Improved auxin level at panicle initiation stage enhance the heat stress tolerance in rice plants

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Abstract
High temperature especially at flowering stage is major yield limiting factor as a result of global warming. Rice plants are most sensitive to high temperature at reproductive stage which significantly enhances the pollen sterility. Reproductive stage demand optimum level of phytohormones like auxin and other energy producing compound. We assume that application of naphthalene acetic acid (NAA) may improve the auxin level in heat stressed plants which may improve the pollen viability and crop yield. Pot experiment was conducted to examine the application different concentrations of NAA (0, 10, 20, 30, 50 µmol L-1) on rice crop grown under natural and heat stressed environment at flowering stage. NAA was applied immediately after flowering and then subjected to heat stress later on for few hours. It was found that heat stress at flowering stage significantly reduced the rice crop yield and quality but exogenous application of Naphthalene acetic acid (NAA) improved the crop tolerance to heat stress which leads toward better crop productivity.

Key words
Rice, Naphathaline acitic acid, yield and quality

Introduction
An uneven climate change and ever-increasing population in the world are impacting the global security of food (Lesk *et al*., 2016). Abiotic stresses, especially the reduced soil moisture contents and increased temperature are serious threats for crop production (Challinor et al., 2014). In rice crop, flowering stage is most sensitive to high temperature which decreases sterility in spikelet, or it may affect germination (Satake and Yoshida 1978; Fu *et al.,* 2012).

Heat stress is defined as the rise in temperature beyond a critical threshold for a period that is sufficient to cause irreversible damage to plant growth and development (Wahid *et al.,* 2007). Heat stress can lead to decrease in the production of agricultural products and can even lead to social and food problems. Mostly crops are very sensitive at pollen tube development at which production of phytohormrones increased along with enhanced metabolism (Kovaleva et al., 2004; Wang et al., 2010; Selinski et al. 2014). Auxin plays the main role in pollen tube development and other reproductive tissues (Feng et al. 2006; Cecchetti et al. 2008; Chen and Zhao 2008). Abiotic stress induces abnormalities, for example, reduced auxin leven which results in spikelets strerility especially in rice crop (Fu et al. 2015; Zhang et al. 2017). Naphthalene acetic acid (NAA) is commonly used to boost auxin level in crop production.

Keeping in view the emerging abiotic stresses and role of auxin level in rice crop, we assumed that rice productivity can be improved with optimum auxin level especially at panicle initiation stage which is most sensitive reductive stage in rice crop.

Methodology
Pot experiment was conducted during rice growing season of year 2017-18, at agronomic research farm, Bahauddin Zakariya University Multan. The experiment was planned focusing on application of naphthalene acetic acid (NAA) at flowering stage. Varying concentration of NAA (0, 10, 20, 30, 50 µmol/L) were applied in rice plants kept under normal and heat stress condition. Rice variety: super basmati seeds were soaked in water for 48 hours and then sprouted seeds were sown in pots. Pots were filled with 8 Kg soil and twenty seeds were sown in each pot. Experiment was arranged in three replication. After emergence, plants were thinned to four per pot at five leave stage. All plants in different pots were subjected to grow under normal condition up to the flowering stage. Then, plants were sprayed with 100 ml/pot of the appropriate concentration of naphthalene acetic acid (NAA). Afterward, half of the pots were shifted in glass house for high temperature (40° C) for about 2 hours. All normal and heat stress plants were tagged for further data collection. Various yield and quality parameters were noted at physiology maturity stage. Data were

analyzed by applying Fisher's a[0]nalysis of variance and the Least Significant difference (LSD) test at 5% level of probability to compare treatments means using statistical software MSTATC (Steel and Torrie 1997).

Results and Discussion

Panicle initiation stage is very important critical stage in rice, any stress at this stage leads to reduced yield and quality. Results picture exhibited that heat stress significantly reduced the performance of factors contributing toward crop yield. But the crop performance was improved with the application of naphthalene acetic acid (NAA) on flowering stage. Crop significantly improved the grains per panicle, panicle length, 1000 grain weight and grain yield with the application of NAA (10 µmol/L, 20 µmol/L). Over dose of NAA > 20 µmol/L could not improve the crop performance. It was also obvious from the quality parameters that NAA significantly decreased the problematic grains like sterile, opaque, abortive in heat stressed plants while improved the percentage of normal kernels (Table-1). It has been already explained that heat stress at flowering leads toward enhanced sterile kernels due to disabilities in pollen germination and pollen tube elongation (Jiang et al. 2015; Coast et al. 2016). Our results are in correlation with previous findings as sterile, opaque and abortive kernels were significantly increased after heat stress at panicle initiation stage. While, application of NAA reduced the percentage of problematic grains with 10 µmolL^{-1} and 20 µmolL-1 concentration. It might be due the improved auxin level in the plants as NAA is most widely used exogenous application of auxin in plants (Sakata et al. 2010) which act as molecular signal for pollen tube growth (Chen and Zhao 2008). Heat stress may disrupt the auxin level which impaired the pollen tube elongation that lead toward reduced crop yield and quality. Findings also suggested that both lower doses of NAA enhanced the total soluble protein as well as super oxidase dismutase (SOD) in heat stressed plants which further mediated the heat stress and improved the crop tolerance (Fig-1).

