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Kelpak® Bioregulators – mode of action and responses in agricultural crops

The biostimulant Kelpak® is extracted from the seaweed species *Ecklonia maxima*, using a "cell burst method". This unique extraction process ruptures the cell walls by creating high pressure differentials within the cells, thereby releasing their cellular contents. No high temperatures or chemicals, which may be detrimental to the delicate cellular compounds, are used during the extraction process (Stirk and Van Staden, 1997).

Kelpak® Bioregulators, available in certain countries, are classified as a plant growth biostimulant for use in agriculture. Application to plants regulates and enhances the plant's physiological processes, thereby improving plant growth rate and plant health. The active components affect plants at the cellular level, improving crop vigour, yields, quality and post-harvest shelf life. The growth stimulatory effect of Kelpak® has been attributed to the plant growth regulators found within Kelpak®. The natural active compounds identified in Kelpak® include: auxins, abscisic acid (ABA), brassinosteroids, cytokinins, gibberellins (GAs), polyamines and phlorotannins (Stirk *et al.*, 2004, Papenfus *et al.*, 2012, Stirk *et al.*, 2014, Rengasamy *et al.*, 2015). The combined effects of these compounds lead to a healthier and stronger plant, producing better yields.

Kelpak® Bioregulators elicit many beneficial responses including enhanced root development in a variety of crops (Featonby-Smith and Van Staden, 1983, Featonby-Smith and Van Staden, 1984, Nelson and Van Staden, 1984, Nelson and Van Staden, 1986, Aldworth and Van Staden, 1987, De Waele *et al.*, 1988, Temple and Bomke, 1989, Jones and Van Staden, 1997). The product improves nutrient uptake and shoot growth, flowering, fruit set, fruit retention and fruit size, while delaying senescence (Metting *et al.*, 1990, Crouch and Van Staden, 1994, Khan *et al.*, 2009). Foliar application to crops from early bloom to petal fall significantly increases yields in fruit crops. This is possibly due to improved pollen germination and pollen tube growth, leading to improved ovule fertilization and fruit set. Kelpak® enhances quality attributes of produce, including fruit firmness, sugar content, colour, and longer shelf life (Masny *et al.*, 2004). The product increases the plant's tolerance to and recovery from abiotic stresses such as drought, nutrient deficiency and excessive salinity (Nelson and Van Staden, 1984, Mooney and Van Staden, 1985, Beckett and Van Staden, 1989, Beckett and Van Staden, 1990, Beckett, 1991, Beckett *et al.*, 1994, Papenfus *et al.*, 2013) and biotic stresses such as insect and pathogen attack (Metting *et al.*, 1990, Crouch and Van Staden, 1994, Khan *et al.*, 2009, Craigie, 2011).

Kelpak® Bioregulators are applied at relatively low rates as a foliar spray to plants or seeds and can be applied to soil or other growing mediums as a drench or with drip irrigation. Roots of transplants and nursery plants can be dipped in the product prior to transplanting. Kelpak® differs from crop protection products because it acts only on the plant's vigour and does not have any direct actions against pests or diseases. It is thus complementary to crop nutrition and crop protection practices.

According to IBA and Kinetin quantification bioassays, Kelpak® is a strong auxin dominant product, having an auxin to cytokinin ratio of 360:1. This unique ratio in Kelpak® stimulates prolific adventitious root formation (Crouch et al. 1992). This drastic increase in root tips leads to an increased level of cytokinins in treated plants, as this group of hormones is mainly produced in meristematic tissues of root tips. The increased root volume and number of root tips also increase moisture and nutrient uptake from the soil.

The cytokinin and ABA content in Kelpak® might be partially responsible for the stress resistance inferred with Kelpak® treatment. GA is also present in Kelpak® which is involved in most aspects of plant growth and development including promoting seed germination, organ differentiation, shoot growth, stem elongation, leaf expansion, floral development and fruit set (Tanimoto, 2002, Yamaguchi, 2008). In addition, there is cross talk between GAs and other hormones such as positive interactions with auxin to promote cell expansion and differentiation and root elongation, growth and flowering. Kelpak® application elicits many similar GA-growth responses in plants (Metting *et al.*, 1990, Crouch and Van Staden, 1994).

Brassinosteroids in Kelpak® Bioregulators elicit a wide range of physiological responses. They promote cell division and elongation and influence stem and root growth, floral initiation, flower and fruit development and seed yield (Bajguz and Hayat, 2009, Divi and Krishna, 2010). They also protect plants from abiotic stresses (oxidative stress, drought, salinity, nutrient limitation, extreme temperatures, heavy metals and herbicides) and biotic stresses (e.g. pathogens, Bajguz and Hayat, 2009). Many growth and physiological effects obtained with exogenous brassinosteroid application are similar to those achieved with Kelpak® application (Metting *et al.*, 1990, Crouch and Van Staden, 1994). Thus, the presence of brassinosteroids in Kelpak® may account for some of the numerous beneficial responses elicited with Kelpak® application especially considering the brassinosteroids are effective at low concentrations.

This combination of natural active compounds present in Kelpak® Bioregulators, may act individually or in concert, to contribute to the numerous favourable physiological responses elicited by Kelpak® application in plants.

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