant also show few responses and adaptations to conquer these water stresses. But the only way to prevent rice crop destruction effectively is to adopt new strategy either via Gene alteration, adopting new crop growing methodology and using other biotechnological tools.

2. Cause of water stress in rice

Present rice production technique rely highly on ample water supply thus it is very vulnerable to water stresses and this contributes to severely limit the rice production. Waterstresses affect around 50% of the total rice cultivation around the world. Major causes for water stress in rice can be studied under two category-

2.1 Traditional cause-

- Farmers cultivate rice variety which require more water instead of using Hybrid variety which are more water stress resistant like *BRRIdhan 56*, *Hardinath 1* (Indian drought tolerant varieties).
- Geographically drought prone areas lead to lesser yield and more crop damage due to water scarcity.
- Climate change and other environmental imbalance contributes towards water stress as rice plant may not be able to adapt accordingly.
- Lower rainfall, more permeable soil, primitive agricultural practices are also few of the reason which affect rice cultivation and cause water stress.

2.2 Physiological/ morphological cause-

- Small root system- Rice plants have small root system as compare to other crops which leads to poor water uptake as roots are not able to proliferate in soil so well to absorb water from lower soil moisture.
- Thin cuticular wax- Rice plants show thin cuticular wax which contributes to high transpiration rate and thus more water loss specially in tropical and temperate regions.
- Swift stomatal closure leads to more water stress.
- C3 photosynthetic pathway- Rice plants exhibit C3 photosynthetic pathway which is less efficient in water use as compare to C4 photosynthetic pathway.

3. Identify drought stress-

Drought stress is severely damaging crop during reproductive stages especially during flowering. Rice plant shows many morphological changes during drought stresses. Some of them are-

- Stunted plant growth
- Delayed flowering
- Rolled leaves with burned tips
- Early senescence of leaves
- White head (but the tiller will still be attached to the stem)
- Decolouration of leaves and induced deposition
- Increased number of trichomes and stomata on leaf surface
- In severe water stress Roots will also shrink.

4. Effect of drought stress on rice plant-

Drought tolerance is a complex trait, which is a combined function of various morphological, biochemical and molecular characters. So, now we will see drought induced effect on morphology, physiology, biochemical processes, molecular structure and function as well as on yield.

