Growth and Anti-fungal Effect of Gamma Radiation Treated Chitosan and Alginate on Pineapple Plants

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ABSTRACT— *Promising materials to reduce the use of chemical compounds in cultivation are natural biomaterials. Chitosan and sodium alginate were subjected to a Co-60 gamma treatment in this research. Different concentrations of chitosan (300 ppm), sodium alginate (500 ppm), and a mixed solution (90:10 irradiated Na-alginate: chitosan) were administered through foliar spraying with intervals of 15 and 30 days to observe the impacts on growth and anti-fungal activity. The growth attributes like total number of leafs, productivity of growing and mature leafs and anti-fungal activities were determined up to five months. When sprayed 15 days apart, the mixed solution was found to increase the output of pineapple plants and the height of mature leaves, whereas sodium alginate was found to increase the productivity of growing leaves when sprayed at 30-day intervals. The findings showed that sodium alginate and chitosan that had been irradiated both significantly improved productivity and decreased total fungal count.*

Keywords — Pineapple Plants, Chitosan, Sodium Alginate, Gamma Radiation

1. INTRODUCTION

More product crops are needed in today's overpopulated globe in order to meet demand within its capacity. For instance, it is now common practice to use chemical fertilizer to increase crop output. The indiscriminate use of commercial chemical plant growth promoters or pesticides, however, has a negative impact on soil microorganisms, reduces soil fertility, and pollutes the ecosystem [1]. This can lead to a variety of negative outcomes. One of the most significant fruit products worldwide, particularly in Bangladesh, is the pineapple (*Ananas comosus*). It is a very well-liked fruit because of both its substantial economic worth and nutritional value. The fruit of the pineapple is an excellent source of vitamins A and B, as well as calcium, vitamin C, and vitamin D. Iron and phosphorous are also present [2].

Since there are no other commercially available safe alternatives for pineapple in Bangladesh, growers there use harmful chemical agents like ethrel, ethopen, ethylene, calcium carbide, a combination of potash and salt, etc. as ripening agents and pranofix, boxal, cropscare, PGR gold, ocazin, etc. as growth promoters [3]. Because these pesticides are used in such high concentrations, food safety and security are now major concerns in Bangladesh and other developing nations. Natural biomaterials like chitosan and Na-alginate, which are well known for their safe bioactive compounds, can play a crucial part in boosting the yield and quality of plants and fruits in order to combat these chemical dangers in agriculture.

Chitin, a significant component of crustacean shells and the second-most prevalent biopolymer in nature after cellulose, is the source of the linear polysaccharide known as chitosan, which is commercially accessible [4]. In addition to having a low production cost, chitosan has some intriguing qualities that make it suitable for use in a variety of applications, including biocompatibility, nontoxicity, minimal allergenicity, and biodegradability [5]. Additionally, it was claimed that chitosan treatment increased root nodulation and increased plant resistance to a variety of soil and foliar pathogens [6], suggesting that chitosan could be a helpful tool for agricultural sustainability [7]-[9]. Additionally, it was revealed that sodium alginate is a molecule that controls biological processes in plants and can be used as a plant development regulator in horticulture [10]. Polysaccharides derived from algae are well-liked biostimulators that have multiple impacts on plants

[11]. They are inexpensive, biodegradable, non-toxic, biocompatible, physiologically reactive, and [12]. According to the study of the literature, sodium alginate, when depolymerized [13], [14], stimulates plant growth and development. It is also effectively used to coat fruits and vegetables to increase their shelf life [15].

New and hopeful materials called natural biomaterials have vital qualities like biodegradability or a lack of toxicity. In order to create novel applications, research is currently being done on the radiation processing of biomaterials. As a result, sodium alginate and chitosan, which have undergone gamma radiation processing, can be used as natural plant growth promoters and antifungal agents in place of synthetic growth hormones and pesticides, with no negative effects on human health or the ecosystem.

Therefore, the goal of this research was to assess how gamma-irradiated treated chitosan and sodium alginate affect pineapple plant growth and anti-fungal activity while also enhancing pineapple quality. In this study irradiated biomaterials would find out the actual information and proper knowledge in the areas of science and technology.

2. MATERIAL AND METHODS

The experiment was conducted in the natural field conditions at Madhupur, Tangail, Bangladesh.

2.1 Preparation of chitosan and sodium alginate solution

According to studies, chitosan was extracted from prawn bones [16]. Powdered chitosan was dissolved in 2% acetic vinegar to create chitosan solution. Distilled water was used to create a 2% Na-alginate mix. Then, gamma rays from a Co-60 source were used to administer radiation dosages of 40 and 12 kGy to the chitosan and Na-alginate solutions, respectively.

