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# Hormonal Regulation of Grain Filling in Rice through Foliar Application of Nutrients and Growth Promoters

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**A rapid increase of grain weight after flowering and fertilization in rice plants is closely related to the level of endogenous plant hormones. There is a rapid increase in grain weight after fertilization, suggesting that endogenous plant hormones play an important role in increasing grain filling and rate of rice. The rates of cell division and grain filling are not only correlated with the levels of ABA and ethylene, but are also correlated with the ratio of ABA to ACC in grains. Hence, a study was conducted at the Department of Rice, Tamil Nadu Agricultural University, Coimbatore during *Kharif* season with nine treatments in three different rice genotypes (ADT (R) 49, Rice CO 52 and CO (R) 50). In our study, ABA concentration was higher in the superior grains of the genotype rice CO 52 (38.0 ng. g$^{-1}$) than the genotype ADT (R) 49 and the low ABA concentration was observed in the control in both the genotypes. Similarly, the ethylene concentration was high under control in the inferior grains of the rice genotypes ADT (R) 49 - 0.053 nmol. g$^{-1}$ DW (dry weight) h$^{-1}$and Rice CO 52 - 0.042 nmol. g$^{-1}$ DW h$^{-1}$than the treated plants. To conclude, the hormone ethylene and ABA contents in superior and inferior grains of current study had shown the ABA concentration is higher in the superior grains than the inferior grains and the ethylene concentration was also higher in the inferior grains than the superior grains. ABA application promoted endosperm growth by improving the assimilate partitioning to filling of grains.**

**Key words:** Rice, Superior grains, Inferior grains,Abscisic Acid, Ethylene, 1-MCP.

Rice (*Oryza sativa L.*) is the most important food crop around the world, which provides over 21% of the energy of the world's population (Fitzgerald *et al*., 2009). In Asia, 90 per cent of the world's rice is produced and consumed. Grain filling in rice is characterized by its duration and rate which exhibit significant genotypic variation in each crop season.In general, the grains usually located on apical primary branches in a panicle have earlier flowering time, fill faster and produce heavier grains defined as superior grains. The later-flowering inferior grains which are usually located on proximal secondary branches, which fill slowly and poorly, consequently produce lighter grains.In compact-panicle rice high grain density compromises with the metabolic dominance of apical spikelets; the development of spikelets becomes relatively homogeneous in which ethylene production is stimulated to the detriment of grain filling.

A rapid increase of grain weight after flowering and fertilization in rice plants is closely related to the level of endogenous plant hormones. The spikelet development may also be mediated through endogenous hormones (Yang *et al*., 2000, 2001) and a low ratio between promotive and inhibitory hormones in inferior spikelets may lead to their poor development (Naik and Mohapatra, 1999). Antagonistic interactions between ABA and ethylene may be involved in mediating cell division and grain filling.Nitrogen, in one form or another, accounts for about 80 per cent of total mineral nutrients absorbed by plants.Potassium application can enhance the number of grains per spike, the percentage of filled grains and 1000-grain weight of rice (Bahmanyar, 2005). The critical micronutrient for plants is zinc as it is an essential component of thousands of proteins in plants (Broadley*et al.,* 2006). The main physiological function of *6-benzylaminopurine* is to promote cell division and induce cell differentiation. Homobrassinolidesare also associated with increased metabolic processes likephotosynthesis (Sairam, 1994) and protein synthesis (Kalinch*et al*., 1985). Tsukaguchi*et al*. (1999) have suggested that ABA has involved in assimilate partitioning among spikelets in rice panicles. 1-Methylcyclopropene (1-MCP), a potent inhibitor of ethylene action (Taiz and Zeiger. 2002) has been applied to a rice cultivar sensitive to the hormone at the pre-anthesis stage of the development.Mohapatra*et al.* (1993) have suggested that manipulation of spikelet development with hormones or external growth regulators or nutrients may be an option for improved partitioning of assimilates in favor of the inferior spikelets for higher grain filling. With these ideas in view, the present study was investigated to study the regulation of grain filling process by the level of endogenous hormones present in the superior and the inferior grains.

