Effect of gibberellic acid on growth and development plants and its relationship with abiotic stress

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ABSTRACT: Gibberellic acid (GA3) is a plant hormone belongs to gibberellins. Plants produce low amount of GA3, therefore this hormone is produced by microorganisms. Exogenous GA3 on culture medium was used to increase height of Dyckia maritima shoots to facilitate In vitro manipulation. Grapevine fruits (Thompson seedless) treated with GA3 had increased its size and production. Foliar application of GA3 and nutrients had improved the productivity and quality of lily cut flowers. Stimulation of the enzyme protein synthesis by GA3 stimulates the overall protein synthesis.

Keywords: yield, stress, Antioxidant enzyme

INTRODUCTION

Now-a-days growth promoting hormones are commonly used in agriculture to enhance productivity. Gibberellic acid is one of most important growth stimulating substance used for promoting cell elongation, cell division and thus to promote growth and development of many plant species. Gibberellic acid (GA3) is a plant hormone belongs to gibberellins. Plants produce low amount of GA3, therefore this hormone is produced by microorganisms. Nowadays, it is industrially produced by submerse fermentation, but this process presented low yield with high production costs and hence higher sale value. One alternative process to reduce costs of the GA3 production is Solid-State Fermentation (SSF) that allows the use of agro-industrial residues. Various processes of GA3 production using SSF have been studied, with different yields, substrates/supports, strategies and bioreactors (Hollmann, 1995; Bandelier, 1997; Escamilla, 2000; Machado, 2002; Shukla, 2005; Corona, 2005; Rodrigues, 2009). Zhao-Oingyan (1995) studied the effect of GA3 on two disease resistant spinach varieties. Wang, (2000) observed in three different species that low concentration of GA3 slightly promoted germination but inhibited germination at high concentration. Effect of gibberellic acid on germination of Pedicularis species (Ai-Rong, 2007) Eremurus spectabilis (Rahmanpour, 2005), Rhodiola rosea (Aiello & Fusani, 2004) and Pterocarpus angolensis (Chisha – Kasuma, 2007) have been studied. The role of an agronomist is, therefore, to manipulate the crop in order to counteract the influence of salt stress, and boost performance even under saline conditions. In this regard, attention has now come to be focused on the use of plant growth regulators, such as gibberellic acid (GA3), which are known to be importantly concerned in the regulation of plant responses to the external environment and to control a number of stress-induced genes (Naqvi, 1999). Lavandula dentata (Machado, 2011). Secondary metabolites accumulation can be increased with GA3 application, as observed in Lathyрус sativus (Bano & Sanaullah, 1995). Primary metabolites also can be increased with GA3 application, one example is the sucrose accumulation in sugarcane due to elongation of internodes during winter (Taiz & Zeiger, 2004). Exogenous GA3 on culture medium was used to increase height of Dyckia maritima shoots to facilitate In vitro manipulation (Silva, 2004). Grapevine fruits (Thompson seedless) treated with GA3 had increased its size and production (Abu- Zahra, 2010). Foliar application of GA3 and nutrients had improved the productivity and quality of lily cut flowers (Sajid,
2009). Ozmen, (1995) found that, exposure to GA3 resulted in a significant reduction of the total protein amount of hepatic tissue when compared with the control mice. Moreover, Sakr, (2003) found that oral administration of GA3 induced different biochemical and histochemical changes in the liver of the treated rats. Biochemical changes were in the form of early increase followed by late decrease in liver enzymes ALT and AST. Histochemical observations revealed marked reduction in total carbohydrates and total protein contents in the hepatocytes. Although innumerable works have confirmed the potential of GA3 to synergistically improve crop performance under normal conditions, very little light has been thrown on the influence of GA3 sprayed during salt stress. A few studies have, however, demonstrated the ability of foliar pretreatment with GA3 to overcome adverse effects of NaCl stress (Chakraborti and Mukherji, 2003). GA3 has also been shown to alleviate the effects of salt stress on pigment content, Hill activity (Aldesuquy and Gaber, 1993) and water use efficiency (Aldesuquy and Ibrahim, 2001). Endogenous gibberellins influence various development processes, such as stem elongation, control various aspects of seed germination, including dormancy break and mobilization of endosperm reserves, moreover, gibberellins influence transition from juvenile stage to mature stage, induction of flowering, sex determination and fruit set establishment in the reproductive development (Taiz & Zeiger, 2004). GA3 is known to have a secondary enhancement effect on protein content through the intensification of nitrate reductase activity (Shah, 2004). Stimulation of the enzyme protein synthesis by GA3 stimulates the overall protein synthesis (Premabatidevi, 1998). People may be exposed to residues of GA3 in diet derived from consumption of different types of fruits and vegetables treated with GA3. Exposure to residues may also be through drinking water (Tomlin, 2004). Dorgham (1991) have led to the suggestion that salinity promotes the fixation of inorganic nitrogen into protein, thus favouring protein synthesis. Application of GA3 under such conditions was found to synergistically increase seed protein content, being in accordance with the results of Singh and Sharma (1996) and Aldesuquy and Ibrahim (2001). On the contrary, GA3 is known to promote PN through enhancement of not only the carboxylase activity of Rubisco (Yuan and Xu, 2001), but also the rates of cyclic and non-cyclic phosphorylations (Naidu and Swamy, 1995). growth regulators according to the American Society of Agricultural Science (Fishel, 2006). Gibberellic acid (GA3) is one of the most active hormones of gibberellins. It affects many