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Research Article

Inducing the Growth and Yield of Mungbeans Applied with Different Level of Concentrations of Bio-Stimulant Solutions

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ABSTRACT

The study sought to determine the effects of different levels of concentrations of bio-stimulant solution (BSS) in inducing the growth, flower, and yield of mung bean. The study was conducted at UNO-R School of Agriculture, Philippines last February to April 2022. Pagasa 3 variety was used as planting material. The study was laid out in RCBD) with four treatments and replicated 4 times. The BSS was diluted in water and applied 6 inches from the base of the plant as per research protocol. Statistical analysis revealed highly significant differences among treatments in growth parameters such as plant height and leaf area index (LAI) at 35DAS. Likewise, there was high significant difference among treatments on the days to 50% flowering of the plant. Furthermore, results showed highly significant differences among treatments in the number of pods per plant, pod weight per plant, number of seeds per pod, 100 seed weight, and yield of mung bean. For the highest plant height, LAI, and period of flowering they were obtained from plants applied with 150ml BSS, followed by 100ml BSS, and 50ml BSS. On the other hand, untreated plants have the shortest height, narrower leaves, and late in flower initiation. Mung bean pods per plant were great in number, heavier in weight from plants treated with 150ml BSS among the other treatments, the most number of seeds per pod, and the heaviest per 100-seed weight as well as the highest seed yield per hectare. This study recommends the use of 150ml BSS in inducing the growth and higher yield of mung bean plant production.

Keywords: *Flower inducer, Green manuring, Growth enhancer, Natural farming, LAI*

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Introduction

One of the most economical plant protein sources is mung bean *(Vigna radiata L.).* It is a drought-tolerant crop and requires a warm climate during its growing period that suits the country's temperature and humidity for prevailing optimum yields (Department of Agriculture, 2022; Department of Agriculture, 2019; Dhillon, 2021). Small farmers mostly favor mung bean because it matures early, grows fast, and produces abundant vegetative tops which makes it an excellent crop for green manuring and livestock feed (Ramakrishnan et al., 2011). Mung bean is considered a legume. When properly inoculated and planted into situations with low background soil nitrogen levels, mung beans should fix sufficient nitrogen to support their growth and often leave some residual nitrogen for the following crop (Martin et al., 2020).

However, production of mung bean/mongo in the fourth quarter of 2022 decreased to 3.13 thousand metric tons by -1.5 percent from 3.18 thousand metric tons in the same quarter of 2021 according to Philippine Statistics Authority's report. One possible reason for the decrease is the large proportion of flowers aborted during development due to vascular tissue limitation in the distal part of rachis results in lower yield in mung bean. Results revealed that the genotypes, that produced a higher number of flowers within a shorter period (10–15 days) after the commencement of the flowers, produced higher yields, attributed to a higher number of flowers and pods (Fakir et al., 2011).

Bio-stimulants increase crop yield improve crop quality and protect plants from pests and diseases (Oñal et al., 2023). Its concept is based on the inoculation of mixed cultures of beneficial microorganisms into the soil where microbial equilibrium is being shifted and an environment that is favorable to the growth and health of plants. Applying bio-stimulants to soil or plant leaf surfaces increases the populations of photosynthetic bacteria and nitrogen-fixing bacteria (NFB) (Higa & Wididana, 1988). It also improved microbial activity, organic matter, and enzymatic activity in the soil (Yousfi et al., 2021).

The microorganisms contained in the concoction reportedly produce plant hormones, beneficial bioactive substances, and antioxidants while solubilizing nutrients (Ncube et al., 2011). Results on the study of Pea Production state that it seems probable that foliar application of effective microorganisms favors flower initiation in the test legume species resulting in an increased number of pods (Amalero et al., 2011).

The researchers, therefore, conducted this study to assess the effectiveness of applying the bio-stimulant solution in the induction of growth and flowering stage of mung bean production at different levels. It is to further enhance and increase productivity while promoting natural and pesticide-free crop production.