2.2 Experimental plots designing

The study was conducted on 160 pairs of pineapple plants at Madhupur, Tangail, Bangladesh. The pineapple trees were three months old when they were first planted, and they were roughly the same size. Eight experimental plots in total were created, with plots 1 and 2 acting as the reference (without any growth promoter treatment). Two plots were used to identify each parameter, including irradiated chitosan solution, irradiated Na-alginate solution, and irradiated mixture solution. One plot called for the solution to be sprayed at intervals of 15 days, while the other called for intervals of 30 days. Chitosan solution had an end concentration of 300 ppm, while Na-alginate solution had a final concentration of 500 ppm. Chitosan solution and irradiated sodium alginate were combined in a 9:1 ratio to create the combination solution.

2.3 Foliar application

Early in the morning, the solutions were applied using a standard hand sprayer. While spraying, a cloudy or rainy atmosphere was avoided.

2.4 Evaluation of growth promoting activity of plants

The effectiveness of the foliar spray in promoting growth was assessed by looking at different parameters, such as the length of the growing and mature leaves. After 15 and 30 day intervals, the anti-fungal impacts of three experimental solutions were seen.

2.5 Statistical analysis

Data collection started from the beginning of the first spraying. For a total of five months, measurements were taken at periods of about 15 1st 30 days. The data was analyzed by using SPSS-20.

3. RESULTS AND DISCUSSION

3.1 Measurement of growing leaves

According to figure 1, pineapple plants treated with Na-alginate had growing leaves that were comparatively more numerous after 30 days than after 15 days and the control. However, compared to the control and alginate sprayed after a 15 days interval the quality of the leaves after a 30 days interval was superior.

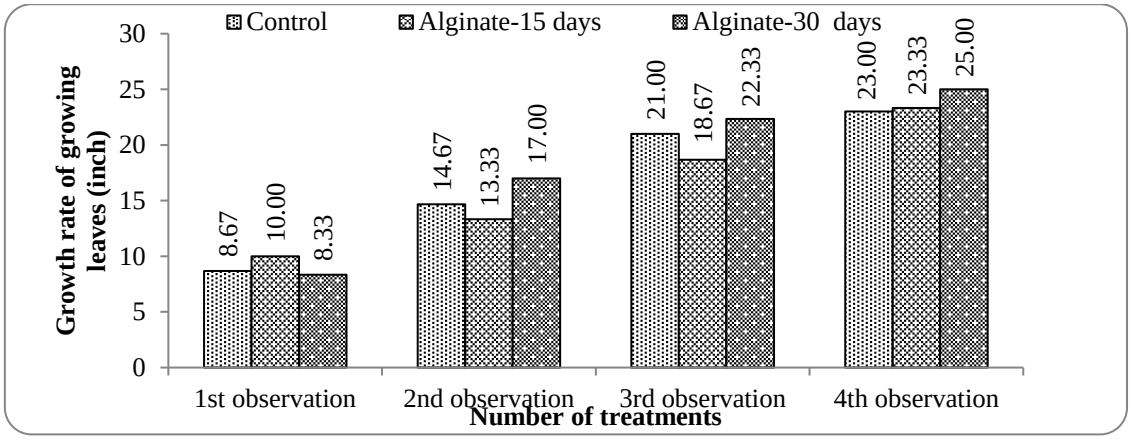

Figure 1: Effect of Na-alginate solution on growing leaves

Figure 2 shows that in the second and third observations, growing leaves were relatively taller after a 15 days interval than they were after a 30 days interval of spraying and control, but in the fourth observation, it appeared that the pineapple plants' growing leaves were relatively taller in the spraying interval of 30 days than they were in the control and chitosan-15 days interval.

