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Response of Mungbean (*Vigna radiata* L.) Applied with Carrageenan as Intercropped Under Banaba (*Lagerstroemia speciosa* L.) Trees in Pampanga, Philippines

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Abstract: Mungbean (*Vigna radiata* L.) is a widely grown legume in the Philippines, valued for its high nutritional content and ability to thrive under diverse environmental conditions. However, its productivity is often affected by factors such as limited light and competition for water and nutrients, especially in agroforestry systems where it is cultivated beneath the canopy of trees like banaba (*Lagerstroemia speciosa* L.). Thus, this study determined the response of mungbean (*Vigna radiata* L.) applied with carrageenan as intercropped under banaba (*Lagerstroemia speciosa* L.) trees in Pampanga, Philippines. Specifically, it aims to determine the following: plant height (cm), length of pods per plant (cm), number of pods per plant, number of seeds per pod per treatment, weight of pods (g) and percentage survival (%). The results showed that T_5 dominantly obtained the highest significant difference among all the parameters at the 1% level. In terms of following parameters, plant height (cm) obtained the highest mean of 61.2 cm, 10.61 cm of length (cm) of pods per plant, 18.13 number of pods per plant, and 11.73 seeds per pod. In terms of survival percentage (%), T_5 had the highest percentage of 100% at the 1% level (Pr>F 0.0009), while T_0 obtained the lowest percentage of 32.22%. T_5 grew, developed, and produced high yields in an open area where sunlight reception was full and no competition for resources occurred. The findings also revealed that environmental factors, particularly light availability and resource competition, played a crucial role in crop performance. The superior performance of T_5 in an open area with full sunlight suggests that minimizing competition and optimizing growing conditions are essential for maximizing mungbean (*Vigna radiata* L.) productivity. Based on the results obtained, the study highlights the potential of carrageenan application to improve the growth and yield of mungbean (*Vigna radiata* L.). Therefore, enhancing site conditions through sufficient light availability and minimizing competition between plant species is crucial for improving mungbean (*Vigna radiata* L.) productivity and ensuring successful crop establishment in agroforestry and intercropping systems.

Keywords: Agroforestry; Banaba; Carrageenan; Intercropping; Mungbean.

INTRODUCTION

Agroforestry was a promising solution for bridging the gap between agriculture and forestry by establishing an integrated system addressing both environmental and social objectives. It could enhance the resilience of agricultural systems and mitigate their impact on climate change. It involved the purposeful integration of woody vegetation, such as trees and shrubs, with crops and/or animals on the same piece of land. This sustainable land-use integration aimed to diversify production systems through interactions between the system components, creating benefits for the environment, economy, and society (Brown et al., 2018).

The main crop to be intercropped was mung bean (*Vigna radiata* L.), also known as green gram or yellow gram, a vegetable plant of the pea family (Fabaceae), cultivated for its edible seeds (Petruzzello, 2023). The mung bean (*Vigna radiata* L.) was one of the most important edible legume crops, grown to more than 6 million hectares worldwide (almost 8.5% of the global legume area) and consumed by most households in Asia. Due to its characteristics of being generally drought-tolerant, having low input costs, and a short growing duration (around 70 days), the mung bean was widely cultivated in many Asian countries, regions of southern Europe, and parts of Canada (Dahiya et al., 2015). Agriculturally, mung beans were particularly valuable as a soil-enriching crop with nitrogen-fixation characteristics and were useful as cover crops and green manure. Yellow gram, a low-producing cultivar with yellow seeds, was frequently grown for this purpose.

Carrageenan Plant Growth Promoter (PGP), a plant food supplement made from red seaweed and broken-down using gamma irradiation, stimulated plant growth. The results of several field tests conducted by UPLB and PhilRice, in partnership with the DA and DOST Regional Offices in Regions 1, 2, 3, 4A, 6, 9, and 11, revealed a yield increase of between 15 and 40% for rice crops treated with carrageenan PGP compared to crops produced according to farmers' customary practices. Initially, 2,500 hectares of rice farmers in each of the regions received the carrageenan PGP. The Carrageenan PGP was currently registered as an inorganic fertilizer by the Fertilizer and Pesticide Authority, with the Philippine Nuclear Research Institute (PNRI) as the licensed manufacturer (ISPWEB, 2022).

