Improved Integrated Crop Management System of Mungbean (*Vigna radiata* Linn) Production in Central Luzon

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Abstract

To address low productivity and increase income, studies were conducted to improve the integrated crop management (ICM) of mungbean. Field experiments established using extracts, biocon agents, and varieties under various cropping systems. In rice-mungbean cropping system, Pagasa 19 applied with Vermitea and Carrageenan exhibited lowest CLS and rust infections. Carrageenan-treated plants produced yield, 0.77t/ha vs Control 0.41t/ha. Under corn-mungbean cropping system, Carrageenan-treated Pagasa 19 had the highest yield of 1.36t/ha. In other trials, CLS infection of Carrageenan-treated Pagasa 19 was reduced by 25.6% and the yield/ha was 62.3% higher than untreated valued at Php 29,400.00/ha. In Pagasa 7, Carrageenan is effective against CLS and rust, and gave the highest yield of 1.37 ton/ha. The Kulabo, whether applied with Carrageenan, Boron or NPV, reduced the CLS infection and increased the yield up to 0.54t/ha. Improved ICM system is vital to reduce loss, improve soil condition, and enhance yield and income.

Keywords: integrated crop management, increase production, mungbean, Central Luzon

1.0 Introduction

Mungbean (*Vigna radiata* Linn.) under the legume family is mainly produced in Southeast Asia, East Asia and South Asia. Locally known as "mungo", mungbean is used as an ingredient in soup, snacks, dishes and desert and is a cheap source of carbohydrates. It is also rich in protein, nutrients and other minerals like iron and folate (Kang et al., 2014). Mungbean, a cash crop, is a short duration palnt that can fit between major cropping systems (Islam et al., 2011) as an intercrop, crop rotation and relay crop because of its distinct agronomic characteristics.

Since mungbean is a nitrogen-fixing crop, it improves soil condition as green manure due to the rhizobia found in its root nodules. Mungbean can fix nitrogen (N) about 64 to 87% equal to 43 to 85 N/hectare, which can be used by the next crop (Rosales et al., 1998). Because of this, it enhances the soil quality and decreases the rate of nitrogen fertilizer applied in the soil especially when grown in rotation with cereals, resulting to increased cereal grain and straw yields due to its residual effects (Yaqub et al., 2010).

Mungbean production is gaining popularity among Filipinos due to its nutritional value, economic and soil amelioration benefits. However, the mungbean industry is facing difficulty in terms of low production due to poor establishment, use of traditional variety, poor management practices particularly the cropping system whether rice-based or corn-based and presence of diseases such as Cercospora leaf spot (CLS) and rust that remarkably affect the quantity and quality of produce leading to yield reduction. Compared to other countries, in 2016, the average yield of mungbean in the Philippines is only 0.69t/ha with a total production of 34,069 metric tons covering an area of 42,980 hectares (Philippine Statistics Authority, 2017). Considering the present volume of production of the country, the continuous importation of mungbean in other countries, particularly in China, Myanmar and Australia is a manifestation of insufficient supply of mungbean in the local market.

Mungbean is prone to attack by a large number of plant pathogens resulting in severe economic losses globally. Pandey et al. (2018) reported that fungi are one of the largest and most important groups of pathogens affecting all parts of the plant at all stages of growth of warm-season food legumes. According to estimates made by Gibbons (1986), the fungal leaf spot caused about 10-50% pod yield loss when left uncontrolled. Among the diseases, Cercospora leaf spot (CLS) is the most devastating disease of mungbean, which causes yield losses of up to 58% (Lal et al., 2001). The causal organisms of this disease are *Cercospora cruenta* and *C. canescens*. Heavy infections of Cercospora can cause premature defoliation of the mungbean plant and the leaves may become malformed and wrinkled. In diseased plants, maturity is delayed resulting in poor pod formation while the seeds developed on severely infected plants are small and immature (Poehlman, 1991). Initial signs of mungbean rust are rusty colored pustules found on the underside of the leaf surrounded by a circle of chlorosis. Rust commonly appears underneath the leaves during pod formation up to maturity stage. The continuous use of chemicals and synthetic fertilizers has caused many problems for the environment, which has been a growing interest in investigating natural materials with pesticidal properties

