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Modulation of alkaloid content, growth and productivity of *Trigonella foenum-graecum* L. using irradiated sodium alginate in combination with soil applied phosphorus

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ABSTRACT

Trigonella foenum-graecum L. (fenugreek) belongs to family Fabaceae and has been used as medicinal herb since times immemorial. Fenugreek seed-alkaloid, known as trigonelline, controls diabetes through operation of the mechanism of insulin secretion, modulation of β cell regeneration and stimulation of activity of glucose metabolism related enzymes. Gamma-irradiated sodium alginate (ISA) elicits plant defence responses and biological activities in plants. A pot experiment was conducted to explore the effect of foliage-applied ISA (0, 40, 80 and 120 mg L^{-1}) alone and in combination with soil-applied phosphorus (40 kg P ha^{-1}) on growth, yield and quality attributes of fenugreek employing the soil deficient in phosphorus. Un-irradiated sodium alginate (UN 40 mg L^{-1}) and de-ionized water were used as control. Of the treatments employed, 80 mg L^{-1} of ISA applied with 40 kg P ha^{-1} (P_{40}) proved the best. It increased the chlorophyll content by 24.85 and 27.40%, carotenoids content by 15.00 and 23.52% at 60 and 90 days after sowing, respectively. Besides, it increased the seed yield by 131.0%, trigonelline content by 17.84%, trigonelline yield by 174.0%, seed alkaloid content by 32.98% and seed alkaloid yield by 208.64% over the control. Gel permeation chromatography of ISA revealed the formation of low molecular weight fractions which might be responsible for plant growth promotion in this study. Trigonelline content was determined by isocratic HPLC equipment (Model, LC-20AD).

1. Introduction

Among the significant diseases of the developed nations, diabetes mellitus (disorder in glucose metabolism) hold a prominent position. According to Wild et al. (2004) about 171 million diabetic patients are present in the world and by the year 2030 the number is going to increase to 340 million. Although a number of synthetic anti-diabetic agents are available in the market but with multitude of side effects; these drugs are also not suitable during pregnancy (King et al., 1998). Therefore, it is desirable to search for the effective, long-lasting and safer anti-diabetic drugs. Fenugreek belongs to the family Fabaceae; its bio-active constituents have been used for centuries for a wide range of diseases like diabetes, fever, abdominal colic, etc. (Sharma, 1986). In addition, fenugreek has shown hypoglycemic effect in diabetic patients (AL-Shamony et al., 1994; Ulbricht et al., 2007). Fenugreek seed-alkaloid, known as trigonelline, controls diabetes through operation of the mechanism of insulin secretion, modulation of β cell regeneration and stimulation of activity of glucose metabolism related enzymes (Zhou et al., 2012).

Trigonelline, a potent alkaloid of fenugreek, belongs to pyridine betaines, having a quaternary amino group (Fig. 1A). It is used medicinally as hypoglycemic, antiseptic, cholesterol lowering and as an anti-migraine agent (Duke, 2001). Trigonelline is also known to improve memory retention and causes inhibition of the platelet aggregation. It helps in insulin secretion, insulin-producing β cell regeneration, activating glucose metabolism related enzymes, scavenging the reactive oxygen species generation and modulating the axonal extension and neuron excitability (Zhou et al., 2012). It was investigated by Tramontano and Jouve (1997) that alfalfa plants underwent a 5-fold increase in proline and a 2-fold increase in trigonelline under salt-stress. Besides, it has been proposed that trigonelline and nicotinamide serve as potent defence-mechanism inducers in plants including those related to