Table-1 Influence of Naphthalene acetic acid (NAA) on yield and quality attributes of fine rice under natural and heat stress conditions

Treatments	Grains/Panicle	Panicle length (cm)	1000-grain weight (g)	Grain yield (g/plant)	Normal kernel (%)	Opaque kernel (%)	Sterile grain (%)	Abortive kernel (%)
N0T0	75.7AB	45.3A	30.3A	30.0A	88.3A	3.0F	1.3B	1.7D
N1T0	78.7AB	44.7A	31.0A	29.3A	87.3A	3.8EF	2.7B	2.0D
N2T0	79.7A	42.6A	31.3A	29.7A	86.7A	4.7EF	2.7B	2.7CD
N3T0	79.3A	41.2A	30.3A	28.3AB	88.0A	5.0E	3.0B	3.7CD
N4T0	79.7A	48.2A	30.7A	28.7AB	85.7A	5.7DE	3.3B	4.3C
N0T1	53.7C	17.5B	18.7C	16.0D	55.7D	10.0A	10.7A	10.0A
N1T1	64.0BC	21.4B	22.7BC	21.7C	67.7C	7.7BC	8.0A	8.3AB
N2T1	74.3AB	27.2B	24.7B	23.3BC	75.0B	7.3CD	7.7A	7.3B
N3T1	58.3C	25.3B	20.0C	21.3CD	67.7C	8.3ABC	8.3A	8.7AB
N4T1	53.3C	25.6B	20.0C	20.3CD	61.3CD	9.3AB	9.7A	9.7A
LSD0.05	14.89	13.45	4.61	5.38	6.70	2.68	3.83	2.06

N0 (No application), N1(10 µmol/L), N2 (20 µmol/L), N3 (30 µmol/L), N4 (50 µmol/L), T0 (No temperature stress), T1 (Under Temperature stress)

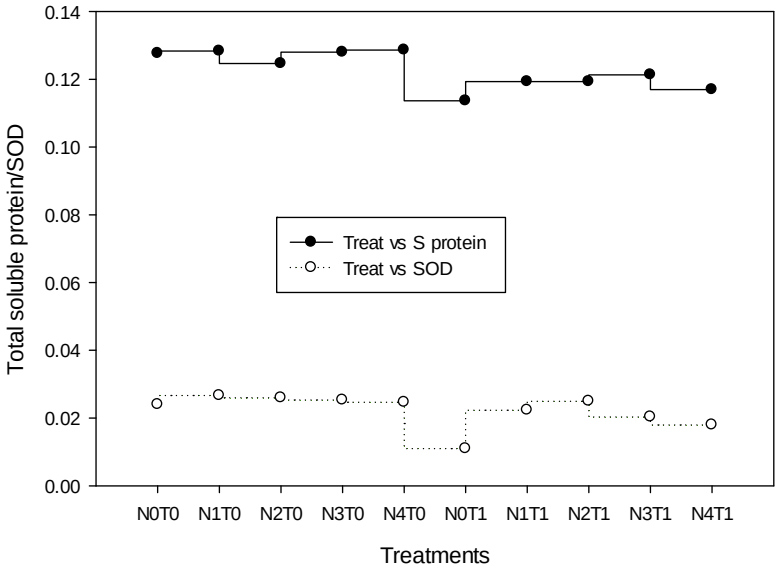

Fig. 1 Influence of Naphthaline acitic acid (NAA) on total soluble protein (mg/g leaf tissue) and Super oxidase Dismutase (SOD) enzyme under natural environment and temperature stress on panicle initiation stage in fine rice. N0 (No application), N1(10 µmol/L), N2 (20 µmol/L), N3 (30 µmol/L), N4 (µmol/L), T0 (No temperature stress), T1 (Under Temperature stress)

Conclusion

Heat stress at flowering stage can significantly reduce the rice crop yield and quality which can be reduced with optimum level (20 µmol/L) of exogenous application of Naphathaline acitic acid (NAA).

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