Review Article

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Effect of Gamma Irradiated Sodium Alginate on Selective Crops as Plant Growth Promoter and Bug control action.

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Abstract

In recent studies, irradiated polysaccharides have mainly been applied in hydroponic or spraying systems for some specific type of crops only. Hence, more studies are desired to establish the optimum conditions for use of such materials as plant growth promoters. In this regard, the growth promotion activity of radiation depolymerized alginate has been investigated for on tomato, spinach, mung dal, jute, pumpkin, egg plant, green chilli, red chilli, cabbage and cauliflower plants up to 30 to 90 days. The growth promotion activity of these plants was tested on various growth parameters which are averages of plants height, number of leaves & stems, leaves area, vine's thickness, root length, size of fruits, number of fruits, harvest time, first flowering, wet & dry weight yield. Solution of SA irradiation at 5 to 50 kGy were prepared and applied by spraying system for the growth promotion of selective plants.

The plant showed insignificant changes for all the studied attributes after the treatment of nonirradiated SA on it and for the control plant.

Keywords: Sodium Alginate, Plant Growth, Bug, Crops, Radiation

Introduction

Natural bioactive agents, such as various polysaccharides, can be beneficially utilized to improve the existing methodologies used to impart value addition in agriculture by converting the bioactive agents into more useful form [1]. Such type of biologically active oligosaccharides, derived from sodium alginate, have been known to act as signal molecules that govern plant growth and development and defense reactions by regulating gene expression [2,3]. SA is a natural polysaccharide, derived from brown algae and is available in large quantities. Application of ionizing radiation to degrade this natural bioactive agent and then using as growth promoting substances is an emerging technology to exploit full genetic potential of crops in terms of growth, yield, and quality [4]. Compared to the conventional techniques such as acid/base hydrolysis and enzymatic methods [5], radiation processing of bioactive agents by Co-60 gamma rays offers a clean one-step method for the formation of low molecular weight oligomers of SA, called oligoalginates [3]. Indeed, foliar application of the degraded oligomers has been proved to stimulate various biological and physiological activities, including plant growth [1-4,6], shoot elongation [3,7], root growth [8], flower production, antimicrobial activity, amelioration of heavy metal stress, synthesis of phytoalexins etc. [9-12].

Therefore, the use of depolymerized sodium alginate (and of other marine polysaccharides) in promoting plant growth and thereby, augmenting the desired active constituents in medicinal and aromatic plants is inexpensive and safe [2, 4, 13-16].

The aim of the present study was to investigate whether the foliar application of irradiated SA could be used to enhance the growth, physiological activities, yield attributes and other active constituents in selective plants.

Materials And Methods

Materials

SA powder used in this work was purchased from UNI- Chem., China. The betel vine garden used for this experiment was situated in Cox'sbazar district, Bangladesh.

Irradiation of SA solution by Co-60 gamma rays

SA powder was stirred in distilled water (3g SA in 100 ml distilled water) for 4 hrs and thus dissolved to obtain 3% SA solution. This solution was irradiated by gamma rays from Co-60 source at various 5-50 kilo Gray (kGy) for degradation.

Experimental design and plot culture

500 ml of 3% Sodium alginate aqueous solution was prepared and then treated with Co60 gamma rays at 12KGy and then this solu-

tion was diluted to 100 ppm, 200 ppm, 300 ppm, 500 ppm, 1000 ppm and applied on the field trial spraying at 15 days intervals on Tomato, Spinach, Mung dal, Jute, Pumpkin, Egg plant, Green chilli, Red chilli, Cabbage, Cauli flower, upto 90 days.

Experimental plot areas were separated for each solution. These plots were prepared by adding natural fertilizer (cow dung) in soil. The plots were watered when needed. A definite amount of SA samples were treated on selective plant specimens. Foliage treatments were made through a hand sprayer over the leaves and stems. Soil was treated with the dispersed sample like regular water spraying.