This study on the growth and yield of mung bean applied with different levels of concentrations of bio-stimulant solutions aims also to contribute to the field and body of knowledge on natural farming and agroecology.

Objectives

The general objective of this study is to determine the effect of different levels of concentrations of bio-stimulant solution in inducing the growth and yield of mung bean.

Specifically, it aims to:

a. Determine the effect of the application of different level concentrations of bio-stimulant solution on the flowering of mung beans.
b. Determine the effective level of concentrations of bio-stimulant solution that could enhance the growth of mung beans
c. Determine the relationship between the growth and yield of mung bean viz-a-viz the application of different levels of concentrations of bio-stimulant solution.

Methods and Materials

Materials

The variety used was Pag-asa 3 with an average yield of 1.10 to 1.57 tons per hectare.

Experimental Design and Treatment

The study employed the Randomized Complete Block Design with four (4) Treatments replicated four (4) times. Data were gathered

from ten (10) sample plants per replication. The treatments were as follows;
Treatment 1 – No BSS (control)
Treatment 2 – 50 ml BSS diluted in water (50.05712 ppm)
Treatment 3 – 100 ml of BSS diluted in water (100.11423 ppm)
Treatment 4 - 150 ml of BSS diluted in water (150.17135 ppm)

Land Preparation, Cultivation, and Seed Sowing

1. The area was prepared thoroughly. Thereafter, furrows were laid out.
2. Seeds were soaked in water for 10 minutes before sowing
3. Four (4) seeds were sown per hill at a distance of 20 cm per hill
4. Seeds were thinly covered with soil and pressed lightly to conserve the soil moisture
5. Cultivation and weeding done as needed.

Maintenance of Plant Population

1. Thinning done 2 weeks after sowing.
2. Only two (2) plants were maintained per hill.

Preparation and Application of Bio-stimulant Solutions

1. Preparation of solutions done at the onset of application.
2. The required concentration of BSS per treatment was diluted in water.
3. Application of solutions done 10 and 25 days after sowing the seeds.

Research Environment

The experiment was conducted at the UNO-R School of Agriculture field, Bacolod City, Philippines last February-April, 2022.

Data Gathered and Period of Gathering

The following was gathered as per schedule:

1. Average Plant Height (in cm) – was gathered at 15, 20, and 35 days after sowing.
2. Average Leaf Area Index (LAI) – was gathered at 20 and 35 days after sowing.
3. Average Flowering Initiation (in the number of days) – was taken by counting the number of days that flowers first occurred in at least 60% viz-a-viz the total sample plant.
4. The following data were taken at harvest:
   a. No. of pods/plant
   b. Pod weight/plant (grams)
   c. Number of seeds/pod
   d. 100 seed weight (grams)
   e. Bean yield (tons/hectare)

Statistical Analysis

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

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

Results and Discussions

Plant Height (cm)

Table 1. Plant height of mung bean applied with different levels of concentrations of Bio-stimulant solution taken at 15, 20, and 35 days after sowing.

Treatments	Plant Height (cm)		
	15DAS	20DAS	35DAS
Control	11.95^{c}	12.57^{c}	34.70^{c}
50ml of Bio-Stimulant	13.57^{b}	15.38^{b}	36.42^{c}
100ml of Bio-Stimulant	14.40^{b}	16.10^{b}	42.70^{b}
150ml of Bio-Stimulant	15.50^{a}	18.85^{a}	54.65^{a}
Pr (>F)	0.0001**	0.0002**	0.0001**
CV (%)	3.95	6.89	7.83

*Means followed by the same letter are not significantly different, ** highly significant*

Table 1 presents the plant height of mung bean, which was determined at 15, 20, and 35 days after sowing. Statistical analysis showed that mung bean plants treated with different levels of concentrations of Bio-stimulant solutions (BSS) had a highly significant effect on plant height.

