

## **Exogenous application of moringa leaf extract improves growth, biochemical attributes, and productivity of late-sown quinoa**

### **ABSTRACT**

Quinoa (*Chenopodium quinoa* Willd.) has gained significant popularity among agricultural scientists and farmers throughout the world due to its high nutritive value. It is cultivated under a range of soil and climatic conditions; however, late sowing adversely affects its productivity and yield due to shorter growth period. Inorganic and organic phyto-stimulants are promising for improving growth, development, and yield of field crops under stressful environments. Field experiments were conducted during crop cultivation seasons of 2016–17 and 2017–18, to explore the role of inorganic (hydrogen peroxide and ascorbic acid) and organic [moringa leaf extract (MLE) and sorghum water extract (sorgaab)] phyto-stimulants in improving growth and productivity of quinoa (cultivar UAF-Q7). Hydrogen peroxide at 100  $\mu$ M, ascorbic acid at 500  $\mu$ M, MLE at 3% and sorgaab at 3% were exogenously applied at anthesis stage of quinoa cultivated under normal (November 21st and 19th during 2016 and 2017) and late-sown (December 26th and 25th during 2016 and 2017) conditions. Application of inorganic and organic phyto-stimulants significantly improved biochemical, physiological, growth and yield attributes of quinoa under late sown conditions. The highest improvement in these traits was recorded for MLE. Application of MLE resulted in higher chlorophyll a and b contents, stomatal conductance, and sub-stomatal concentration of CO<sub>2</sub> under normal and late-sowing. The highest improvement in soluble phenolics, anthocyanins, free amino acids and proline, and mineral elements in roots, shoot and grains were observed for MLE application. Growth attributes, including plant height, plant fresh weight and panicle length were significantly improved with MLE application as compared to the rest of the treatments. The highest 1000-grain weight and grain yield per plant were noted for MLE application under normal and late-sowing. These findings depict that MLE has extensive crop growth promoting potential through improving physiological and biochemical activities. Hence, MLE can be applied to improve growth and productivity of quinoa under normal and late-sown conditions.