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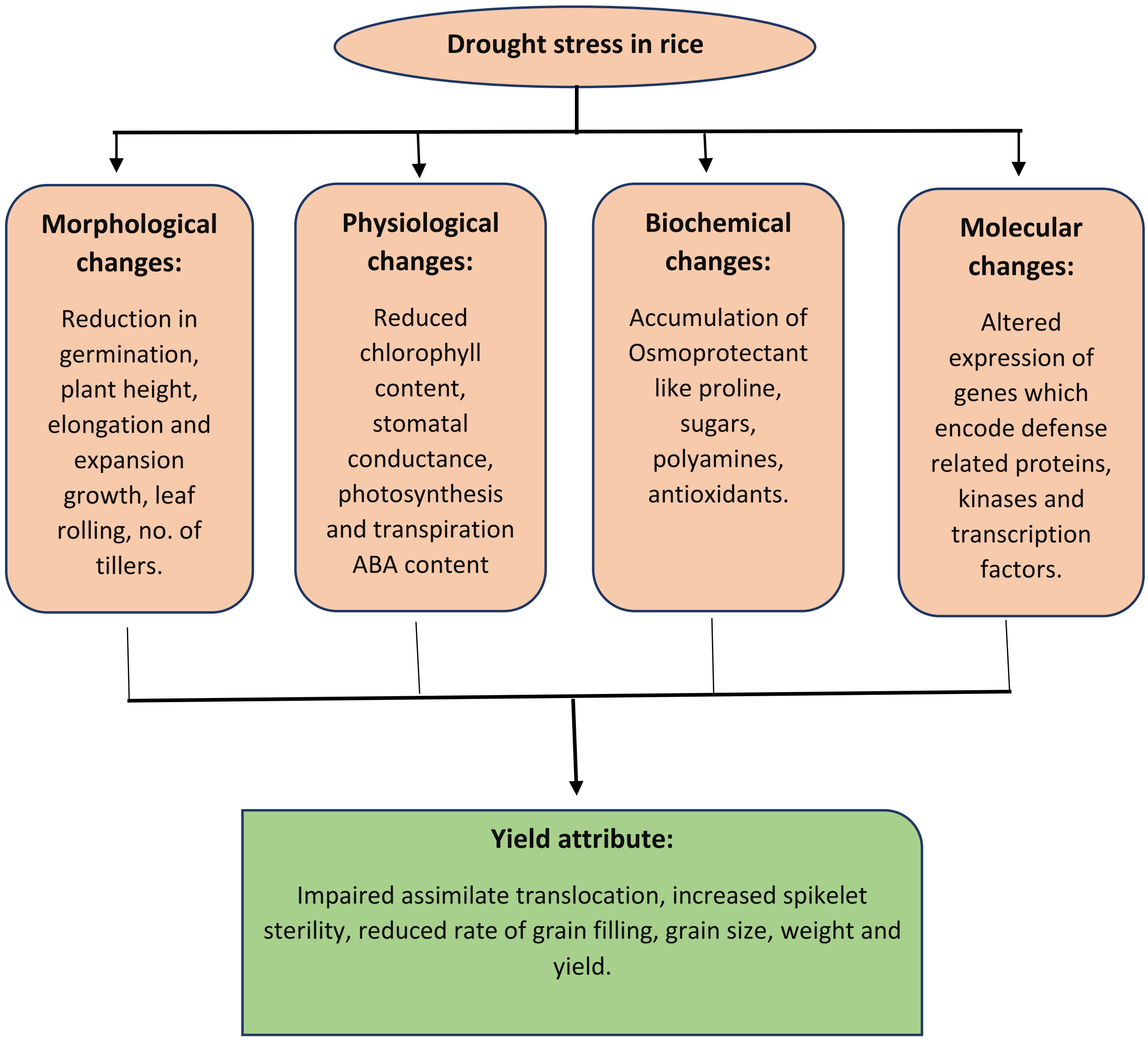

Fig.1. Drought induced various responses in rice which ultimately affect yield. (researchgate.2015)

4.1 Effect of drought on morphology of rice plant-

Various studies on rice plant during water stress has proved that water scarcity induce drastic morphological changes in morphology of rice plant.

- Reduction in plant growth and development of rice (Tripathy et al, 2000).
- Due to reduction in turgor pressure under water stress, cell growth is severely impaired which inhibits cell enlargement, elongation and expansion and cell division leads to stunted growth of rice plant. (Taiz and Zeiger, 2006, Shao et al, 2008).
- Affect the germination of rice seedling and reduces number of tillers (Jiang and Lafitte, 2007; Swain et al, 2014).
- Reduction in biomass i.e. decrease in fresh and dry weight of shoots and roots. (Taiz and Zeiger, 2006).
- Leaf rolling, reduction in no. of leaves which leads to reduced transpiration, induced light interception and reduced photosynthesis. (Kadioglu and Terzi, 2007).

4.2 Effect of drought on physiology of rice plant**-**

Water scarcity affects rice plant physiology in countless ways.

- Drought induce reduction in net photosynthetic rate. CO2 is a major limiting factor for photosynthesis as due to stomatal closure in water scarcity reduces the diffusion of carbon di oxide which reduces the activity of photosynthetic enzymes. (Centritto et al, 2009).
- Also effect Transpiration rate, stomatal conductance, water use efficiency, relative water content etc. (Kumar S et al, 2014).

4.3 Effect of drought on biochemical processes of rice plants-

As water deficit occurs, plants accumulate different types of organic and inorganic solutes in the cytosol to lower osmotic potential, thereby maintaining cell turgor (Rhodes and Samaras, 1994). This biochemical process is known as osmotic adjustment which strongly depends on the rate of plant water stress.

- Proline plays a highly beneficial role in plants exposed to various stress conditions. In plants under water stress, proline content increases more than other amino acids, and this effect has been used as a biochemical marker to select varieties aiming to resist to drought (Fahramand et al, 2014). Thus, proline content can be used as criterion for screening drought tolerant rice varieties.
- Polyamines (PAs) are small positively charged molecules which are involved in the response to drought (Calzadilla et al, 2014). Under drought stress conditions, higher PAs contents in plants are related to increased photosynthetic capacity, reduced water loss, improved osmotic adjustment and detoxification. However, the mechanism of action is not yet fully understood.

