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Improving Wheat Growth and Yield Using Chlormequat Chloride, Salicylic Acid and Jasmonic Acid under Water Stress

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Introduction

Drought stress is most important abiotic stress reducing growth and production of wheat worldwide. Protective role of plant growth regulators (PGRs) against drought stress has been accepted in general, however, comparison of PGRs types to determine the optimum one is crucial. Many PGRs are known to alleviate the negative effects of drought stress in plants. However, limited research has been conducted to investigate the potential benefits of exogenous application of different PGRs in wheat plants grown under drought stress. Chlormequat chloride (CCC), salicylic acid (SA) and jasmonic acid (JA) could consider as three major PGRs using in cereals.

Materials and Methods

To examine the effect of three PGRs consisted of CCC, SA and JA on yield components and grain yield of wheat cv. Roshan under different water stress conditions (a range of light to severe drought levels) two separated experiments were conducted at controlled and field conditions at College of Agriculture, Shiraz University during 2012-2013 growing seasons. Concentration of CCC, SA and JA were 19.0, 1.0 and 0.1 mM, respectively. Drought stress levels were 100%, 80%, 60% and 40% of field capacity in greenhouse and were 100%, 2/3 and 1/5 of field capacity in the field experiment. Field capacity was determined as 25% (g g^{-1}) for the experimental field. Greenhouse and field researches were carried out in factorial experiment based on completely randomized design and in split plot experiment based on randomized complete block design, respectively. Four and three replications were used greenhouse and field experiments, respectively. Roshan as a bread wheat cultivar with standard height was used. Foliar application of 3 PGRs was done at double ridges stage in both experiments; however, irrigation treatments were applied at double ridges stage and early anthesis at greenhouse and field experiment, respectively. For plot irrigation a tape system was used and amount of irrigation was measured by a water meter.

Results and Discussion

The results showed that water stress decreased flag leaf area, ear length, grain number per ear, biological yield and grain yield in the greenhouse and biological yield and grain yield in the field experiment. The maximum of flag leaf area was obtained at anthesis and after that there was no increase in green area. In the other hand, ear length and grain number per ear were fixed at anthesis and so drought stress had less negative impact on flag leaf area, ear length and grain number per ear under field conditions. Increasing the level of drought stress was considerably associated with greater reduction in grain yield and yield components. However, PGR_S application improved yield components and consequently enhanced the grain yield. The higher flag leaf area in PGRs-treated plants might be due to lowering developmental rate or delaying plant maturity and senescence. So, by improving leaf area, PGR application resulted in increased photosynthetic rate leading to a higher yield. Although all PGRs had positive effect on growth and yield of wheat nevertheless, the effect of chlormequat chloride followed by salicylic acid was greater than jasmonic acid; so that foliar applications of chlormequat chloride, salicylic acid and jasmonic acid were associated with 20.7%, 13.8% and 7.24% increase in grain yield, respectively, under controlled conditions. These values were 18.3%, 12.2% and 8.1% for the field experiment. Such compensatory effects of PGRs could be due to various reasons. Chlormequat chloride can stimulate root growth, reduce transpiration, increase water use efficiency, and prevent chlorophyll destruction.

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Similarly, SA application may result in stomatal closure, increased WUE, increased chlorophyll content, increased respiratory-pathways and intercellular CO_2 concentration, and stimulatory changes in other physiological and biochemical attributes. Jasmonic acid is also essential components for the signaling pathway triggering the expression of plant defense genes in response to abiotic stresses. This PGR had a significant role in osmotic adjustment under drought stress conditions.

Conclusions

Overall, drought stress depending on time and severity of application had several adverse effects on wheat cultivar including decreased flag leaf area, ear length and grain number which led to reduced biological yield and grain yield. However, exogenous application of SA, CCC or JA reduced at least some of the harmful impacts of drought stress and in some cases compensated losses or damages caused by the drought, resulting in purging of differences between the control and drought stress conditions. Furthermore, chlormequat chloride might have a wide scope for further investigations as an approach to increase grain yield under limited water conditions.

Keywords: Grain yield, Growth retardants, Yield components