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Research Article

Response of Spring Onion (*Allium fistulosum* L) on the Application of Bio-Stimulant Solution

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ABSTRACT

Spring Onion (*Allium fistulosum*), is a perennial plant and a native of Eastern Asia. It is rich in vitamins A and K, iron, calcium, and dietary fiber, which contribute to various health benefits, blood pressure and cholesterol levels and improve blood regulation. The study aims to evaluate the response of spring onion to the different levels of concentration of bio-stimulant. Around 160 spring onion plants were utilized as planting materials. Before planting, extra leaves were cut to around 3 inches and roots were trimmed off too. The study was conducted at the School of Agriculture, University of Negros Occidental–Recoletos, Philippines using a Complete Randomized Design (CRD). All data gathered were statistically computed, and subjected to ANOVA using STAR 2.0.1. The experiment has four treatments: 0%, 20%, 30%, and 40% BSS, respectively, and was replicated four times. Results indicate that the application of 30% BSS significantly enhances the height to 32.02cm higher by 2.09cm for those with 0% BSS at 29.93 cm only, On the number of slips, 30% BSS has a greater number of slips of 3.42 against those with 0% BSS at 2.17 slips only. Biomass accumulation is highly significant with 3,375.00kg/ha for 30% BSS higher by 1,562.50kg/ha for 0% BSS. The total yield for 30% BSS is 3,000.00kg/ha significantly higher by 1,562.50kg/ha for 0% BSS with 1,437.50kg/ha only. Based on these findings, the application of a 30% BSS is recommended to optimize some of the agronomic attributes and yield of spring onions.

Keywords: *Bio-stimulant, Biomass, Growth performance, Onion slips, Solution, Yield*

Introduction

Spring onion (*Allium fistulosum L.)* is a perennial plant famous for its distinct allium aroma. It belongs to the *Amaryllidaceae* family, including significant plants like bulb onions, garlic, chives, and leeks. Its widespread

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cultivation is due to its adaptability and year-round growth potential. Spring onions are commonly utilized in soups and salads to enrich flavors and conceal unpleasant odors from other ingredients (Kim et al, 2023). The plant has a distinct garlic-like scent (Wang et al, 2023).

Spring onions can be raw or cooked and adapted to different regional cooking styles. Also referred to as scallions, spring onions, or bunching onions, they are distinct from regular bulb-forming onions due to their narrow, elongated bulbs, resulting in a milder flavor suitable for raw consumption. Their growth halts during the winter, and the foliage wilts, indicating a seasonal cycle in their cultivation.

In Nigeria, the *Alliaecae* family is a widely cultivated vegetable family with nutritional, culinary, and medicinal value (Ijeomah et al, 2020).

Spring onions (Allium fistulosum L.) are widely cultivated crops known for their culinary and medical importance (Li et al., 2022).

The health benefits of spring onions are extensive, including the potential to lower the risk of cardiovascular diseases and other types of cancer by reducing blood pressure, blood sugar, and cholesterol.

They contain chromium, which helps with macronutrient metabolism and glucose regulation, and are high in vitamin C, which helps support skin health and immune function. Additionally, they are an essential source of vitamin K for bone health and provide essential minerals like iron and calcium. Moreover, they are a valuable source of dietary fiber.

Claveria, Misamis Oriental, Philippines, is known for its high production of spring onions, especially in elevated areas. The demand in the market has led to increased cultivation, but the supply still needs to be increased. The perishable nature of the commodity contributes to its marketing challenges.

Addressing these shortcomings requires the development of a technology package for spring onion production, starting from the producers and extending through the post-harvest chain to the market to support the local industry (Dollen et al, 2021).

Although grown worldwide, spring onions are most popular in East Asia, where they are grown in Siberia and tropical nations like China, Vietnam, Taiwan, Japan, the Philippines, the Republic of Korea, Malaysia, and Indonesia. With an estimated production area of over 500,000 hectares,

China is the world's largest producer of spring onions, surpassing the production areas of Japan and the Republic of Korea, each with an approximate production area of 25,000 hectares. People in America, Europe, and Africa also produced spring onions in significant quantities.