The literature and studies emphasized that the Carrageenan Plant Growth Promoter played a vital role in planting. This prompted the researcher to conduct the present study to assess the effectiveness of the said supplement on the growth performance of mung beans intercropped with banaba (*Lagerstroemia speciosa* L.) trees in Pampanga, Philippines. Specifically, its goals are to determine the following: plant height (cm), length of pods per plant (cm), number of pods, number of seeds per pod per treatment, weight of pods (g), as well as the survival percentage (%).

MATERIALS AND METHODS

Location of the Study Area

The study was conducted at the Banaba Plantation, Pampanga State Agricultural University. Magalang Pampanga, Philippines.

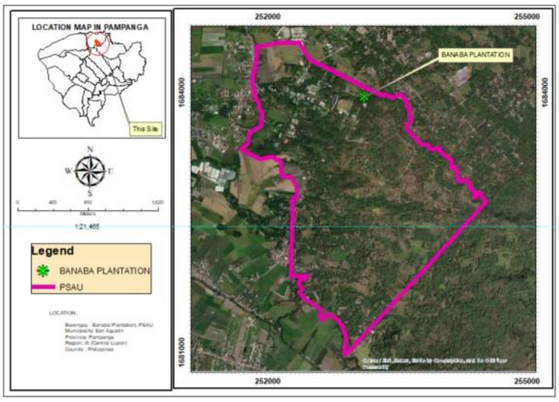

Figure 1. Study Site

Experimental Plant

The experimental plant consisted of Mungbean (*Vigna radiata* L.) seeds of the Labo variety, which reached maturity between 62-74 days after emergence. This variety was drought-tolerant and could thrive in any soil type, suitable for cultivation in all regions of the country. It was typically the variety found in the market.

Soil Analysis

Prior to preparing the land, soil samples were collected. This was done using a shovel to reach the proper depth and follow a zigzag pattern with enough samples. It was pulverized and air-dried, the soil's inactive substance was eliminated. One kilogram of soil samples was brought to the Soil Laboratory of the Department of Agriculture in Region III.

Land Preparation

The preparation of the area involved cleaning, clearing, and/or cutting the grasses and unwanted plants using bolo and other clearing tools. Trimming of some branches of the Banaba stem and leaves was conducted to maintain a warm climate in the experimental site. Plowing and harrowing the land was carried out until the soil achieved fine tilth. Furrows were formed using a grab hoe with a distance of 30 cm between plots and 50 cm away from the Banaba, equivalent to a 50 cm x 50 cm planting distance.

Planting and Spacing

Seeds were directly sown at 30 cm between furrows (2 furrows/plot, equivalent to 32 furrows) and 10 cm away per hill (30 hills/plot, equivalent to 480 hills).

Cultural Management Practices

It included hilling up before flowering, weeding, and watering during planting, flowering, and pod development stages. Field activities were regularly monitored and documented. Watering of the plants was conducted early in the morning or late in the afternoon. After emergence, watering was performed daily, and every 3 days during the seedling and reproductive stages until harvesting. Weeding was done every 3 days to prevent competition between crops and unwanted plants for nutrients and water.

Experimental Design and Layout

The experiment was set up after the Randomized Complete Block Design (RCBD). The area was equally divided into five, representing the replicates per treatment per trial. In which the application of Carrageenan and NPK (14-14-14) was used in the study as follows:

Experimental Treatments

The treatments for the study were the following:

T_0 - Control (Negative/no application)
T_1 - 5 mg/L Carrageenan
T_2 - 10 mg/L Carrageenan
T_3 - 15 mg/L Carrageenan
T_4 - 10 mg/L NPK (based on soil analysis result)
T_5 - Control (Positive/not intercropping)

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Experimental Design

The total area of the study site was 60 m^2. The spacing for banaba (*Lagerstroemia speciosa* L.) was 2 m x 2 m. The blocks were planted with a distance of 1 m between them, while the distance between plots was 50 cm, resulting in a total planting distance of 50 cm x 50 cm. There was a total of 15 plots in the study area with 3 rows and 10 hills per row, totaling 450 mungbean (*Vigna radiata* L.) plants planted.

Application of Fertilizer

The treatment was applied a week after the seeds germinated, and applications followed every 15 days thereafter. The amount of solution sprayed on each plant ranged from 10 ml at the seedling stage to 25 ml during the vegetative to reproductive stage. For the negative control, no treatment was applied. For the positive control, plants were not intercropped and received no treatment. Plants were placed in open spaces with direct sunlight.

Irrigation

Mungbeans (*Vigna radiata* L.) require less water as they are sensitive to water-logging compared to many other crops. Irrigation was necessary during flowering and early pod development. Watering during the germination period was important.

