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S&T REVIEW

COLD STRESS IN WINTER AND SPRING RICE

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ABSTRACT

In terms of area covering, production, productivity, and preference; Rice is ranked second in worldwide after wheat. Having more than 1,700 land races of rice, Nepal is considered as one of the origins for Asian rice. When there occurs out the variation in the normal temperature range in the plant, the various phenomenon like; Physiological, Cellular, metabolic and molecular disfunction is observed out which leads to death of the plant. At lower temperatures, stress tolerance can be induced by exposure to reduced temperature and is known as chilling tolerance and/or cold acclimation. Chilling tolerance is the ability of a plant to tolerate low temperatures (0–15 ◦C) without injury or damage, while cold acclimation is an enhanced tolerance to the physical and physiochemical vagaries of freezing stress. It limits the geographic distribution of plants and reduces the yield of some crops by shortening their growing season. Rice is mainly considered as a chill sensitive crop. The general aims of the review paper are to identify the various cold stress symptoms seen in rice and also recommend the best solution for removing cold stress on rice i.e., on both farmer level and researcher level. Therefore, this review focuses on the increasing in tolerance level of the cold stress.

KEYWORDS

Spring rice, Cold Stress, Tolerance, Chilling Injury, Freezing Injury, Symptoms, Damage

1. INTRODUCTION

In terms of area covering, production, productivity and preference; Rice is ranked second in worldwide after wheat (Tripathi et al., 2019; Gowda, 2012). Rice contributes 7% to GDP and 20% to AGDP. The total production of rice is 5.56 million metric ton under 1.46 million ha area with productivity of 3.81 mt/ha (MOALD,2019). The given below table 1 and Table 2 signifies the area of cultivation in Nepal at different Agro-ecological zones

Table 1: Area of Cultivation in Nepal at Different Agro Ecological Zones

Agroecological zones	Area of Cultivation
Terai Region	70%
Hilly Region	26%
Mountain Region	4%

(Source: MOALD, 2015)

Table 2: Area of cultivation of rice in Nepal at different growing season

Growing Seasons	Area of Cultivation
Main (Barkhe) Season	92%
Spring (Chaite) Season	7%
Boro and Bhadaiya Season	1%

(Source: MOALD, 2015)

In the low-lying areas of Nepal there is the special rice cultivation practice at the time of November to May which utilize out the residual water available in the field; moisture retention capacity and surface water storage which is known as Boro rice Cultivation. It is considered as the alternative way of utilizing the fallow land area as in this area after the harvesting of the normal rice it is not utilize out for any winter crops as there is presence of excessive moisture and the water retention (Bhujel and Ghimire, 2006). This method of rice cultivation coincides with the Nepali month "Chaitra" and so named as Chaite rice as it is sown in the last week of February to the first week of March and follows transplanting of 30-40 days old seedlings. In plant we observe out the maximum rate of growth and development in an optimum temperature (Fitter and Hay, 1981).

When the temperature deviates out from the normal temperature range there occurs various changes within the plant: Physiological, biochemical, metabolic and molecular changes. Due to this it lead the plant to make an effort on maximizing out the various growth and developmental phenomenon and also maintaining out the homeostasis of cell under the adverse conditions. On further increasing out the stressful conditions plant phenomenon leads to be more abnormal, impaired or dysfunctional cellular and whole-plant processes until the cardinal temperatures are reached for the survival (Fitter and Hay, 1981). When there occurs out the variation in the normal temperature range in the plant, the various phenomenon like; Physiological, Cellular, metabolic and molecular disfunction is observed out which leads to death of the plant. Plants experience stress condition under the high temperature exposure as well under the lower temperature exposure.

At the low temperature, stress tolerance can be persuaded by the exposure at the reduced temperature and is known as chilling tolerance and/or cold acclimation. Chilling tolerance is the ability of a plant to adopt at low temperatures range (0–15 ◦C) without injury or damage, while cold acclimation is a phenomenon of adaptation of the tolerance to the physical and physiochemical vagaries of freezing stress (Somerville, 1995; Guy, 1990; Thomashow, 1999). Both cold acclimation and chilling tolerance involve simultaneously bringing out variation at the biochemical, molecular and metabolic processes (Thomashow, 1999; Larkindale et al., 2005; Kotak et al., 2007; Zhu et al., 2007). This cold acclimation and chilling tolerance lead to reducing the geographic distribution of plants and also results in the variation on the yield of some crops by shortening their growing season. Rice is mainly considered as the chill sensitive crop.

2. OBJECTIVE

The general aims of the study are to identify the various cold stress symptoms seen in rice and also recommend the best solution for removing cold stress on rice i.e., on both farmer level and researcher level. Therefore, this review focuses on the increasing tolerance level of the cold stress.

The following are some of the specificized objectives:

a. To know about cold stress phenomenon.

b. To find out the visible and other symptoms created through cold stress in seedling stage.

c. To find out and recommend possible measures to overcome cold stress in seedling stage.