Germany boasts the most extensive spring onion growing area in Europe, with estimates ranging from 1300 to 1400 hectares. Africa's leading producers of spring onions include Ghana, Sudan, Kenya, Cameroon, Congo, the Democratic Republic of the Congo, Sierra Leone, Zambia, and Zimbabwe, primarily for local consumption.

However, Morocco (around 350–400 ha) and Egypt (about 4000 ha) produce more than any other African country and are major producers of fresh spring onions to European markets. Tropical, subtropical, and temperate climates are all favorable for spring onions. The crop's capacity to adapt to various growing environments and temperatures indicates how widely cultivated and consumed it is (Kim et al, 2023).

The spring onion is grown in all parts of the world. However, a significant area for cultivation continues to be East Asia from Siberia to tropical Asia, such as China, Taiwan, Japan, Philippines, Malaysia, and Indonesia (Kayat et al, 2021).

Bio-stimulants, non-nutrient substances or microorganisms, are pivotal in promoting plant growth and productivity, decreasing the reliance on fertilizers, and offering sustainable and advantageous means to enhance crop productivity. The fundamental purpose of bio-stimulants is to regulate and alter the physiological processes in plants by improving nutrient efficiency, alleviating stress, and concurrently enhancing both the quality and quantity of yield, as indicated through visual assessment.

Different raw materials, including algae/brown algae (Phaeophyceae), humic acids, protein hydrolysates, plant hormones, plant growth-promoting bacteria, and other mixed compounds, have created bio-stimulant formulations. The primary objective of this section is to outline the application of bio-stimulants for enhancing plant growth and development and to discuss their impact on plants under abiotic stress conditions (Pandey et al, 2022).

Minerals, vitamins, plant hormones, oligosaccharides, and amino acids are abundant in bio-stimulators. These substances are essential in improving soil health, fertility, sorption, and nutrient degradation. Therefore, it is essential in nutrient cycling, abiotic stress control, heavy metal bioavailability, and greenhouse gas emissions (Bashir et al, 2021).

The quantity of amino acids, growth regulators, macronutrients and micronutrients, cytokinins and gibberellins, and vitamins in the soil is increased by the use of different types of bio-stimulants (Tariq et al., 2022).

Bio-stimulants, which economically and reliably improve treated plants' innate stress tolerance and growth metabolism, constitute a sustainable approach to improving productivity. Bio-stimulants are a class of agricultural inputs derived from natural resources that, when applied to the plant as a foliar or as a root drench, induce an innate, natural ability to cope with stress and improve water management and nutrient uptake (Shukla et al, 2022).

The bio-stimulants market is increasing year by year. The market for active ingredient bio-stimulants (such as amino acids, seaweed extracts, humic substances, and microbial amendments) was valued at $2.6 billion in 2019 and to nearly double to $5 billion by 2025, with an annual growth rate of 11.2% during the forecast period (Rouphael & Colla, 2020).

The growth of the bio-stimulators market is expected. At a compound yearly growth rate of 11.24%, By 2025, it is expected to be up to USD 4.9 billion (Shahrajabian et al, 2021).

The size of the bio-stimulants market is projected to grow from USD 4.14 billion in 2025, according to a new Grand View Research report (Bulgari et al, 2019).

In new areas, including Asia and Africa, the growth regulators and bio-stimulants market is expected to expand (Gupta et al, 2023).

In today's world, agriculture constantly encounters challenges to produce more high-quality food for an expanding population amidst a changing climate. New agricultural practices need to innovate methods for crop production, nutrition management, and plant health to meet the demand.

Furthermore, developing new compounds or biological agents capable of enhancing plant yield, regulating plant physiology and metabolism, and improving crop performance and agro-product quality is essential. Over the past ten years, agents with these characteristics have been suggested as crucial for sustainable agriculture.

Bio-stimulants, which are agents, have been shown to enhance plant nutrition, quality, yield, and resistance to environmental stress in various crops. Specifically, the utilization of protein hydrolysates as bio-stimulants demonstrates encouraging outcomes in reducing the reliance on agrochemicals and enhancing productivity parameters across different cultivars, aligning with the challenges of modern agricultural production.

This review focuses explicitly on the utilization of protein hydrolysates as bio-stimulants for plants, detailing the typical and potential agro-industrial by-products used as source substrates for formulating protein-based bio-stimulants, as well as the commercial or experimental proteolytic enzymes employed for hydrolysate production (Moreno-Hernández et al, 2020).