Harvest Management

Mung beans (*Vigna radiata* L.) were harvested by manually picking or hand-picking mature pods early in the morning to prevent shattering.

Statistical Analysis

The data collected in the study were statistically analyzed and examined via Analysis of Variance (ANOVA) in a Randomized Complete Block Design (RCBD) through computer-run statistical software.

RESULTS AND DISCUSSIONS

Plant Height (cm)

Figure 2 showed the plant height of mungbean (*Vigna radiata* L.) at harvest. The T_5 achieved the highest growth with a mean of 61.2 cm, followed by T_2 at 22.67 cm, T_3 at 19.6 cm, T_0 at 19 cm, and T_4 at 18.87 cm, while T_1 had the lowest plant growth with a mean of 13.13 cm.

Based on the analysis of variance it was shown that T_5 was highly significant at the 1% level (Pr > F = 0.0001) among all the treatments.

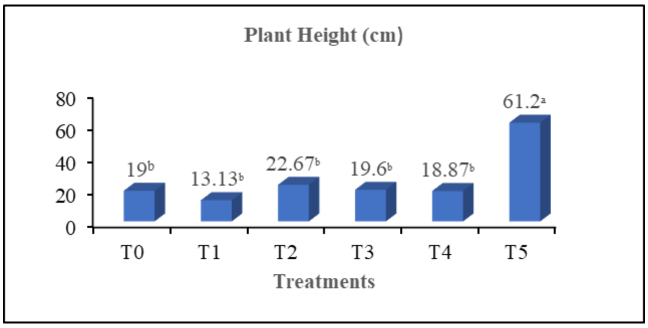

Figure 2. Plant Height of Mungbean

According to Horticulture (2019), one of the important factors in maintaining plants was light. The growth and development of plants depended on the sunlight they received. Specifically, light intensity influenced the production of plant food, stem length, leaf color, and reproductive stage. This was also evident in the present study, where direct sunlight from the sun caused the T_5 mungbean (*Vigna radiata* L.) to develop and grow more than the intercropped mungbean (*Vigna radiata* L.), even though they were not supplemented with any kind of fertilizer. Moreover, understorey plant growth was affected by competition for the limited availability of resources, particularly light, water, and nutrients.

Length of Pods per Plant

Figure 3 showed the results of the length of pods per plant. T_5 obtained the longest pods with a mean of 10.61 cm, followed by T_3 with 7.75 cm, T_2 with 7.06 cm, T_4 with 6.97 cm, T_0 with 6.72 cm, while T_1 recorded as the shortest pod with a mean of 5.21 cm. T_5 showed highly significant among the treatments at a 1% level (Pr > F = 0.0000), which was comparable to T_1.

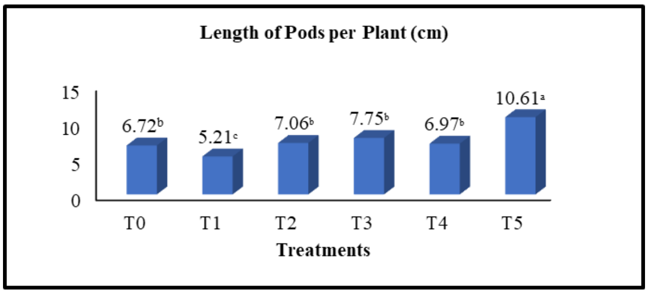

Figure 3. Length of Pods per Plant

The study conducted by Tanaka (2017), found that the pod elongation of cowpeas was significantly different (P > 0.05) when cultivated in an open space where it received direct sunlight, and the elongation of the pods was inhibited when in shade.

Number of Pods Per Plant

Figure 4 showed the number of pods per plant. The T_5 obtained the highest number of pods per plant with a mean of 18.13, followed by the T_3 with 2.73, T_0 and T_2 with 2.67,

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T_4 with 2.23, while T_1 received the lowest count of 1.53. There was a highly significant difference among the treatments. However, T_5 was highly significant at a 1% level (Pr > F = 0.0000) among all the treatments.