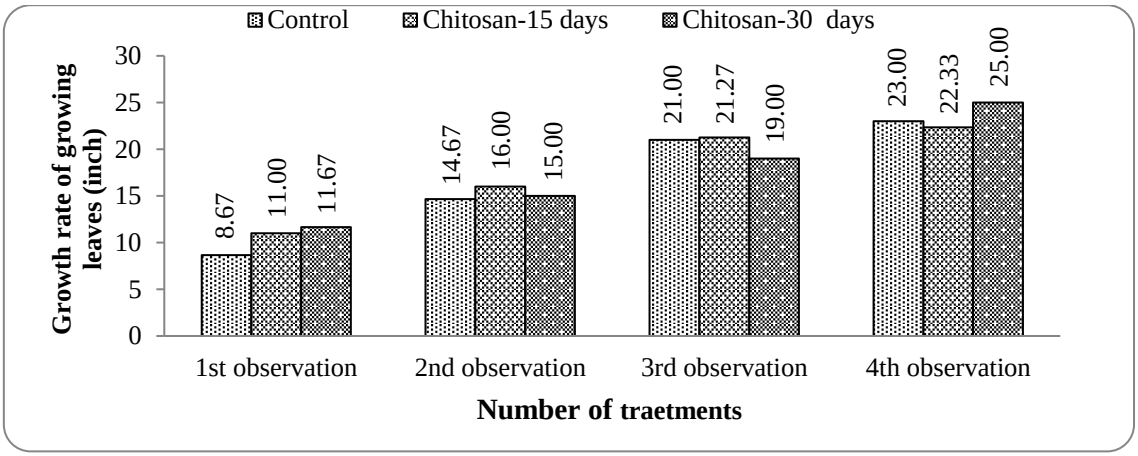

Figure 2: Effect of chitosan solution on growing leaves

According to figure 3, mixture solution was sprayed onto each plot at intervals of 15 and 30 days for a period of up to five months. It was found that the pineapple plants' growing foliage increased more quickly after a 15 days interval than they did after a 30 days interval of spraying. Additionally, it demonstrated that the growing leaf height of the mixture solution sprinkled at intervals of 30 days was lower than that of the control as well as the solution sprayed at intervals of 15 days.

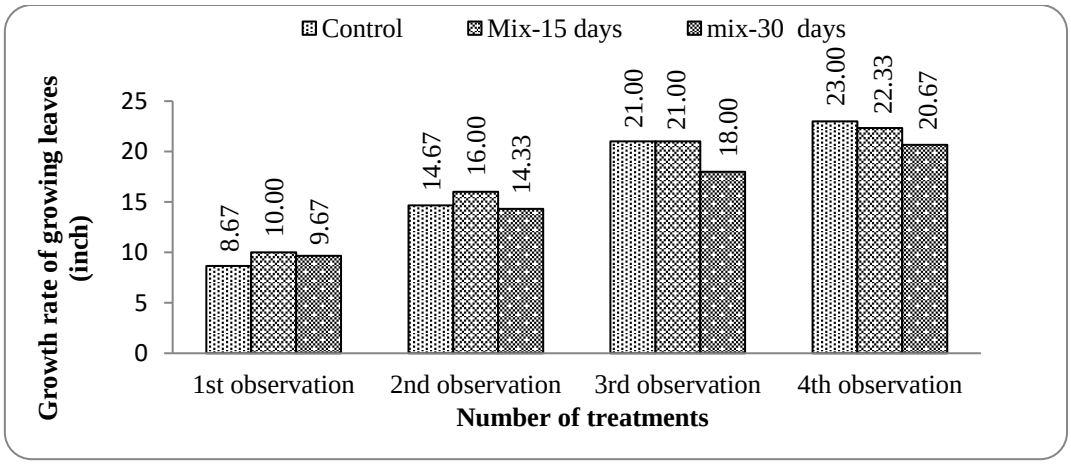

Figure 3: Effect of mixture solution on growing leaves

3.2 Measurement of mature leaves

Table 1: Effects of radiation processed alginate, chitosan and mixture solution on mature leaves against number of months

Treatments	1st observation Rate of growth (inch) (Mean ± SD)	2nd observation Rate of growth (inch) (Mean ± SD)	3rd observation Rate of growth (inch) (Mean ± SD)	4th observation Rate of growth (inch) (Mean ± SD)
Control	30.10 ± 0.78	32.27 ±1.19	34.00 ± 0.85	35.30 ± 0.51
Na-Alginate 15 days	31.36 ± 1.00	32.33 ± 1.45	33.33 ± 1.05	34.50 ± 0.90
Na-Alginate 30 days	30.13 ± 0.69	31.00 ± 0.85	32.89 ± 0.90	35.79 ± 1.23
Chitosan-15 days	32.67 ± 1.18	34.33 ± 0.67	35.00 ± 0.87	35.89 ± 1.45
Chitosan-30 days	34.00 ± 1.14	35.33 ± 0.65	36.00 ± 0.76	36.45 ± 1.00
Mixture-15 days	30.67 ± 1.05	35.00 ± 0.96	36.67 ± 1.21	36.80 ± 0.87
Mixture-30 days	32.33 ± 1.00	34.33 ± 1.09	35.00 ±1.34	35.21 ± 0.89

Table 1 shows that the growth rate of mature leaves treated with a Na-alginate interval of 30 days was significantly greater than that of the control and Na-alginate interval of 15 days. On the other hand, compared to the control and Na-alginate sprayed after a 15-day interval, the quality of the leaves after a 30-day interval was superior. The improved outcomes for chitosan spraying at intervals of 30 days were shown in table 1. After a 30-day interval, the mature leaves treated with chitosan solution were found to have noticeable effects. It was found that the mature leaves of pineapple plants had comparatively higher heights after a 15-day interval than after a 30-day interval of spraying. The aforementioned chart also showed that the mature leaf height of the mixture solution sprayed after intervals of 30 days was less than that of the solution sprayed after intervals of 15 days and control.