At 15 and 20DAS, the highest plant height of mung bean was observed from plants treated with 150ml BSS (T4) with an average of 15.50cm and 18.85cm, respectively. This was followed by 100ml BSS (T3) with a mean of 14.40cm and 16.10cm, which was comparable to plants applied with 50ml BSS (T2) with an average height of 13.57cm and 15.38cm, respectively. On the other hand, plants with no BSS (T1) obtained the shortest growth of 11.95cm and 12.57cm, at 15 and 20DAS, respectively which was significantly inferior by 3.55cm and 6.28cm compared to plants treated with 150ml BSS (T4).

Moreover, the highest plant height of mung bean at 35DAS was obtained from plants applied with 150ml BSS (T4) with an average of 54.65cm, followed by T3, T2, and T1 with a mean of 42.70 cm, 36.42cm, and 34.70 cm, respectively. The highest plant height of 54.65cm from plants applied with 150ml BSS (T4) was significantly better by 19.95cm against the control.

The best effect of seaweed extract used as a bio-stimulant was observed in increasing the length of the height of mung beans by almost 39% as compared to the control (Di-Filippo-Herrera et al, 2019).

Foliar application of bio-stimulant on bell peppers increased significantly the plant height and LAI (Mahmood et al., 2017).

Leaf Area Index (LAI)

Results showed no significant differences in the leaf index of mungbean at 20DAS but revealed highly significant differences among treatments at 35DAS of observation. Mung bean plants applied with 150ml BSS (T4) were observed to have wider leaves at 35DAS with an average of 3.27cm, which was comparable to the application of 100ml BSS (T3) with a mean of 3.15cm. This was followed by 50ml BSS (T2) with a leaf area index of 2.62cm, while untreated plants (T1) got an average of 2.12cm. Comparably, mung bean plants under 150ml BSS (T4) were significantly wider by 34.88cm than control plants. The result of the study by Koneni (2016) indicates that bio-stimulants significantly responded to mung beans both in soil and foliar application. Furthermore, the LAI had constantly increased from 15 DAS and reached a maximum of 1.673 at 45 DAS (Koneni, 2016).

High-yielding mung bean varieties should have a larger leaf area and higher dry mass production (Mondal et al., 2012).

Table 2. Leaf Area Index (cm) of mungbean applied with different levels of concentrations of Bio-stimulant solution taken at 20 and 35 days after sowing.

Treatments	Leaf Area Index (cm)	
	20 DAS	35DAS
Control	0.49	2.12^{c}
50ml of Bio-Stimulant	0.58	2.62^{b}
100ml of Bio-Stimulant	0.61	3.15^{a}
150ml of Bio-Stimulant	0.66	3.27^{a}
Pr (>F)	0.2295^{ns}	0.0000**
CV (%)	17.88	4.86

*Means followed by the same letter are not significantly different, ** highly significant, ns – not significant.*

Days to 50% flowering

Results showed that the flowering time of mung bean treated with different concentrations of bio-stimulant solutions had high significant difference from untreated plants. Mung bean plants applied with 150ml BSS (T4) exhibit the earliest 50% flowering on the 30th day, followed by plants under 100ml BSS (T2)

on the 32nd day, plants under 50ml BSS (T2) on the 35th day, and the last was the control (T1) on the 42nd day.

Mung bean plants under 150ml BSS (T4) exhibit early flowering, significantly shortened by 12 days compared to the control. Based on this study, the use of a bio-stimulant solution promotes early flowering of mung bean. This result is supported by the studies of Malbataan et al (2023) on cowpea and "bush sitao" where the period of flowering with the application of irradiated carrageenan (IC) was shortened by two to four days for cowpea and seven to eight days for "bush sitao." (Malabataan et al., 2023).

