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Foliar application of *Aloe vera* and date palm extracts as natural biostimulants enhances yield, nutrient status and essential oil of cumin (*Cuminum cyminum* L.)

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The study examined the individual and combined effects of *Aloe Vera* Leaf Extract (ALE) (0, 2, and 4 ml L⁻¹) and Date Palm Seed Extract (PSE) (2 and 4 g L⁻¹) on Cumin (*Cuminum cyminum* L.) growth, biochemical content/composition, nutrient content/composition, and essential oil profiles. Application of ALE 4 ml L⁻¹ and PSE 2 g L⁻¹ as foliar treatments improved the characteristics of reproductive development by increasing seed inflorescence weight and diameter by 122.84% and 58.32%, respectively, compared to the control. Spraying ALE (4 ml L⁻¹), PSE (4 g L⁻¹) + ALE (4 ml L⁻¹) + PSE (2 g L⁻¹) on foliage resulted in an increase of 8.33% in number of flowers per plant and 51.31% increase in total yield/plant. Total phenolic content increased by 10.40%, 8.50% and 8.76% with PSE 2 g L⁻¹, PSE 4 g L⁻¹ and ALE 2 ml L⁻¹ compared to the control, respectively. ALE at a concentration of 2 ml L⁻¹ significantly increased the total flavonoid content by 115.59% compared to the control. Carbohydrate content of seeds and leaves increased significantly by 30.27% and 102.55% with ALE 2 ml L⁻¹ compared to the control, respectively. The ALE 4 ml L⁻¹ treatment resulted in a 166.66% increase in sulfur, while the ALE 4 ml L⁻¹ + PSE 4 g L⁻¹ combination resulted in a 0.239% phosphorus content compared to the control. There were 4 total compounds that were identified from both the 4 ml L⁻¹ ALE treatment and the 4 g L⁻¹ PSE treatment, 1,3-benzodioxole, 4,5-dimethoxy-6-(2-propenyl)-, carvone, D-limonene. These studies suggest that both ALE and PSE can enhance the growth of plants, yield from their harvest, physicochemical properties, and phytochemical profiles; Therefore, enhancing the growth and development of plants through a more sustainable approach to enhance their production and increasing bioactive compound production will be achieved by using environmentally friendly, low-input chemicals such as ALE and PSE.

Keywords *Aloe vera*, Palm seed extract, Seed yield, Phytochemicals, Essential oils

The agricultural system has been confronted with a broad array of challenges that demand an increase in crop yield with minimal damage to the environment as a result of an overreliance on chemical fertilizers and pesticides during recent decades¹. Due to growing concern for the safety of the food produced, as well as soil health, biodiversity, and climate change, sustainable food production is becoming more popular in the agriculture industry. Likewise, consumers have expressed a greater desire to purchase sustainable products². Therefore, crop improvement and sustainable agriculture are two of the primary research focuses of the plant sciences in developing strategies that do not have adverse environmental effects³.

Plant biostimulants have become one of the promising strategies in respect of improving plant growth, yield and quality with consideration of sustainability⁴. Plant biostimulant refers to a naturally occurring substance or microorganism that, when applied to plants or their rhizosphere, has the ability to influence a plant's

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