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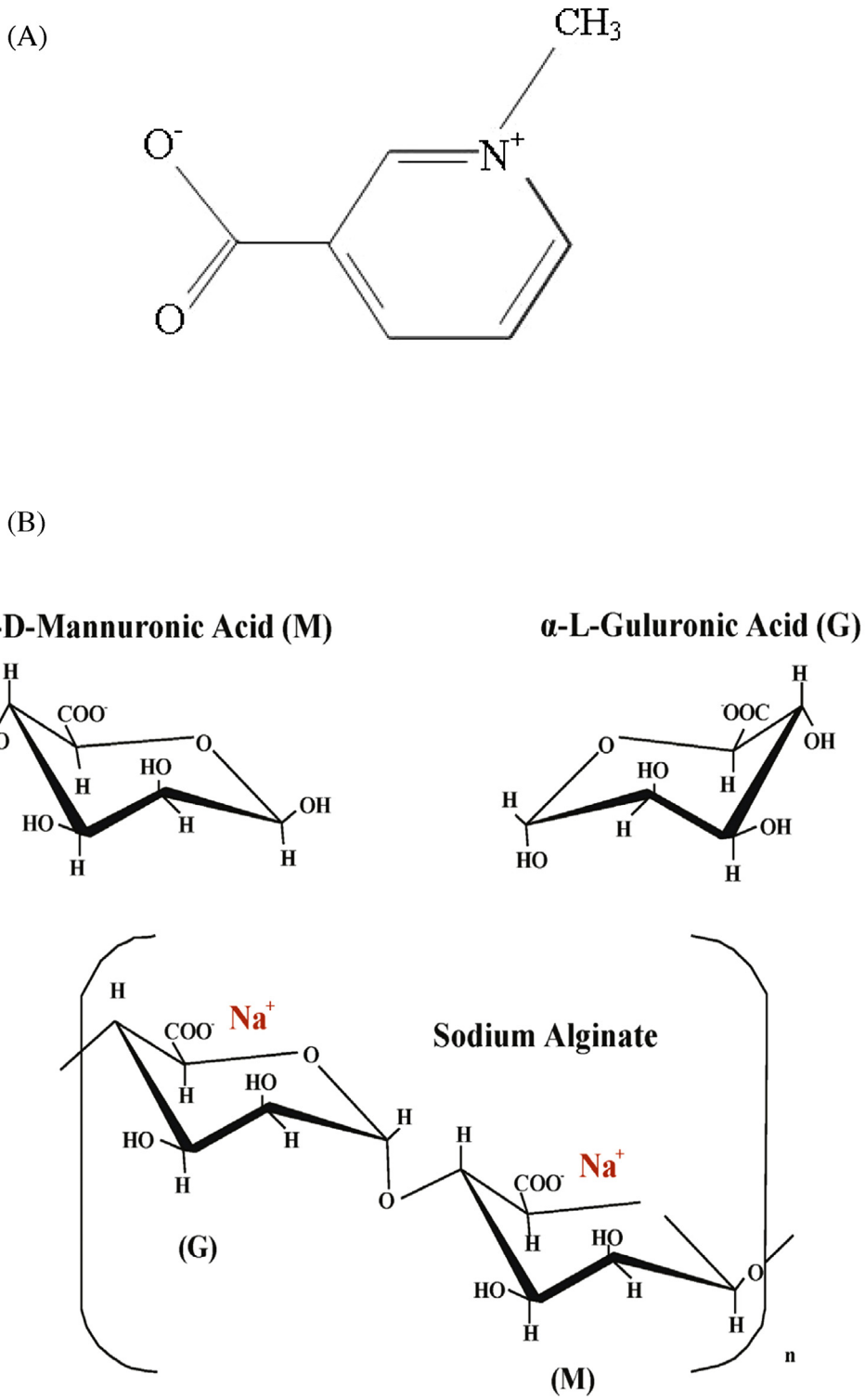

Fig. 1. (A) Structural formula of trigonelline. 1 (B) Structure of sodium alginate and its monomers (β-D-mannuronic acid (M) and α-L-guluronic acid (G).During irradiation of sodium alginate glycosidic bonds are broken down.

glutathione metabolism and accumulation of secondary defence compounds (Berglund, 1994).

Alginates are prominent natural polysaccharides available in nature. They are present in the cell wall of marine brown-algae like *Sargasum* (Anthony et al., 2007). Sodium alginate is the sodium salt of alginic acid, derived from brown algae and consists of residues of homopolymeric poly-β-(1,4) D-mannuronic acid and poly-α-(1,4) L-guluronic acid (Fig. 1B). Sodium alginate can be depolymerised into its oligomers by acid/base hydrolysis or by enzymatic degradation procedure (Hien et al., 2000); but, the use of ionizing radiations for degrading the alginates and other natural bioactive polysaccharides is a novel, clean and one-step technology (Kume et al., 2002). In fact, the naturally occurring polysaccharides, such as alginates, chitosan and carrageenan, can be degraded into low

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