Yield Parameters

Table 3. Yield parameters of mung beans applied with different levels of concentrations of Bio-stimulant solution

Treatments	Yield Parameters				
	Number of pods/plant	Pod weight/ plant (g)	Number of seeds/pod	100 seed weight (g)	Seed Yield (ton/ha)
Control	4.00^{d}	0.030^{d}	8.00^{d}	35.00^{d}	1.25^{d}
50ml of Bio-Stimulant	8.00^{c}	0.075^{c}	13.00^{c}	45.00^{c}	1.63^{c}
100ml of Bio-Stimulant	10.00^{b}	0.100^{b}	16.00^{b}	55.00^{b}	1.73^{b}
150ml of Bio-Stimulant	12.00^{a}	0.145^{a}	17.00^{a}	58.00^{a}	1.92^{a}
Pr (>F)	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
CV (%)	1.39	4.86	3.27	2.27	0.6293

*Means followed by the same letter are not significantly different, ** highly significant*

The yield parameters of mung beans are shown in Table 3. Statistical analysis showed highly significant differences among treatments on the yield parameters of mungbean such as the number of pods per plant, pod weight per plant, number of seeds per pod, 100-seed weight, and seed yield. The number and heaviest pods per plant were obtained from plants treated with 150ml BSS (T4) with an average of 12 pods and 0.145g pod weight per plant. These were followed by 100ml BSS (T3), 50ml BSS (T2), and control (T1) with averages of 10, 8, and 4 pods per plant and average of 0.100g, 0.075g, and 0.030g of pod weight per plant, respectively.

Likewise, the highest number of seeds per pod and most heavy in terms of 100-seed weight were observed from plants treated with 150ml BSS (T4) with an average of 17 seeds per pod and 58g of seed weight, respectively. These were followed by 100ml BSS (T3), 50ml BSS (T2), and control (T1) with a mean of 16 seeds, 13 seeds, and 8 seeds per pod and 55g, 45g, and 35g of seed weight, respectively.

Relatively, the application of different levels of concentrations of bio-stimulant solution significantly affects the seed yield of mung bean. Plants treated with 150ml BSS (T4) obtained the highest yield of 1.92 tons/ha, followed by 100ml BSS (T3), 50ml BSS (T2), and control (T1) with an average yield of 1.73, 1.63 and 1.25 tons/ha of seed yield, respectively.

Moreover, mung bean plants treated with 150ml BSS (T4) had significantly increased by eight pods per plant, 0.115g pod weight, 9 seeds per pod, 23g of 100 seed weight, and 0.67 tons/ha seed yield compared to untreated plants.

The study of Majkowska-Gadomska, et al. (2021) on the other hand, shows that the application of bio-stimulant did significantly differ in the yield (total fruits) of pepper. (Majkoweka-Gadomska et al., 2021).

Combined application of bio-slurry and organic material and N-fertilizer has a direct effect on hundred seed weight, grain yield, and straw or biomass as studied by a group of Tadeves et al. (2021).

The applications of different concentrates of azolla as bio-stimulant significantly increase the length of pods and number of pods but it does not affect the number of seeds per pod and yield (Paler & Alcantara, 2021).

Limitations of the Study

The study was limited only to the growth and yield of mung bean plants applied with the different levels of concentrations of bio-stimulant.

This research was conducted in a 100-square-meter area. It was laid out at the School of Agriculture field of the University of Negros Occidental-Recoletos (UNO-R), Philippines from February 1, 2022, to April 30, 2024. There were four treatments and replicated four times using the randomized Complete Block Design (RCBD).

Conclusions and Recommendations

The different levels of concentrations of bio-stimulant solutions resulted in a significant change in the growth and yield of mung bean plants. The use of 150ml BSS significantly influences the plant height, and leaf area index and promotes the early flowering of mung beans. Similarly, yield parameters such as the number of pods per plant were significantly increased by eight pods, heavier than 0.115g pod weight per plant, increased by nine seeds per pod, heavier than 23g per 100 seed weight, and increased by 0.67 tons/ha seed (bean) yield.

Based on the findings, this study recommends the use of 150ml BSS in inducing the growth and higher yield of mung bean plant production.

Conflict of Interest

No other group is involved in this study

Acknowledgment

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APPENDIX

Climate

The province of Negros Occidental in the Philippines is under Type I climate, where two seasons are present. The dry season is from November to April, and the rest of the year is the wet season with the maximum rain period from June to September. The average rainfall and temperature throughout the experiment are presented in Figure 1 using the climate-data.org. (https://en.climate-data.org/asia/philippines/negros-occidental/bacolod-5074/#climate). The date of planting had started in February and harvest time was done in April 2022.