Thus, there is a need to improve the crop management system of mungbean to enhance production and increase the income of farmers.. A crop management system is an integral and vital part of crop production capable of soil and water improvement, and conservation. Besides it maintains the long-term soil productivity that affects the magnitude of soil erosion and soil organic matter dynamics to increase crop yields (Blanco-Canqui and Lal, 2010). Likewise, improving the management practices of a specific crop will surely increase the farmer's profit. According to Ahamed (1999) and Singh et al., (2007), the overall improvement in growth and yield part of a particular crop is due to the total combined effect of management practices employed.

Planting rice or corn after mungbean increases grain yield because mungbean fixes atmospheric nitrogen to the soil, making it available to roots for its plant growth and development. Moreover, the risk of damages caused by biotic and abiotic factors reduces through various cropping system. Meanwhile, the use of a traditional variety of mungbean that is long duration (70-80 days), low-yielding with non-synchronous maturity and susceptibility to insect-pest and diseases is also a contributing factor in low production (Chadha, 2010). As cited by Singh and Tripathi (2005), varieties influence the growth and yield characteristics of mungbean such as plant height, pods per plant, seed per pod, and seed weight. The National Seed Industry Council (NSIC) developed and approved mungbean varieties like Pagasa 19, Pagasa 7, and Kulabo that are high-yielding, with short maturity and resistant to diseases tested for its adaptability in the region.

Plant extracts were found efficient in the management of root and foliar diseases (Pandey et al., 2018). The use of biological control agents (BCAs) like nucleopolyhedrosis virus (NPV) and extracts such as carrageenan from seaweeds and vermitea from vermicompost are environment-friendly and cost-effective derivatives in controlling diseases. The biological control measures using commonly occurring fungi, bacteria and viruses are newly reported by Kapooria, 2007; Jayarai et al., 2008; Bi et al., 2011. These agents give protection to the plants against infection caused by pathogens without interfering on the growth and maturity of the crops (Ning et al., 2003). On the other hand, carrageenan, marine algae that contain large amounts of polysaccharides are sulfated galactans that composed of 1,3 and 1,4 galactose residues, divided into three major classes, namely, (1) kappa, (2) iota, (3) lambda carrageenans (Bi et al., 2011). Mercier et al. (2001) mentioned that generally, kappa carrageenan stimulated a group of plant defense responses due to its high sulfate content. Khan et al., (2009) stated that extracts from seaweeds could serve as a vital source of defense elicitors and enhanced defense structure of plants (Bi aBi, Iqbal, Ali, Arman and Hassan, 2008).

Hence, the research project aimed to improve integrated crop management (ICM) system of mungbean in Central Luzon through the use of NSIC approved and high-yielding varieties, use of available BCAs, application of extracts like carrageenan, vermitea and others in rice and corn-based cropping systems. Through improved ICM, disease infections of CLS and rust could be reduced; agronomic characteristics and yield components such as numbers of pods per plant, number of seeds per pod and weight of 100 seeds to enhance production by 20% (yield ton/ha) could be improved; and farmers' income through the Marginal Benefit-Cost Ratio (MBCR) may be increased. All these can leads to a stable and continuous supply of mungbean in the country.

2.0 Materials and Methods

Study 1: Disease Management of Cercospora Leaf Spot and Rust of Mungbean using Various Extracts in Rice and Corn-Based Cropping Systems

This study, adopting the two most common cropping systems, namely, rice-based and corn-based, was conducted from October 2016 to May 2017 in Pampanga. One cropping season made per cropping system followed the experimental layout (Figures 1 and 2). The land was thoroughly prepared to enhance germination, ensure uniform plant growth and prevent weeds. Whether in rice-based cropping system or corn-based cropping system, the Pagasa 19 mungbeans were planted immediately after harvest. This was done while the soil moisture was still high to hasten seed germination.