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## Material and Methods

The field experiment was conducted during Kharif 2016 at Department of Rice, Tamil Nadu Agricultural University, Coimbatore. The experiment was plotted in a randomized block design with three replications and nine treatments. Three rice genotypes such as ADT 49, rice CO 52 and CO (R) 50used as experimental material with all normal cultural practices followed for rice cultivation. The treatments, as T2 - 2% DAP+ 1% KCl, T3 - 2% MAP+ 1%KCl , T4- ZnSO4 0.5%, T5 - Nutrigold 0.5%, T6 - 6-Benzylaminopurine 30 ppm, T7 – Brassinosteroids 0.3 ppm, T8 - 1- NAA - 100 ppm and T9 - 1-MCP 20 ppm. The control plots (T1) were sprayed with water. Foliar spray was taken up at two stages, pre-anthesis (just before heading) and post-anthesis (2 weeks after flowering or during grain filling stage). Five plants were collected from each treatment and replications for recording observations on grain filling traits and yield and yield components. The endogenous hormones ABA and ethylene concentration in seeds during physiological maturity were estimated in the two best performing genotypes ADT (R) 49 and Rice CO 52 in both superior and inferior grains by the High Performance Liquid Chromatography (HPLC) and the Gas Chromatography Mass Spectrometry (GCMS).

## Results and Discussion

### *ABA and ethylene concentration in grains*

The present data showed variations in the hormone concentration (ABA and ethylene) in grains ofrice genotypes (ADT (R) 49 and Rice CO 52) due to the different foliar treatment.

On analysis of abscissic acid in rice grains, the ABA content increased significantly in both the genotypes compared to control. Thegenotype Rice CO 52 recorded highest value in the superior grains (30.7 ng. $g^{-1}$) followed by ADT (R) 49 (27.3) (Table 1). Similarly the lowest mean value had recorded in the inferior grains of the genotype ADT (R) 49 -18 ng. $g^{-1}$). Considering the treatments,$T_9$ -1-MCP (20 ppm) was observed higher ABA concentration (38 ng.$g^{-1}$) in the superior grains of the genotype CO (R) 50. Similarly, in case of inferior grains, the treatment $T_6$ - 6-Benzylaminopurine (30 ppm) was recorded (21) in the same genotype.

On analysis of ethylene, the ethylene concentration is higher in control compared to the foliar applications. The treatment $T_9$ -1-MCP (20 ppm) which is an ethylene inhibitor to reduce ethylene action, recorded the lowest ethylene concentration (0.008 and 0.005 nmol. $g^{-1}$ DW $h^{-1}$) in the superior grainsof two rice genotypes ADT (R) 49 and Rice CO 52(Table 1). Correspondingly, the inferior grains were observed the higher value when compared to the superior grains in both the genotypes.

Grain filling process in rice was closely associated with the changes in hormone contents (Yang *et al*., 2003).The hormone concentration in grains significantly increases with the different foliar application.A higher ratio of ABA and ethylene in rice spikeletswould be required to enhance the grain filling rate.

**Table 1.Effect of nutrients and plant growth promoters on abscisic acid and ethylene concentration on seeds at physiological maturity**

| Treatments | Abscisic acid (ng.$g^{-1}$) | | | | Ethylene (nmol.$g^{-1}$ DW $h^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | ADT (R) 49 | | Rice CO 52 | | ADT (R) 49 | | Rice CO 52 | |
| | Superior grains | Inferior grains | Superior grains | Inferior grains | Superior grains | Inferior grains | Superior grains | Inferior grains |
| Control | 20.0 | 12.0 | 23.0 | 16.0 | 0.015 | 0.053 | 0.011 | 0.042 |
| 6-Benzylaminopurine (30 ppm) | 28.0 | 22.0 | 31.0 | 26.0 | 0.013 | 0.042 | 0.010 | 0.035 |
| 1-MCP (20 ppm) | 34.0 | 20.0 | 38.0 | 21.0 | 0.008 | 0.024 | 0.005 | 0.022 |
| Mean | 27.3 | 18.0 | 30.7 | 21.0 | 0.012 | 0.040 | 0.009 | 0.033 |