Results of the study of Dhillon (2021) on the effect of temperature on the growth rate of mung beans indicate that mung beans are dependent on temperature. Results show that the growth of mung beans is enhanced by warm temperatures (Dhillon, 2021).

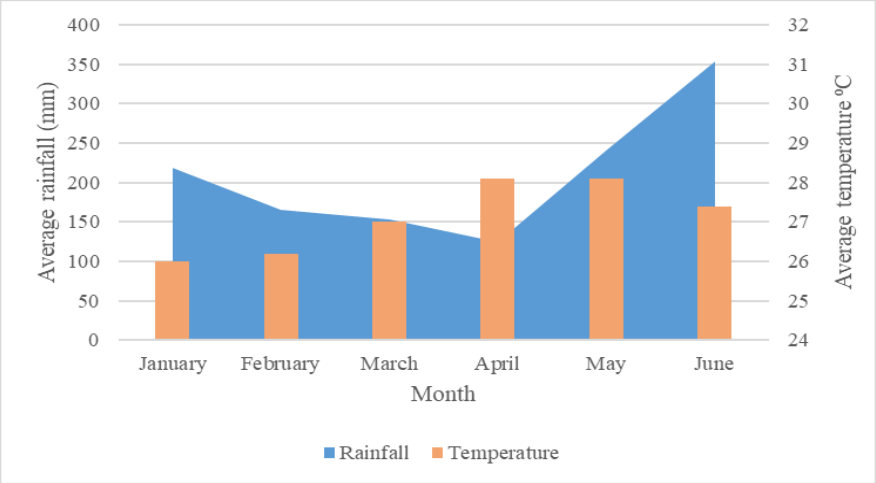

Figure 1. The average rainfall (mm) and temperature (^{0}C) throughout the experiment

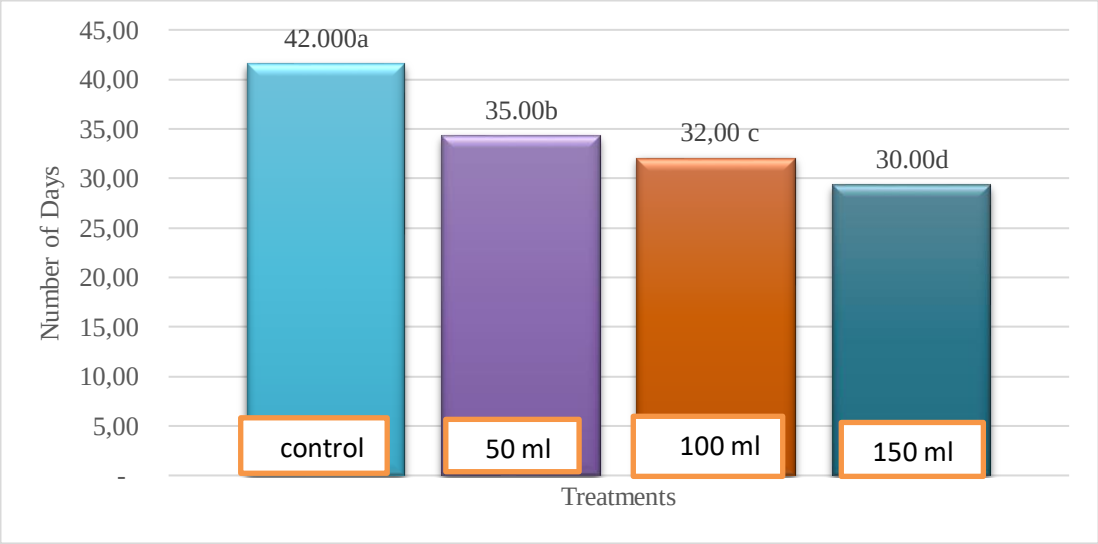

Figure 2. Days to 50% flowering of mung bean applied with different levels of concentrations of Bio-stimulant solution
*Means followed by the same letter are not significantly different, ** highly significant*