3. Discussion

3.1 Type of Low Temperature Injury

When the plant gets exposed to the low temperature then it experiences two types of injuries i.e.

Chilling injury: it is the injury which occurs due to the exposure of the plant to the lower temperature i.e.<10^{0}C. This phenomenon remains capable of being changed but ultimately leads to cause cell damage due to prolonged cold exposure.

Freezing injury: It is the injury which occurs due to the exposure of the plant at the temperature 0^{0}C. In the protoplasmic structure, when there is large growth of ice crystals which is enough to disrupt the cells, then in the protoplasmic structure the intracellular freezing becomes fatal.

A water vapor deficit is created as cellular water is transferred to ice crystals formed in the intercellular space due to which in the extracellular freezing, the protoplasm of the plant becomes dehydrated.

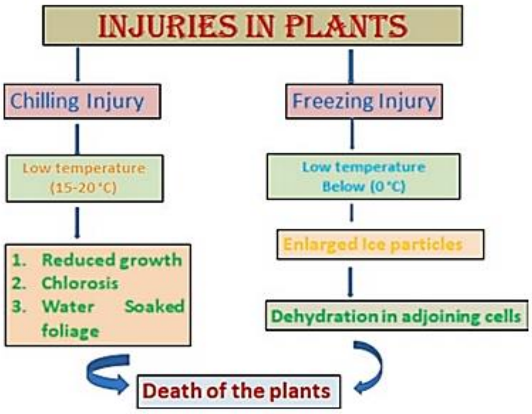

Figure 1: Consequences observed on plants due to cold stress phenomenon (Sindhu et al., 2020)

Among these two types of low temperature injury, i.e., chilling injury and freezing injury. In Rice crop, chilling injury is most commonly observed injury whereas freezing injury may also occur once in a while.

3.2 Effect of Low Temperature on the Physiological Response of Rice

In rice, Low temperature is the main reason of the serious yield reduction as it alters out the various physiological process from a seed germination to maturity. The development of the visual symptoms is seen as there is change in physiological activities. At the lower temperature, the photosynthetic activity and the carbohydrates metabolism decreases whereas the rate of respiration and the ion leakage increases. Low temperature consequences lead to nutrient deficiency at the root (Gagoi and Baruah; 2000). Without withering, under the permissive temperature conditions; In the developing young leaves the low temperature induces chlorosis which remain white (Yoshida et al., 1996). At the chilling temperature, feedback inhibition of the photosynthetic enzymes occurs which induces the starch buildup in the chloroplast that hinders out the photosynthetic activities. At the chilling temperature, there occurs decrement in the utilization of the excitation energy, Photoinhibition of the photosynthetic machinery is enhanced (Sonoike, 1999).

Types of Plant Species, Developmental Stage, Nutrition, Irradiance and other climatic conditions before, during and after the chilling exposure are some of the factors that influence the degree of the dysfunction. Among the 2 subspecies, i.e., Indica subspecies and the Japonica subspecies, indica subspecies are known to be the more sensitive to the low temperature than that of japonica subspecies (Cruz and Milach, 2004; Hetheringthon et al., 1989). Among the phenological stages of rice, Early germination and microspore genesis stage in the rice are considered to be more sensitive to low temperature stress (Bosetti et al., 2012; Cruz and Milach, 2004; Gunawardena et al., 2012). Increased nitrogen application greatly exacerbated the seedling and/or panicle development stage at the low temperature. Owing to the photooxidation damaged determined by the increase of the harmful active oxygen species, under the illuminated condition chilling causes greater injury (Krishnaswamy and Seshu, 1984; Wise and Naylor 1987). The damage in the photosynthetic machinery can be reduced by cloudy conditions or darkness during the chilling stress.

3.3 Analysis of the Cold Temperature Response on rice cultivars

In time of seedling stage and the reproductive stages, evaluations of rice cultivars for improved cold tolerance is mainly performed. In the direct-seeding production system, at the germination stage, the cold tolerance is a significant component of rapid seedling establishment and development of uniform crop strands. (Krishnasamy and seshu, 1989). Considerable variation in the extent of cold tolerance is exhibited by seedlings of various O.sativa germplasm accessions as rice is cultivated in the regions that range from tropical to temperates (Kim and Tai, 2011; Sharifi, 2010). So, It is essential to evaluate the cold tolerance at the seedling stage which is the important factor for the adaptation to high altitude or high latitude loactions that can experience cold temperatures at night or early or late in the growing season. For the pollen survival, seed set and grain filling to ensure maximum yield, During the reproductive stage cold tolerance is considered to be critical. (Sush et al., 2010).

4. Conclusion

At the present context researchers are mainly involved in identifying and developing the variation that are observed in the rice due to the reduction in the optimal temperature of the rice. By using out various plant breeding procedure and genome modification techniques have provided the optimum level of tolerance to the cold temperature. Through this process it results out the formation of the unwanted collateral translates or missing the translational products along with the expected output. Sustainable output result is predicted to come only when the researchers consider all the regulatory mechanism and pathway in a single event of approach.

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