Bio-stimulants' effectiveness was assessed by analyzing various morphological, physiological, and quality traits. Through a wide range of studies, it was found that the bio-stimulants analyzed generally improved seed and transplant vigor, promoted vegetative growth, enhanced nutrient uptake and distribution within the plant, boosted the antioxidative capacity of plant tissues to increase stress tolerance, and enhanced overall plant yield and fruit/flower quality.

The research suggests potential benefits of utilizing bio-stimulants in horticultural production, particularly in challenging growth conditions such as during transplanting, reduced fertilization, or exposure to other abiotic stresses. The effects of bio-stimulants on plants may vary depending on the dosage, timing of application, growth conditions, and plant species, possibly due to interactions among the physiologically active compounds in bio-stimulants (Parađiković et al, 2018).

Bio-stimulants not only help break dormancy, increase fruit size, enhance root system development, increase the activities of photosynthetic and other vegetative tissues, enhance plant vigor and uniformity, regulate flowering, and stimulate fruit set and ripening, but they also support antistress, stimulate growth, enhance nutrient absorption, and increase crop productivity.

The use of bio-stimulants in agriculture has shown enormous potential to combat climate change stresses like droughts, salinity, and heat stress, among others. Bio-stimulants refer to organic compounds, microbes, or combinations of both that have the potential to influence plant growth by inducing molecular changes as well as physiological, biochemical, and anatomical adjustments. (Bhupenchandra et al, 2022).

Bio-stimulants are natural substances that enhance crop productivity and nutrient absorption, thereby decreasing reliance on synthetic fertilizers (Xu & Geelen, 2018).

The metabolites or intermediates that may influence the quality of the nutritional parts of the plant are biostimulants that can support plant stress tolerance and productivity under adverse growth conditions (Teklić et al, 2020).

There is no doubt that bio-stimulants play an essential role in increasing crop production, making food at low prices, and improving the quality of food. The importance of bio-stimulant formulations has been brought to the fore.

It is, therefore, necessary to ensure that the bio-stimulant formulation is chemically stable and physically uniform in all foreseeable storage conditions to accurately apply a minimum effective dose for target areas (Kumar et al, 2020).

New strategies for sustainable food production and security need to be put in place with a view to the modernization of agriculture. The potential for sustainable and economically advantageous solutions to improve agricultural practices and crop productivity, which could lead to the introduction of novel approaches that will bring about improvements in plant growth and health, is represented by bio-stimulants, defined as non-nutrient substances or microbiologists capable of promoting plant growth and healthy development (Nephali et al, 2020).

The general findings indicate that on average, there is a 17.9% increase in yield when using bio-stimulants. The most significant effect was observed when applying bio-stimulants to the soil. The application of bio-stimulants in dry climates and for vegetable farming had the most significant influence on crop yield. Bio-stimulants demonstrated higher effectiveness in soils with low organic matter, non-neutral pH, saline conditions, insufficient nutrients, and sandy texture (Li et al, 2022).

Agroecosystems have been disrupted by abiotic and biotic factors, leading to a decline in crop quality and productivity. A potential solution to these environmental challenges is the use of bio-stimulants, which are eco-friendly and can address a variety of issues in sustainable agriculture. Bio-stimulants can enhance plant defense mechanisms under stress, ultimately improving plant growth through physiological, chemical, and molecular changes.

One of the primary challenges confronting the world currently involves the necessity to generate additional food to satisfy the requirements of a growing population. Agro-productivity is threatened by dwindling arable land, rising human activity, and climate change that causes frequent flash floods, protracted droughts, and abrupt temperature swings.

Warm weather also increases the prevalence of pests and diseases, ultimately lowering crop production. Coordinated global efforts are needed to implement ecologically safe and sustainable agricultural practices to increase crop growth and productivity. Bio-stimulants can enhance plant development, even under challenging environments (Bisht & Chhabra, 2024).

Increasing crop yield is essential to meet the growing demand for food. Therefore, a green, practical, sustainable, and economically productive system is required to improve agricultural agronomic qualities. Bio-stimulants are among the most effective and promising methods for organically improving crop productivity and growth while resolving concerns with chemical fertilizers.