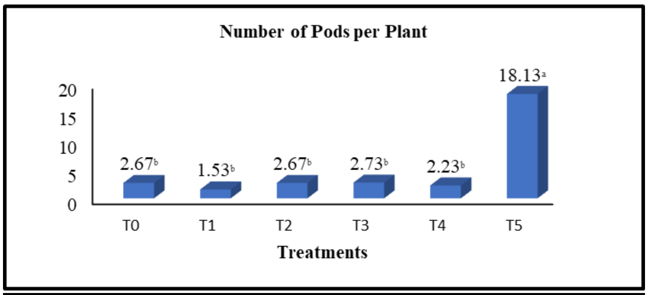

Figure 4. Number of Pods Per Plant

The study by Diatta et al. (2018) found significant differences in the number of pods per plant of Mungbeans (*Vigna radiata* L.) due to favorable sunlight conditions. In contrast, the study by Kakiuchi et al. (2006) reported that shade reduced the number of pods per soybean plant, which was also observed in the present study.

Number of Seeds Per Pod

Figure 5 showed the number of seeds per pod. T_5 obtained the highest number of seeds per pod with a mean of 11.73, followed by T_3 with 9.4. T_0 was comparable to T_4 with 8.4, and T_2 with 7.89, while T_1 had the lowest number of seeds per pod with 4.53. Based on the analysis of variance in there was a highly significant difference among the treatments. T5 was highly significant at the 1% level (Pr > F = 0.0001) among all the treatments but significant to T_3.

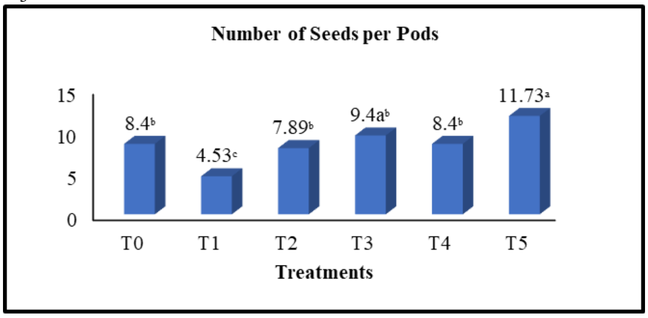

Figure 5. Number of Seeds Per Pods

In the study conducted by Kadam et al. (2023), the Mungbeans (*Vigna radiata* L.) cultivated in the open area (direct sunlight) with a spacing of 10cm x 10cm showed significant differences in terms of the length of the pods and number of seeds per pod because both parameters are correlated with each other, which means that the longer the pod, the more seeds inside the pod (Gatan et al., 2019). This correlation was also evident in the present study. Since T_5 (not-intercropped) was noted as highly significant in terms of the length of the pods, as mentioned above, it also found a highly significant result in the number of seeds per pod.

Weight of Pods per Treatment

Figure 6 showed the weight of the pods. T_5 obtained the heaviest pods with a mean of 17.01 g, followed by T_3 with 15.38 g, T_4 with 12.42 g, T_2 with 11.41 g, T_0 with 10.92g, while T_1 had the lightest pods with 7.75 g. Based on the analysis of variance there was a highly significant difference among all the treatments. T_5 was highly significant at the 1% level (Pr > F = 0.0004) among the other treatments but not highly significant to T_3.

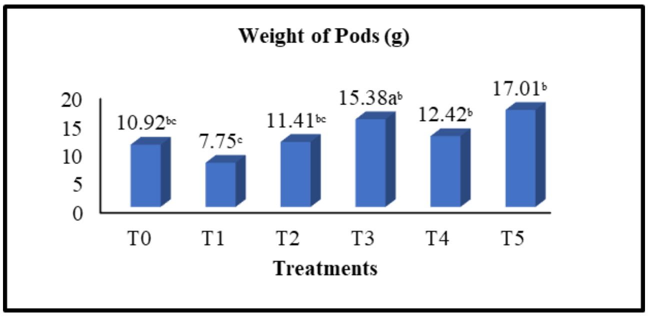

Figure 6. Weight of Pods per Treatment

Based on the figure above, T_5 had the heaviest weight of pods. The length of pods and number of seeds are strongly correlated with the weight of pods (Canci et al., 2014). In the present study, it is evident that T_5 (not-intercropped) showed highly significant superiority in terms of pod length, which also implies a higher number of seeds per pod contributing to a heavier weight of pods. In conformity with the study of Shovan et al. (2008), which also noted a significant increase in pod length, number of seeds per pod, and seed yield by twenty-seven percent (27%), leading to an increase in the weight of the mungbean (*Vigna radiata* L.) pods directly sown in the field with direct sunlight.