Experimental Design and Treatments

The study was consisted of one trial. The field area was laid out after the Randomized Complete Block Design (RCBD) through equal distribution of the land per block. Randomization was done using the fish-bowl method. The site was equally divided into four - each representing a block. Each treatment was replicated four times. The treatments are as follows:

T_1 – Control (negative control)
T_2 – Fungicide (positive control)

T_3 – *Trichoderma harzianum* ((30L/ha)
T_4 – Vermitea (30L/ha)
T_5 – Oriental Herb Nutrient (OHN) (30L/ha)
T_6 – Kakawate extract (30L/ha)
T_7 – Carrageenan (4.8L/ha)

The T_1 and T_2 served as the negative control and positive control, respectively. The treatments were based on the use of various extracts that are natural and commonly used in the area. Each treatment was foliar-sprayed three times. For every treatment, the first application was done two weeks after the plant had emerged while the second application was done two weeks after the first application. The last application was done two weeks after the second application. These are the three applications per treatment, such as carrageenan based on the study conducted by Gatan et al. 2019.

T_2	T_7	T_1	T_5
T_7	T_2	T_6	T_3
T_3	T_6	T_3	T_1
T_6	T_4	T_5	T_4
T_4	T_1	T_2	T_7
T_1	T_5	T_7	T_2
T_5	T_3	T_4	T_6
BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4

Figure 1. *Experimental Layout in Study 1 (Rice-Based)*

T_1	T_5	T_7	T_4
T_3	T_1	T_2	T_6
T_5	T_6	T_4	T_5
T_7	T_4	T_1	T_2
T_4	T_2	T_6	T_3
T_6	T_3	T_3	T_1
T_2	T_7	T_5	T_7
BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4

Figure 2. *Experimental Layout in Study 1 (Corn-Based)*

Experimental Area and Cultural Management

In each cropping system of rice and corn, about 1,000m^2 (20x50m) of an area was used equally to 5x50m per block. The recommended cultural management practices for mungbean were adopted from the National Seed Industry Council Mungbean Guide (2015) such as inoculation of seeds using Rhizobium at 100g for every 5 kg of seeds before planting, hilling up and manual weeding done before flowering. Mungbean is a relatively drought-tolerant crop; hence, three irrigations were provided during its critical growth. This included crop establishment, flowering and pod development to give enough soil moisture. Field monitoring was done regularly and incidence of diseases, particularly CLS and rust was recorded.

Data Gathered

At the maturity stage of mungbean, ten sample plants were collected randomly from different experimental plants per trial. The data gathering and the parameters were gathered based on the NSIC Mungbean Guide (2015). The data gathered included the reaction to CLS and rust, number of pods and the seeds per pod, the weight of 100 seeds, yield (t/ha), and the MBCR. The MBCR was computed using the formula - added benefit due to treatment less treatment cost divided by the treatment cost. The MBCR determined the economic benefit derived out of the treatment.

Data Processing and Summarization

Before the conduct of the study, the test of normality and calculation of sample size was conducted to make sure of the use of Analysis of Variance (ANOVA). The ANOVA used computer-run software and Statistical Tool for Agricultural Research (STAR) for statistical analysis of data. The variables that were compared in the ANOVA were the treatments in different agronomic characteristics and yields. The Least Significant Difference (LSD) using Pairwise comparison at 5% level of significance was used to find the multiple comparison tests of the treatment, to determine which treatment is comparable with the positive and negative controls, and to identify which treatment had the most significant result on various characteristics and yields.