mechanisms of plant growth including stem elongation by stimulating cell division and elongation, flowering, fruit development and breaking dormancy (Neil and Reece, 2002). Gibberellic acid (GA3) is highly persistent and bioactive in soil for months. The Environmental Protection Agency has determined its use to be only allowed in low doses (Schwechheimer and Willige, 2009). A growing amount of evidence indicates that GA3 alters the antioxidative systems in the rat's tissues. Antioxidant enzyme activities were significantly decreased in the erythrocyte, liver, and brain tissues of rats treated with GA3 (Tuluce and Celik, 2006). Aguilar-Becerril (1980) tested the effect of the growth regulators 2,4-D, promalin, IBA, and GA3 on fruit weight, length, development of abortive seeds, and fruit ripening and composition. These treatments and combinations thereof were applied 2 days before anthesis to intact floral buds, and 4 times subsequently at intervals of 10 days. Promalin (GA4/7 + benzyladenine) was the most effective in increasing fruit size, whereas GA3 was most effective in augmenting the proportion of abortive or false seeds and reducing total seed weight. Gil and colleagues (Díaz and Gil, 1978; Gil, 1977; Gil and Espinoza, 1979) successfully obtained parthenocarpic prickly pear fruits with applications of gibberellic acid to emasculated floral buds. They obtained normal-size fruits with a single application of 500 ppm or 3 applications of 100 ppm GA3 to emasculated floral buds. Although the fruits were parthenocarpic, the treatments also stimulated the development of the ovular integuments and the funiculus, resulting in abortive seeds with hard coats. They also found that GA3 treatments generally induced longer fruits and slightly reduced the soluble solids content of the pulp. Martinez-Rodriguez and Arreola-Avila (1990) reported a large increase in abortive seeds with a single application of 100 ppm GA at flower opening. GA treatments are widely used to stimulate development of parthenocarpic fruits in other plant species (Schwabe and Mills, 1981). Some researchers have proposed that the ABA produced in the carnation gynoecium determines the longevity of the carnation flower (Shibuya, 2000), because the hormone accumulates in the gynoecium well before ethylene production increases and senescence is evident (Nowak and Veen 1982, Onoue, 2000). Certainly, it has been shown that removal of the gynoecium from the carnation flower inhibits the increase in floral ethylene production, delays petal senescence, and prevents exogenous ABA from accelerating senescence (Shibuya, 2000). However, because it has also been shown that ethylene action is required for the increase in ABA to occur in the gynoecium (Nowak and Veen 1982) External supply of cytokinins and gibberellins has also been reported to reduce leaf chlorosis and yellowing in several cut foliage and flower species (Skutnink, 2001, Ranwala, 2003, Mutui, 2006, Singh, 2008). However, the efficiency of plant growth regulators (PGRs) in delaying senescence and enhancing postharvest life depends on the plant species used (Paull and Chantrachit, 2001), type and concentration of preservative solution and the method of application (Ranwala, 2003). Several applications of GA3 in the agriculture and plant biotechnology can be evidenced in these studies: The presence of GA3 combined with
others plant growth regulators promoted best morphogenic events in Lycopersicon esculentum (Afroz, 2009). Accordingly, it must be possible to increase berry size by means of GA3 application. Although, there are many studies reporting the effect of GA3 (Lavee and Nir, 1986; Williams, 1996; Zabadal and Dittmer, 2000; Hyunggook, 2008), the role of gibberellins on berry growth has not been completely elucidated. The timing of ABA accumulation in petals suggests that the hormone co-ordinates the early events in the senescence signal transduction pathway in some flowers, whereas in others it affects only the latter stages of senescence, perhaps serving to drive the process to completion. In daylilies, the ABA content of the petals increases before the increases in activities of hydrolytic enzymes and well before the flowers have opened (Panavas, 1998), whereas in roses, the ABA content increases comparatively late in the petals, 2 days after the surge in ethylene production (Mayak and Halevy, 1972). The involvement of gibberellins in berry development was first described by Coombe (1960). Seeded berry has a high gibberellins concentration at fruit set, that persists for, at least, three weeks, then falling to a very low values and reincreasing after that, giving rise to a second peak two weeks later; finally concentration diminishes and remains low during fruit ripening (Scienza, 1978). Unexpectedly, similar pattern is found in seedless grapes (Iwahori, 1968; Pérez, 2000). Phytohormones like gibberellic acid and Kn were reported to overcome the inhibitory effect of salinity on germination. A combination of 3% NaCl and 50 ppm Kn increased the germination by 100 per cent as compared to that of control whereas 3.5% soil salt concentration along with 50 ppm Kn reduced the germination in wheat (Babu and Kumar, 1975). Gibberellic acid and Kn increased the rate of germination of barley and lettuce seeds under salt-stress treatment (Kabar 1989, Kabar and Baltepe, 1989). Phytohormone, in general, was found to regulate the transport of ions in plants (Karmoker 1984). Hence, phytohormone-induced alleviation of the inhibitory effect of salinity may be due to the phytohormone-induced changes in ionic balance in seedlings. The delay in germination is mainly due to higher Na+ accumulation in the seeds of wheat (Begum, 1992, Akbarimoghaddam, 2011).

MATERIALS AND METHODS

This paper is a review of the literature search on ISI, Scopus and the Information Center of Jahad and MAGIRAN, SID is also abundant. Search library collection of books, reports, proceedings of the Congress was also performed. All efforts have been made to review articles and abstracts related to internal and external validity.

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