Survival Percentage

Figure 7 showed the survival percentage of mungbean (*Vigna radiata* L.) per treatment after 75 days. The T_5 obtained the highest percentage of survival at (100%), followed by the T_2 (51.11%), T_4 (50%), T_3 at (46.67%), T_1(40%), while T_0 obtained the lowest percentage of survival with (32.22%). Based on the analysis of variance there was a highly significant difference among the treatments. However, T_5 was highly significant at a 1% level (Pr > F = 0.0009) among the treatments.

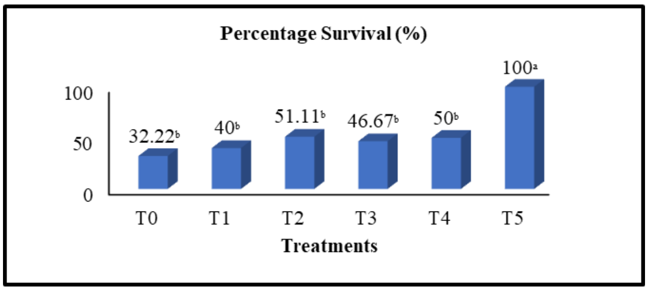

Figure 7. Survival Percentage

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The survival percentage of mungbean (*Vigna radiata* L.) under control or untreated conditions planted in a heavily grazed field (direct sunlight) was 98.90%, which closely matches the results of the present study, with a 100% survival rate under the control treatment (Hao Qu 2012; Guayan, et al., 2021). The high survival rate observed in the study may be linked to favorable growing conditions, particularly adequate exposure to sunlight, which is crucial for photosynthesis, plant vigor, and successful establishment of crops. Mungbean (*Vigna radiata* L.), as a warm-season legume, thrives under full sunlight and well-drained soil environments, allowing seedlings to maintain efficient physiological processes and adapt well during early developmental stages. In addition, mungbean (*Vigna radiata* L.) and other legumes naturally exhibit adaptability and resilience under suitable field conditions, which further enhance their survival and support strong stand establishment.

In contrast, Zhang et al. (2020) stated that abiotic stress caused by deficiencies or excesses in environmental factors, such as low light penetration and distribution to crops, can reduce plant growth, productivity, and survival rates. This decline under low-light conditions occurs because light serves as a key limiting factor in the physiological processes of the crop. When mungbean (*Vigna radiata* L.) is exposed to shading or insufficient light, its source leaves may undergo structural deterioration, including damage to palisade and spongy mesophyll tissues. This weakens the photosynthetic capacity of the leaves by reducing net photosynthetic rate, stomatal conductance, and transpiration activity. As a result, while full sunlight promotes optimal vegetative growth and high survival rates, shaded or low-light environments create structural and metabolic limitations that significantly decrease biomass production and overall crop productivity (Gong et al., 2022).

CONCLUSION

As reflected by the research findings and discussion section, the researcher successfully unveiled the best treatment applied in this study, which elaborately discussed and tackled each parameter.

The parameters that were gathered included plant height, number of pods, length of pods, number of seeds per pod, weight of the pods, and survival percentage. In terms of plant height, T_5 obtained the highest mean (61.2cm), while T_1 obtained the lowest mean (13.13cm), which was highly significant ($P < 0.05$). In the length of pods, T_5 obtained the highest mean of (10.61 cm), while T_1 obtained the lowest mean of (5.21 cm), which was noted as highly significant ($P < 0.05$). For the number of pods per plant, T_5 obtained the highest mean (18.13), while T_1 obtained the lowest mean (1.53), which was highly significant ($P < 0.05$).

For the number of seeds, T_5 obtained the highest mean (11.73), while T_1 obtained the lowest mean (4.53), which was highly significant ($P < 0.05$). In terms of the weight of pods, T_5 obtained the highest mean (17. 01 g), while T_1 obtained the lowest mean (7.75 g), which was highly significant ($P < 0.05$). In terms of survival percentage, T_5 obtained the highest mean (100%), while T0 obtained the lowest mean (32.22%), which was highly significant ($P < 0.05$). Therefore, we recommend the following: a) Other crops should be intercropped with banaba (*Lagerstroemia speciosa* L.) for further investigation and validation of its allelopathic effects on the growth and productivity of crops. b) Mungbeans (*Vigna radiata* L.) should be planted directly in the field with the application of Carrageenan at a concentration of 15 mg/L. c) Future researchers can study other crops supplemented with Carrageenan to assess its effectiveness and d) Further studies are recommended on intercropping Mungbeans (*Vigna radiata* L.) with other trees using Carrageenan supplementation at a concentration of 15 mg/L.

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Conflict of Interest

There are no conflicts of interest declared by the authors.

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