Study 2: Pilot Testing and Technology Transfer of Improved ICM Systems of Mungbean in Central Luzon

The study was conducted from March 2017 to January 2018. Demo sites were chosen for the improved ICM system for mungbean making sure of one study per cropping system in rice-mungbean and corn-mungbean cropping system. In each cropping pattern, at least one hectare per area was used as demo site. The field layout for Study 2 is presented in Figures 3 and 4. Each experimental layout is about 1,000m^2 (20x50m).

Variety

The NSIC approved varieties of mungbean used in the study were Pagasa 7, Pagasa 19 and Kulabo, which are commonly used by the farmers and sold in the market. According to NSIC List of Registered Mungbean Varieties of the Bureau of Plant Industry (BPI), the Pagasa 7 mungbean variety which was developed by the Institute of Plant Breeding (IPB) matures in 66 days after emergence (DAE) with a seed yield of 1.68 t/ha. It has shiny green seeds that are suitable for sprout production and starch for noodle production. On the other hand, Pagasa 19 mungbean which was developed by IPB has a glossy green seed with a maturity period of 57 to 69 DAE and a seed yield of 1.21-1.27 t/ha. Kulabo, a variety developed by BPI, has a dull green seed color with 80 days maturity and seed yield of 1.09-1.17 t/ha. The seeding rate per variety was 25 kg/ha.

Treatments and Treatment Applications

The treatments composed of the Farmer's Practice which served as the positive control, the Carrageenan which was sourced out from the Philippine Nuclear Research Institute (PNRI) of the Department of Science and Technology (DOST), and the Boron which was also found effective in increasing the yield of legumes because of its ability to improve root nodule development for more N fixation and protein production. Boosting production and retention of flowers and pegs and enhancing calcium utilization and pod development, vermitea is an excellent organic fertilizer and pesticide due to the beneficial microorganisms (Arancon et al., 2007). This, along with several plant growth hormones, enzymes and vitamins, enhances growth and productivity and protects plants against various diseases. NPV is a large group of viruses in the family Baculoviridae that includes many significant pathogens of pest insects.

T_1 - Farmer's Practice (Positive Control)
T_2 – Carrageenan (100ppm – 4.8L/ha)
T_3 – Boron (750g/ha)
T_4 – Vermitea (30L/ha)
T_5 – Nucleopolyhedrosis virus (NPV) (4.8L/ha)

Each treatment foliar except Positive Control (T_1), was sprayed three times adopting the procedure in the study of Gatan et al., 2019. The first application was done two weeks from the time the plant had emerged. Then, the second application was made two weeks after while the third spraying followed two weeks after. The Carrageenan was sprayed at 4.8L/ha while Boron was sprayed at 750g/ha. The amount of vermitea used per hectare was 30L while the NPV was sprayed at a rate of 10ml/L upon the appearance of the disease, particularly CLS and rust (Figures 5 and 6)

Data Processing and Summarization

The ANOVA used the STAR computer-run software to analyze and compare the treatments in various agronomic characteristics and yields. LSD at 5% level of significance was used to find the multiple comparison tests of the treatment, to identify which treatment is comparable with the positive and the negative controls, and to determine which treatment had the most significant result on various characteristics and yields.

T_3	T_4	T_2	T_1
T_2	T_3	T_5	T_3
T_4	T_1	T_3	T_5
T_1	T_5	T_4	T_2
T_5	T_2	T_1	T_4
BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4

Figure 3. *Experimental Layout in Study 2 (Rice-Based)*

T_4	T_5	T_3	T_2
T_2	T_1	T_5	T_5
T_3	T_4	T_1	T_3
T_5	T_2	T_4	T_1
T_1	T_3	T_2	T_4
BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4

Figure 4. *Experimental Layout in Study 2 (Corn-Based)*

3.0 Results and Discussion

In the first study under the rice-mungbean cropping system, the mungbean treated with different extracts had more number of pods per plant than the negative control. The increase in the number of pods per plant is one of the indicators that the mungbean yield was enhanced. The