Various kinds of organic or inorganic chemicals, known as bio-stimulants, bio-effects, protectors, or bio-based products, are composed of microorganisms or bioactive molecules that enhance their growth and production when applied to target plants (Kaushal et al, 2023).

Bio-stimulants play a crucial role in environmental conservation and resource preservation by enhancing plants' efficient utilization of nutrients. They help decrease greenhouse gas emissions by optimizing nitrogen usage. Through improved nutrient absorption, bio-stimulants aid in the conservation of non-renewable resources.

Furthermore, they boost the uptake of water and nutrients from the soil, stimulate root growth, and enhance plant resilience to water, heat stress, and high salinity, consequently reducing the necessity for pesticides (Marcel et al, 2021).

Bio-stimulants reduce fertilizer and increase fertilizer growth, water resistance, and abiotic stresses. These substances are effective in small concentrations, contributing to the good performance of plant vital processes and providing high yields and excellent quality products (De Vasconcelos & Chaves, 2020).

To ensure crop production with reduced fertilizer application rates, the effect of bio-stimulants on nutrient use efficiency can be a significant part of this process (Wozniak et al., 2020). In addition to reducing reliance on chemical fertilizers, bio-stimulants are a group of substances of natural origin that contribute to increasing plant yields and nutrient uptake. Xu et al, (2018).

Objectives of the study

This study aimed to evaluate the effectiveness of the different levels of concentration of bio-stimulant solution in inducing the growth and yield of spring onion plants.

Specifically, it aimed to:

1. Assess the effect of the different levels of concentrations of bio-stimulant solution on the growth of spring onion plants.
2. Identify the optimal levels of concentrations of bio-stimulant solution that could increase the yield of spring onions.
3. Determine other growth characteristics correlated with the yield of spring onion plants.

Materials and Methods

Materials

One hundred sixty spring onion plants were prepared as planting materials.

Methods

Research Design and Treatments

This study assessed the response of spring onion to the different levels of concentration of bio-stimulant solution applied. There were four (4) treatments and were replicated four (4) times. The study was laid out in a Completely Randomized Design (CRD).

Treatments

T1 – 0% BSS
T2 – 10% BSS
T3 - 20% BSS
T4 – 30% BSS

Cultural Management

Preparations of Planting Area, Materials, and Poly-ethylene Bags

1. The experimental area of 100 square meters was clean and leveled off.
2. Around 160 polyethylene bags were filled up with soils as planting mediums.
3. After filling up with soil, the bags were laid out per the treatment design.
4. Soil samples were taken from each P-bag for analysis before the actual planting of the green onion.

Soil Sampling Procedure

1. A handful of soil was gathered in every P-bag.
2. Soil samples gathered were mixed thoroughly by hand and air-dried for 3 days.
3. One (1) kilo of soil sample per treatment was placed in a plastic bag and was properly labeled.
4. Samples were brought to the soil laboratory for analysis.

Planting

1. Around 160 matured spring onions were prepared as planting materials.
2. The planting materials were separated individually
3. Extra leaves and roots were trimmed off to 3 inches only.

4. The planting materials were soaked in water for 12 hours.
5. One onion slip was planted per P-bag.

Watering and Maintenance

The plants were regularly watered to keep the soil moist

1. The plants were monitored regularly and ensured that water penetrated the soil, to encourage the development of roots.
2. Holes at the bottom of the bags were made to drain out excess water.

Monitoring of the Presence of Pests and Diseases

Regular monitoring for the presence of pests or diseases was done throughout the study.

Weeding

Hand weeding was regularly done.

Preparation and Application of Bio-stimulant

1. Preparation of solution was done separately per treatment before application.
2. Application of solution was done, using a measuring cup and placed at the base of each growing setts.
3. Application of bio-stimulant solution was done at 10, 20, and 45 days after planting.

Research Environment

The experiment was conducted at the UNO-R School of Agriculture Field, Bacolod City, Philippines last December 4, 2023, to February 18, 2024.

Data Gathered

1. Height of slip
2. Number of slip
3. Biomass
4. Final Yield

Statistical Analysis

All data gathered were statistically computed, and subjected to Analysis of Variance (ANOVA) in CRD using STAR 2.0.1.

The Least Significant Differences (LSDs) were used to determine significant differences among treatments.