Measurement of various plant growth parameters

The plant heights were measured from its base to the highest point. This was recorded in a chart with both the date and the height. It was repeated every two to three days. In order to measure the number of leaves, the number of leaves on each plant was counted and recorded. Every visible leaf on the plant, including the tips of new leaves just beginning to emerge was counted. For measuring the leaf area the examined leaf was placed over a graph paper and traced. Thicknesses of leaves were measured by slide calipers and root lengths of betel vine were measured on the first and last day of experiments. Stems were counted on each day of experiment.

Results & Discussion

Growth promotion effect on plants height

The fig.1 shows that the changes of plant height after 90 days due to applying nonirradiated and irradiated SA (at 12 kGy) of different concentration. An enhancement of plant height of tomato was observed at 500 ppm solution concentration and plant height of spinach, mungdal, jute, pumpkin, egg plant, green chilli showed best result at 300 ppm and red chilli plant showed best height after applying 1000ppm solution.

Foliar spray of alginate derived oligosaccharide SA could stimulate the synthesis of some antioxidative enzymes in a short period of time to catabolize reactive oxygen species (ROS), thus, protecting the cellular membranes from being damaged. Actually irradiation can modify the viscosity molecular weight, hydrophilic and mechanical properties of alginates resulting in enhance properties. Sodium alginate also acts as signal molecules that regulate growth and development of the plant as well as defense reactions by regulating gene expression ^[2,3] and thus plant increase support happen. In the case of irradiated SA it is supposed that irradiated SA acts on the cell membrane in such a way that enzyme(s), or secondary messenger(s) [L (+) – adenosine] could trigger the cascading effect, which might result in increased plant metabolism and accumulation of various critical intermediary metabolic compounds, leading to improved growth of the plants.

Figure 1: Growth promotion effect of SA and irradiated SA on selective crops' height on 90 days of foliar spray.

Growth promotion effect on shoot growth

The fig.2 shows that the changes of shoot growth after 90 days due to applying nonirradiated and irradiated SA at 12 kGy of different concentration. It was found that an enhancement of shoot growth of tomato, mung dal, jute, egg plant and red chilli plant was observed best at 500 ppm solution concentration and 300 ppm concentration was found best to spinach, pumpkin and green chilli plant.

Radiation, a convenient tool for degradation of polysaccharides, can be performed at room temperature and the degraded product obtained by this process can be used without any purification. Although SA can be depolymerised through enzymatic degradation

but plant researchers suggest the use of radiation processing technology for degrading the polysaccharides ^[3, 17]. Irradiated SA has several novel unique features that can be useful in agriculture. In fact, polysaccharides, such as SA, undergo chain scission by irradiation. The irradiation of SA by gamma rays affects the overall polymer cross-linking process. Consequently, its application influences the biological properties of the plant cells ^[18]. However, the phenomenon which stimulates the processes related to promotion of plant growth still needs further investigations. In addition, various researchers have emphasized that irradiated SA could successfully act as a plant growth promoter and also a potent enhancer of the activity of various enzymes in the plants ^(3,19-25).

Cell division, enlargement and differentiation are the main processes that determined the quality and quantity of plant growth. These processes are affected by various internal and external factors including (a) supply and absorbion of nutrients, which have critical importance in cell metabolism and (b) involvement of

phytohormones/plant growth regulators for maintaining a healthy source-sink relationship. Plant growth regulators get involved through the modification of transcription, translation and/or differential sensitivity of the tissue.

Figure 2: Growth promotion effect of SA and irradiated SA on selective crops' shoots growth after 90 days of foliar spray.

Growth promotion effect on number of leaves

The fig.3 shows that the changes of number of leaves after 90 days due to applying nonirradiated and irradiated SA at 12 kGy of different concentration. An increased production of number of leaves of tomato was observed at 500 ppm solution concentration and for spinach, pumpkin, green chilli and red chilli plant shows best number of leaves after applying 300 ppm solution than control. The leaf analysis of *Mentha arvensis* and *Cymbopogon flexuosus* revealed enhanced N, P and K contents due to irradiated SA

application. In this regard, irradiated SA appears to facilitate the efficient absorption and utilization of mineral nutrients [26, 27]. Similar enhancement in leaf N, P and K contents due to irradiated SA application to various other crops has been reported by [26-29]. They applied various concentrations of irradiated SA on the leaves of *Papaver somniferum* L. and reported that irradiated SA at 120 ppm concentration improved leaf-nitrogen content to the maximum.