Carrageenan treated plants significantly gave the highest number of pods per plant and the number of seeds per pod compared to the remaining treatments. However, there were insignificant differences among the treatment as regards the 100 seed weight (p-value of 0.5071). Carrageenan treated mungbean plants significantly yielded the highest among all treatments at 0.77t/ha with a p-value of 0.0000. A yield increase of about 0.18–0.36t/ha over the untreated plants. They were sprayed with various extracts such as Carrageenan, Trichoderma, Vermitea, OHN and Kakawate. The MBCR of the extracts ranged from Php2.77-243.85, wherein the Carrageenan-treated mungbean plants had the highest MBCR of 243.85 (Table 1) with a net income of Php13, 941.50/ha.

Since mungbean is a drought-tolerant crop, the harvested yields in all treatments were relatively low possibly because both typhoons "Lando" and "Nona" occurred during the reproductive stage of the plants. As reported by Williams et al. (1995) and Islam (2008), the continuous heavy rain during the reproductive period causes massive loss of both mungbean yield and quality. Kumar et al. (2013), however, claimed that mungbean plants are not suitable for waterlogged soil conditions.

Table 1. *Agronomic characteristics and yield potential of Pagasa 19 mungbean variety planted after rice and applied with different extracts in Pampanga*

Treatments	Number of pods per plant	Number of seeds per pod	Weight of 100 seeds	Yield (t/ha)	MBCR
T_1-Control	11.2 ± 0.26^d	8.33 ± 0.18^d	7.82 ± 0.39	0.41 ± 6.39^e	-
T_2- Fungicide	17.8 ± 1.04^{ab}	10.47 ± 0.36^c	7.25 ± 0.55	0.63 ± 25.26^{cd}	84.04
T_3- Carrageenan	18.2 ± 1.00^a	12.40 ± 0.18^a	7.35 ± 0.47	0.77 ± 22.18^a	243.85
T_4- Trichoderma	16.4 ± 0.33^{bc}	11.07 ± 0.28^b	7.37 ± 0.49	0.65 ± 26.30^c	14.76
T_5- Vermitea	19.0 ± 0.91^a	11.20 ±0.14^b	7.33 ± 0.26	0.71 ± 16.7^b	47.58
T_6- OHN	16.0 ± 0.43^c	10.53 ± 0.18^c	7.24± 0.09	0.59 ± 11.72^d	2.77
T_7- Kakawate	15.4 ± 0.61^c	11.27 ± 0.20^b	7.44 ± 0.30	0.64 ± 20.91^{cd}	75.17

Values are mean of four replications ± standard deviation. Mean values in each column with the same letters are not significantly different according to the Least Significant Difference (LSD) at P < 0.05.

In another experiment using the corn-mungbean cropping system, insignificant differences were perceived among treatments across all the parameters (Table 2). This could be due to the good soil condition negating the effects of the various treatments. Mungbean is a nitrogen-fixing crop. Thus it improves soil condition as green manure due to the rhizobia found in its root nodules. According to Rosales et al. (1998), mungbean can fix nitrogen about 64 to 87% which is equal to 43 to 85kg N/ha, an amount used by the next crop.

However, the Carrageenan treated Pagasa 19 mungbean plants obtained a higher yield per hectare of 1.36 t/ha compared to the untreated plants having 1.04 ton/ha. An extra potential income amounting to Php 19,200/ha (320kg@60/kg) through Carrageenan application could be obtained.