4.4 Effect of drought at molecular level of rice plants**-**

At the molecular level, the response to drought stress is a multigenic trait.

- Stress inducible genes are those that regulate gene expression and signal transduction in the stress response in rice plant, which include transcription factors and protein kinases (Seki et al, 2003).

- These drought-induced regulatory and functional genes have been used to increase drought tolerance through gene transfer.
- Transcription factors are the major regulators of gene expression (Nakashima et al, 2014) and are considered to be key targets for biotechnological engineering of stress tolerance in plants (Liu et al, 2014).

5. Technique to prevent water stress in rice plants-

Rice production is a complex “biological factory”. Farmers work in a system of great unreliability. Heavy rainfalls, droughts and temperature rises are already affecting the production and quality of products.Nevertheless, farmers have developed routines and strategies to cope with uncertainties and continuously create more resistant varieties.
Rice in Southeast Asia: Facing Risks and Vulnerabilities to Respond to Climate Change. So, it is a need of an hour to adapt a new techniques and practices to prevent rice plant destruction from water stresses. So, few techniques and practices are given below: -

5.1 Inducing C4 pathway in rice plant: -

An international long-term research collaboration (international C4 rice project, Oxford University 2020) aimed at creating high yielding and water use efficient rice varieties, has successfully installed part of the photosynthetic machinery from maize into rice.

They assembled five genes from maize that code for five enzymes in the C4 photosynthetic pathway into a single gene construct and installed it into rice plants.

Rice plant uses the less efficient C3 photosynthetic pathway. Scientists predict that the introduction of the more efficient C4 photosynthesis traits into rice can potentially increase photosynthetic efficiency by fifty percent, improve nitrogen use efficiency and double water use efficiency.

Although introducing all the genes required to make C4 rice still a long way off.

5.2 System of Rice Intensification (SRI): -

Compared with common rice production practices, SRI has numerous benefits as it is an example of options available to farmers and nations to promote community-led agricultural growth, while managing soil and water resources more sustainably and even enhancing their future productivity (Africare, Oxfam America, WWF-ICRISAT Project, 2010).

Successful applications of SRI have shown that farmers are able to increase their paddy yields by 50–100% while using fewer inputs, in particular water (farmers were able to reduce their water requirements by about 25–50%) (Uphoff, 2007).

rice cultivated under SRI grows with stronger stalks and longer roots, it is more resistant to episodes of drought, waterlogging, storm and typhoons.

5.3 Breeding and Hybrid rice varieties: -

The requirements of drought tolerant rice varieties have long been felt to ensure crop production in rainfed areas. Being a semiaquatic crop, rice gets severely affected by even moderate intensities of drought and varying levels of yield decline can be seen depending on the variety being grown. Drought tolerance can broadly be achieved through three major mechanisms: -

. (1)Drought escape due to early completion of the life cycle: this is particularly useful in the scenario where drought is a recurrent phenomenon at the end of the growing season. In such cases, early flowering varieties can escape terminal drought.

(2) Dehydration avoidance which enables the plant to uptake or conserve more water to avoid dehydration: this is achieved through traits related to root architecture, stomatal control, and transpiration efficiency.

(3) Dehydration tolerance which is achieved through traits such as cell membrane stability, osmotic adjustment, stem reserve mobilization, and stability of flowering process:conventional andmolecularbreeding approaches targeting these traits have been used in the past to develop drought tolerant rice varieties.

Conclusion

Drought is one of the most widespread and damaging of all environmental stresses, affecting 23 million hectares of rainfed rice in South and Southeast Asia alone. Drought affect rice plant at every level either it is morphological, physiological, molecular as well as biochemical which together alter yield of rice production. As rice is one of the most important staple crop around the globe it is a need of an hour to work in the area of acclimatization of rice crop either via improving traditional agricultural practices or via adopting different Biotechnological practices to reduce drought effect like Intensification of rice plant, Altering genes like converting C3 to C4 synthetic pathway etc.

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