Figure 3: Growth promotion effect on number of leaves of selective crops' after 90 days of foliar spray.

Growth promotion effect on leaves area

The fig.4 shows that the changes of leaves area after 90 days due to applying nonirradiated and irradiated SA at 12 kGy of different concentration. It was observed that an increased leaves area of

tomato was observed at 500 ppm solution concentration and for spinach, jute, pumpkin plant shows best leaves area after applying 300 ppm solution than control. The applied of growth promoters had started foliar growth after 7 days of seeding.

Figure 4: Growth promotion effect on leaves area of selective crops' after 90 days of foliar spray.

The increased content of photosynthetic pigments due to irradiated SA application on leaves in this study could also be attributed to possible the increase in number and size of chloroplast, the amount of chlorophyll per chloroplast and proper gramma development. This perception is further confirmed by the correlation studies, wherein leaf-nitrogen content was positively correlated with total content of chlorophyll and carotenoids. It was revealed that the irradiated SA enhanced N content in leaves. It is well known that nitrogen markedly promotes the synthesis of active photosynthetic pigments [28]. A promotive effect of irradiated SA on chlorophyll content might perhaps be attributed to the irradiated SA increased leaf-N that is a constituent of chlorophyll molecule. Irradiated SA also increased the total chlorophyll and carotenoids contents in the leaves of fennel [28], opium poppy [29], and beetroot [27, 30].

Growth promotion effect on number of fruits

The fig. 5 shows that the changes of number of fruits after 90 days due to applying nonirradiated and irradiated SA at 12 kGy of different concentration. An enhancement of number of fruits of tomato, green chilli, red chilli and egg plants was observed at 500 ppm solution concentration and all concentration proved the better than control after applying irradiated SA.

Enhancement in leaf-nutrients, particularly N, due to irradiated SA application, could be attributed to the compositional or chemical change in plants leading to alterations in nitrogen concentration. Presumably, increased uptake of nutrients enhanced the photosynthesis and improved translocation of photosynthates and other metabolites to the sinks that might presumably contribute to the improved yield of irradiated SA treated plants.

Figure 5: Growth promotion effect on production of selective crops' after 90 days of foliar spray.

As a rate limiting photosynthetic enzyme, it regulates the synthesis of carbon compounds which are transported to the sink organs and are utilized for sustaining growth and development of fruits.

3.6 Growth promotion effect on size of fruits and weight

Fig.6 showed the sizes of fruits (diameter of fruits in cm²) of different plants after 90 days due to applying of nonirradiated and

irradiated SA of 100 to 1000 ppm concentration. Figure 7 showed the photograph of control and irradiated SA applied tomato (Fig. 7a, 7b), cabbage (Fig. 7c, 7d) and cauliflower (Fig. 7e, 7f) plants along with their fruits. It has also noticed from the photograph that the size and weight (Fig. 8) of the fruits were also increased after the treatment applied.

Figure 6: Growth promotion effect on sizes of fruits of selective crops' after 90 days of foliar spray.

Fig. 7a

Fig. 7b

Fig. 7c

Fig. 7d

Fig. 7e

Fig. 7f

Figure 7: Growth promotion effect on fruit's size of selective crops after 90 days of foliar spray

a. Tomato (control),	b. Tomato (500 ppm treated) ;
c. Cabbage (control),	d. Cabbage (300 ppm treated) ;
e. Cauliflower (control)	f. Cauliflower (500 ppm treated)

Growth promotion effect on fruit's weight

The fig.8 shows that the weight gains of fruits after 90 days due to applying nonirradiated and irradiated SA at 12 kGy of different concentration. Increased weight gains on tomato was observed at

500 ppm solution concentration and for spinach, mung dal, jute, pumpkin, egg plant, green chilli and red chilli plant shows best weight gain after applying 300 ppm solution than control.