3.3 Observation of anti-fungal effect

Observation of anti-fungal effect of irradiated chitosan, Na-alginate and mixed solution on pineapple plants

Regular observation revealed a significant impact of irradiated sodium alginate on the overall fungal count of pineapple leaves. Concentrated sodium alginate had a lower fungus count than control plants at 500 ppm. More concentrated solutions were found to have greater antifungal activity, and plants treated with irradiated chitosan and Na-alginate were free from various parasite, fungal, and pest attacks.

4. CONCLUSION

It can be concluded that, radiation-processed biomaterials have an increasing effect on pineapple plants' productivity and anti-fungal action. Different pineapple plant responses to biomaterials at varying concentrations were observed. It should be noted that although the experiment demonstrated a progressive impact on pineapple plants, its statistical validity could not be established. This could have been caused by seasonal factors, poor plant selection, or a brief experiment. A subsequent trial will investigate the growth-promoting and antifungal properties of biomaterials.

5. REFERENCES

[1] Youssef MMA, Eissa MFM. Biofertilizers and their role in management of plant parasitic nematodes. A review. Journal of Biotechnology and Pharmaceutical Research, vol. 5(1), pp.1-6, 2014.

[2] Hossain MF, Akhtar S, Anwar M. Nutritional value and medicinal benefits of pineapple. International Journal of Nutrition and Food Sciences, vol. 4(1), pp. 84-88, 2015.

[3] Proshad R, Islam MS, Islam MN, Hossain MR, Kormoker T, Billah KMM. Promiscuous application of toxic agrochemicals on pineapple: health hazard implications in Bangladesh. Food Research. Vol. 2(2), pp. 139-145, 2017.

[4] Elieh-Ali-Komi D, Hamblin MR. Chitin and chitosan: production and application of versatile biomedical nanomaterials. International journal of advanced research, vol. 4(3), pp. 411-427, 2016.

[5] Kumar MR, Muzzarelli R, Muzzarelli C, Sashiwa H, Domb AJ. Chitosan chemistry and pharmaceutical perspectives. Chemical reviews, vol. 104(12), pp. 6017-6084, 2004.

[6] Hamel LP, Beaudoin N. Chitooligosaccharide sensing and downstream signaling: contrasted outcomes in pathogenic and beneficial plant–microbe interactions. Planta, vol. 232, pp. 787-806, 2010.

[7] Acemi A, Bayrak B, Çakır M, Demiryürek E, Gün E, El Gueddari NE, Özen F. Comparative analysis of the effects of chitosan and common plant growth regulators on in vitro propagation of Ipomoea purpurea (L.) Roth from nodal explants. In Vitro Cellular & Developmental Biology-Plant, vol. 54, pp. 537-544, 2018.

[8] Dzung PD, Phu DV, Du BD, Ngoc LS, Duy NN, Hiet HD, Hien NQ. Effect of foliar application of oligochitosan with different molecular weight on growth promotion and fruit yield enhancement of chili plant. Plant production science, vol. 20(4), pp. 389-395, 2017.

[9] Malerba M, Cerana R. Chitosan effects on plant systems. International journal of molecular sciences, vol. 17(7), pp. 996, 2016.

[10] Salachna P, Grzeszczuk M, Meller E, Soból M. Oligo-alginate with low molecular mass improves growth and physiological activity of Eucomis autumnalis under salinity stress. Molecules, vol. 23(4), pp. 812, 2018.

[11] Battacharyya D, Babgohari MZ, Rathor P, Prithiviraj B. Seaweed extracts as biostimulants in horticulture. Scientia Horticulturae, vol. 196, pp. 39-48, 2015.

[12] Khan W, Rayirath UP, Subramanian S, Jithesh MN, Rayorath P, Hodges DM, Prithiviraj B. Seaweed extracts as biostimulants of plant growth and development. Journal of plant growth regulation, vol. 28, pp. 386-399, 2009.

[13] Luan LQ, Hien NQ, Nagasawa N, Kume T, Yoshii F, Nakanishi TM. Biological effect of radiation-degraded alginate on flower plants in tissue culture. Biotechnology and applied biochemistry, vol. 38(3), pp. 283-288, 2003.

[14] Nagasawa N, Ha VTT, Hien NQ, Nakanishi TM. Enhancement of plant growth stimulation activity of irradiated alginate by fractionation. Radiation Physics and Chemistry, vol. 78(9), pp. 796-799, 2009.

[15] Espino-Díaz M, Molina-Corral F, Sepulveda D, González-Aguilar G, Olivas G. Alginate coatings containing high levels of isoleucine improve aromatic and standard quality in fresh-cut apple. Eur. J. Hortic. Sci, vol. 81(3), pp. 175-84, 2016.

[16] Dutta PK, Dutta J, Tripathi VS. Chitin and chitosan: Chemistry, properties and applications. 2004.