Results and Discussions

Plant Height

Application of bio-stimulant at different concentrations enhances the height of spring onion plants.

Table 1 presents a significant variance in outcomes across different treatments. Specifically, the application of 40% BSS exhibited the longest average slip length of 25.57cm at 15 DAP, compared to 0% BSS which only averaged 19.43cm.

Following the 40% BSS in descending order were the 30% BSS with an average slip length of 24.48cm at 15DAT, and 20% BSS with 21.70cm. These findings suggest that higher concentrations of the bio-stimulant may positively influence the growth and development of spring onion plants through increased slip length.

Table 1. Average height (cm) of spring onion applied with different levels of concentration of bio-stimulant solution 15, 30, and 45 days after planting

Percent Concentration of Bio-stimulant	Height of Spring Onion Plant (cm)		
	15DAT	30DAT	45DAT
0% BSS	19.43^{d}	24.93^{b}	23.93^{c}
10% BSS	21.70^{c}	26.23^{b}	25.30^{c}
20% BSS	24.48^{b}	26.02^{b}	27.60^{b}
30% BSS	27.57^{a}	29.33^{a}	32.02^{a}
Mean	**23.30**	**26.63**	**27.21**
Pr (>F)	0.0000**	0.0002**	0.0000**
CV (%)	3.99	3.59	4.44

*Means with the same letter are not significantly different from each other, **=highly significant*

Bio-stimulants, as discussed by the group of Giulia Franzoni (2022), are innovative agronomic tools that bridge the gap between fertilizers and plant growth regulators. These products, whether organic or inorganic, contain bioactive substances and/or microorganisms. When applied to the plant or its rhizosphere, they enhance plant growth and productivity.

They achieve this by improving the efficiency of nutrient absorption and assimilation, increasing tolerance to abiotic stresses, and/or enhancing the quality of the product, irrespective of nutrient content.

Number of Slips

Table 2 presents the average number of spring onion slips at 30 and 45 days after planting (DAP), under different concentrations of bio-stimulant solution.

The measurements at 30DAP showed no significant differences in the number of slips among the treatments, suggesting that the initial impact of bio-stimulants on slip emergence is minimal. By 30DAP, however, there were highly significant differences across the treatments, with higher concentrations of bio-stimulant solution showing an increase in the number of slips. This pattern indicates that bio-stimulants have a more pronounced effect as the plants develop.

At 30DAP, spring onions applied with 40% BSS are numerically higher in terms of several slips at an average of 2.20 while 0% BSS has 1.80 slips only.

A significant result was shown in 45DAP, wherein spring onion applied with 40% BSS had a greater number of 3.43 slips higher by 1.25 from those 0% BSS with 2.17 slips only. Those applied with 20% BSS have an average slips of 2.83 significantly higher than those applied with 10% BSS with 2.52 slips. This finding is indicative of the enhanced efficacy of bio-stimulants in stimulating slip proliferation over time.

Table 2. An average number of spring onion slips applied with different levels of concentration of bio-stimulant solution 30 and 45 days after planting.

Percent Concentration of Bio-stimulant	Number of Spring Onion Slips	
	30DAP	45DAP
0% BSS	1.80	2.17^{d}
10% BSS	1.95	2.52^{c}
20% BSS	2.12	2.83^{b}
30% BSS	2.20	3.42^{a}
Mean	**2.02**	**2.74**
Pr (>F)	0.0542^{ns}	0.0000**
CV (%)	9.67	6.91

*This means that the same letters are not significantly different from each other, ns=not significant, **=highly significant*

This research contributes to the understanding of bio-stimulant effects on green onion growth and highlights the importance of adjusting agricultural inputs to optimize crop yield and quality.

The role of bio-stimulants in sustainable agriculture is increasingly recognized, as they enhance nutrient efficiency and reduce reliance on chemical fertilizers, which is critical in the context of global resource scarcity and environmental sustainability (Georgina et al, 2021).

The Biomass and Yield

Table 3 presents the accumulated biomass and yield of spring onion slips among the four treatments. It can be observed that applying a concentration of 40% BSS can accumulate the largest biomass of 3,375kg/ha, followed by 20% BSS with a biomass of 2,700kg/ha. Furthermore, the application of 10% BSS has a biomass of 2,375kg/ha and the 0% BSS has the lowest biomass accumulation of 1,812kg/ha.