Figure 8: Growth promotion effect on fruits' weight of selective crops after 90 days of foliar spray

The enhanced values of yield attributes with spray of irradiated SA might be ascribed to the role of irradiated SA in plant growth in general. Like irradiated SA, various other plant growth regulators have been used to improve the yield and quality of essential oil of these crops. Increasing concentrations of growth regulators such as folic acid (25 and 50 ppm), ethephon (50 and 100 ppm) and irradiated alginic acid (IAA,100 ppm) has, for example, been reported to increased the percentage of dihydrocarvone content in the essential oil of dill. In addition, the oil content and yield were elevated by kinetin (20 mg per litre) application indicating that affected target at the terminal enzymic transformations in the carvone pathway from limonene.

Growth promotion effect on root length

The fig.9 shows that the increased root length of selective plants' after 90 days due to applying of nonirradiated SA and different concentration of 12 kGy irradiated SA. It was observed that increased root length of tomato were found at 500 ppm solution concentration and for spinach, mungdal, jute, pumpkin, egg plant, green chilli and red chilli plant shows best weight gain after applying 300 ppm solution than control. Fig.10 showed the photograph of control and irradiated SA applied tomato (Fig. 10a), red

chilli (Fig. 10b) and green chilli (Fig. 10c) plants along with their roots. It was observed from Figure 10 that root of tomato plants increased upto 21 cm applying 500 ppm irradiated SA than that of control. Thus almost 162% increased root indicated the remarkable growth of tomato plants.

Plant requires an adequate supply of nitrogen in order to synthesize amino acids, proteins, nucleic acids and other cellular constituents necessary for their growth and development. The first step of nitrate assimilation involves the reduction of nitrate to unstable nitrite by nitrate reductase (NR), which is the rate-limiting enzyme in nitrogen assimilation and a key enzyme of metabolic regulation. Nitrate reducing power of the plant is one of the important factors determining the plant growth. However, the process of nitrate reduction is directly or indirectly dependent on the metabolic sensors and/or signal transducers [31]. The level of the enzyme is dependent on a number of factors, boom within or outside the plants. One of the major regulatory factors, determining the activity of NR, is the level of endogenous phytohormones per se or those added from outside [32]. There might be significant improvement in NR activity at all the five stages of sampling due to irradiated SA application compared with the Control.

Figure 9: Growth promotion effect on root length of selective crops after 90 days of foliar spray

Fig.10a.

Fig.10b.

Fig.10c.

Fig.10d.

Figure 10: Growth promotion effect on root length of selective crops after 90 days of foliar spray

a. Image of tomato plant's root (control) ; b. Image of tomato plant's root (12 kGy, 500 ppm irradiated SA treated); c. Image of the roots of red chilli plants; d. Image of the roots of green chilli plants

Tomoda et al. (1994) ^[20] revealed that depolymerised alginate had growth promoting effects on the elongation of barley root, especially that of the radical. They observed the effective concentration of alginate (100-300 µg/L) for elongation of roots with no inhibition at the highest concentration. In another study ^[33], use a mixture of oligosaccharides of sodium alginate, showed growth promoting activity of SA regarding elongation of lettuce root at a concentration range of 200-3000 µg /mL. In the light of above facts, it was concluded that alginate acts as an endogenous elicitor-like substance ^[34-36].

Growth promotion effect on reduction of disease

Effect of irradiated SA on reduction of diseases was investigated and their data is represents in Fig.11. To detect the disease control; the affected leaves were counted after every 7 days. The numbers of affected leaves were observed more in control sample than treated sample. Fig.12 showed the photograph of control and irradiated SA applied plants along with affected leaves.

The role of irradiated SA as disease control in plant is well known. During cultivation tomato vine is very much affected by various forms of mildew and blight disease and some common tomato pests named stink bugs, cutworms, tomato hornworms and tobacco hornworms, aphids, cabbage loopers, whiteflies, tomato fruit worms, flea beetles, red spider mite, slugs, ^[37] and Colorado potato beetles^[3].

Figure 11: Growth promotion effect on reduction of disease of selective crops after 90 days of foliar spray

Figure 12: Growth promotion effect on reduction of disease of Red chilli plants after 90 days of foliar spray

Conclusion

In treated plants the absorption of irradiated SA acted as a growth promoter, disease control activity which resulted in elongation of plant root and shoot growth, increase in plant productivity and an improvement in physiological parameters compared with the untreated plants and could act as a bio-fertilizer.

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