The hormone ethylene and ABA contents in superior and inferior grains of current study were depicted in Table. 1 showed the ABA concentration is higher in the superior grains than the inferior grains and the ethylene concentration was also higher in the inferior grains than the superior grains. In concordance with that the present study, the ABA concentration was higher in the superior grains of the genotype Rice CO 52 (38.0 ng. $g^{-1}$) than the genotype ADT (R) 49 and the low ABA concentration was observed in the control in both the genotypes.

Similarly, the ethylene concentration was high under control in the inferior grains of the rice genotypes ADT (R) 49 - 0.053 nmol. $g^{-1}$ DW $h^{-1}$and Rice CO 52 - 0.042 nmol. $g^{-1}$ DW $h^{-1}$than the treated plants. The ethylene inhibitor 1- MCP (20 ppm) has shown high ABA and ethylene ratio. Similar results were reported by Kato *et al*. (1993) that ABA content in large-sized grains was higher than that in small-sized grains during rice grain filling and ethylene concentration was higher in the spikelets in the lower part of the panicle than those in the upper part of the rice panicle and the similar significant positive results was observed by Panda *et al*. (2009).

### *ABA and ethylene ratio in grains*

Considering the ABA and ethylene ratio, the treatment 1- MCP (20 ppm) had recorded the high ABA and ethylene ratio in superior grains (ADT (R) 49 – 4250.00, Rice C0 52 – 7600.00) and in the inferior grains (ADT (R) 49 – 833.33, Rice C0 52 – 954.55) (Fig.1). This high ABA and ethylene ratio obtained is due to the application of 1 - MCP (20 ppm), an ethylene inhibitor, inhibits the production of ethylene in grains.

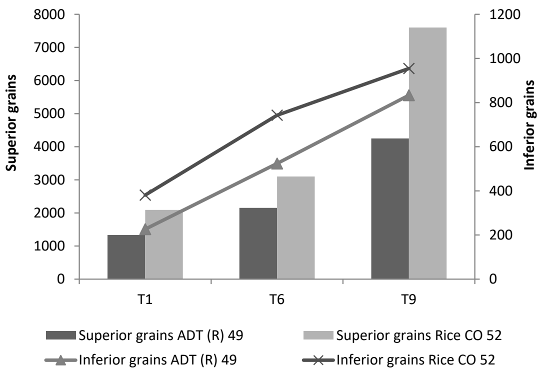


**Fig. 1. Effect of nutrients and plant growth promoters on ABA and ethylene rate**

The present study reveals that the spikelet development can be manipulated with hormones or external growth regulators or nutrients may be an option for improved partitioning of assimilates in favor of the inferior spikelets for higher grain filling as suggested by Mohapatra*et al.* (1993). Ethylene inhibitors when applied to rice panicles at booting stage could significantly enhance the activities of sucrose synthase and invertase enzymes only in the kernels of inferior spikelets and therefore the grain filling is accelerated in the inferior spikelet as reported by Naik and Mohapatra (2000).

The increase in the ABA and ethylene ratio is one of the important strategy to improve the grain filling process in rice and they can be obtained by external usage of plant growth hormones. Although, the manipulation of endogenous hormones can be of great trait for improving the yield in rice, further extensive research is needed on the regulatoryrole of ABA in grains during grain filling process for the better performance of crop. Further investigation is needed to understand the cross-talk between ABA and ethylene and its response toabiotic stress and the relationship to grain filling process in rice.

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