Relatively, spring onion applied 30% BSS also has the largest yield of 3,000.00kg/ha, followed by 20% BSS with a yield of 2,250.00kg/ha. Onion applied with 10% BSS has a yield of 2,062.50kg/ha while 0% BSS lowest yield of 1,437.50 kg/ha. This suggests that the use of bio-stimulants can enhance the growth and productivity of spring onion plants, leading to increased biomass and yield.

These findings indicate that treatment 30% BSS was the most effective concentration in increasing both the biomass accumulation and yield of spring onion slips. The higher biomass and yield of 30% BSS solution suggest that the specific conditions provided in this concentration, such as nutrient availability, watering schedule, and bio-stimulant, could enhance the growth and productivity of spring onion slips.

Table 3. The biomass accumulation (kg/ha) and total yield (kg/ha) of spring onion applied with different levels of bio-stimulant solution.

Percent Concentration of Bio-stimulant	Biomass (kg/ha)	Yield (kg/ha)
0% BSS	1,812.50[d]	1,437.50[d]
10% BSS	2,375.00[c]	2,062.50[c]
20% BSS	2,700.00[b]	2,250.00[bc]
30% BSS	3,375.00[a]	3,000.00[a]
Mean	**2,565.62**	**2,187.50**
Pr (>F)	0.0000**	0.0000**
CV (%)	8.55	7.74

*This means that the same letters are not significantly different from each other, **=highly significant*

The use of bio-stimulants, either alone or in combination with inorganic fertilizers, offers a promising alternative for increasing crop yield while enhancing soil health. However, the particular methods by which bio-stimulants improve soil health and agriculture productivity are unknown.

The primary goal of this study was to assess the effects and mechanisms of bio-stimulants on major soil biological health components and their implications for crop yields.

Soil biological and physicochemical parameters, as well as crop production, were measured to provide quantitative information about the effects, magnitude, and mechanisms of bio-stimulant application on soil health. Such knowledge will aid in the widespread adoption of bio-stimulant techniques by farming communities. (Wadduwage, J., 2021).

Correlation of Selected Characteristics

The competency of associating between characteristics provides the strength of a linear relationship between two parameters and helps identify the most important characteristic (s) to be considered in determining possible phenomena of ineffective characterization. In this novel study, it is important to obtain information on the relationship between yield determinants and accelerating accumulation of biomass, tiller height, and number of spring onion plants.

Correlated Characteristics of Spring Onion Plant with the Yield

Among the characteristics tested for correlation with the yield of spring onion plants, all three characteristics are positively correlated. Among the positive correlation, the tiller height, number of slips, and biomass are strongly correlated with the yield, with coefficients with *r-values* of 0.93, 0.91, and 0.97, respectively.

Table 4. Characteristics of spring onion plants that significantly correlated with yield applied with different levels of bio-stimulant solution.

Characteristics Correlated with Yield	Correlation Coefficient *(r)*	P-value	Interpretation
Slips height	0.9326	0.0000**	Strong (+) linear correlation
No. of slips	0.9100	0.0000**	Strong (+ linear correlation
Biomass	0.9787	0.0000**	Strong (+) linear correlation

***=highly significant at a 1% level of probability,*

For further discussion of the data presented in the above-mentioned table (Table 4), the yield can be directly correlated with the height of slips (*r-values*=0.93), number of slips (*r-values*=0.91), and biomass accumulation *(r-values*=0.98), respectively.

Conclusion and Recommendations

The different concentrations of bio-stimulant resulted in enhancing the growth and maximizing the yield of spring onion plants. The use of 30% bio-stimulant solution has a highly significant influence on the height of slips, number of slips, and biomass accumulation of spring onion plant

Based on the findings, this study recommends the use of a 30% concentration bio-stimulant solution to enhance the growth and maximize the yield of spring onion

For correlated traits with yields, three characteristics are in strong positive linear correlation. Making it true that the height of the slips, the number of the slips, and biomass are directly correlated with the yield.

The researchers suggest further study of the effects of different levels of concentration of bio-stimulant solution on the different variables in spring onion production, e.g. at different elevations, locations, seasons, and types of soils, among others.

Conflict of Interest

No other group is involved in this study

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