Table 2. *Disease reaction, agronomic characteristics and yield potential of Pagasa 19 mungbean variety planted after corn and applied with different extracts in Pampanga*

Treatment	CLS Infection	Rust Infection	No. of Pods per Plant	No. of Seeds per Pod	Weight of 100 Seeds (g)	Shelling Percentage	Yield (t/ha)
T_1-Control	2.88± 0.08	3.05 ±	10.11± 1.16	11.25± 0.1	5.44± 0.11	60.72± 1.53	1.04
T_2-Fungicide	2.20± 0	2.19	11.39± 2.10	11.53± 0.29	5.70± 0.30	68.26± 0.86	1.33
T_3-Trichoderma	2.03± 0.05	2.15	10.73± 1.29	11.40± 0.50	5.34± 0.07	62.32±5.85	1.18
T_4-Vermitea	2.03± 0.06	2.18	10.76± 1.04	11.13± 0.46	5.29± 0.15	61.61± 4.96	1.14
T_5-OHN	2.00± 0	2.25	11.09± 1.66	11.73± 0.21	5.70± 0.33	63.18± 2.76	1.32
T_6-Kakawati	2.00± 0	2.28	11.07± 3.61	11.80± 0.18	5.50± 0.24	62.62± 1.05	1.29
T_7-Carrageenan	2.00 ± 0.05	2.18	11.33± 2.68	11.60± 0.40	5.52± 0.32	63.92± 6.63	1.36

Values are mean of four replications ± standard deviation. Mean values in each column with the same letters are not significantly different according to the Least Significant Difference (LSD) at P < 0.05.

Table 3. *Disease reaction, agronomic characteristics and yield potential of Pagasa 19 mungbean variety applied with different extracts in Pampanga*

Treatment	CLS infection	Rust infection	No. of seeds per pod	Weight of 100 seeds (g)	Yield (t/ha)	MBCR
T_1- Farmer's Practice	2.42 ± 0.13^b	1.32 ± 0.15	10.55 ± 1.24^b	5.73 ± 1.08^{ab}	0.81 ± 0.23^b	-
T_2-Carrageenan	1.80 ± 0.32^a	1.15 ± 0.06	12.45 ± 0.95^a	6.05 ± 0.42^a	1.30 ± 0.16^a	21.63
T_3- Boron	2.65 ± 0.10^b	1.20 ± 0.08	10.98 ± 0.45^b	5.01 ± 0.86^{ab}	0.99 ± 0.15^b	4.74
T_4- NPV	3.38 ± 0.49^c	1.35 ± 0.10	11.35 ± 0.37^b	3.93 ± 0.50^c	0.93 ± 0.26^b	1.26
T_5- Vermitea	2.80 ± 0.26^b	1.50 ± 0.47	10.97 ± 0.25^b	4.71 ± 0.75^{bc}	0.90 ± 0.18^b	0.61

Values are mean of four replications ± standard deviation. Mean values in each column with the same letters are not significantly different according to the Least Significant Difference (LSD) at P < 0.05.

In pilot testing trials, the CLS infection of Pagasa 19 mungbean variety was significantly reduced by 25.6% when applied with Carrageenan extract but with not with rust infection (Table 3). The lowest CLS infection came from Carrageenan-treated plants. This is possibly due to the ability of Carrageenan to trigger plant defense responses (Kloareg & Quatrano, 1988). The number of seeds per pod including the 100 seed weight (g) was significantly enhanced when plants were applied with Carrageenan, and these were contributory in improving the yield of mungbean by 62.3% (1.30t/ha vs 0.81t/ha Farmer's Practice). The yield increase of 0.49t/ha (@60/kg) corresponds to Php 29, 400/ha additional income and MBCR of 21.63% from Carrageenan-treated plants (Table 3).

In a field trial in Tarlac, Carrageenan-treated Pagasa 7 mungbean plants, significantly obtained the lowest rating of CLS infection and rust infection compared with the Farmers practice and NPV-treated plants but comparable with the other treatments. According to Verkleji (1992), foliar applications of seaweed extracts like carrageenan reduce fungal diseases. Also, as reported by Shukla et al., (2016), carrageenan can induce plant defense response against fungi, bacteria virus, viroids and insect pests.

Moreover, the application of Carrageenan significantly improved the number of seeds per pod including the 100 seed weight which contributed to the notable increased on yield/ha of mungbean by 48.9% (1.37t/ha vs 0.92t/ha) when compared to the untreated plants. Algal compounds present in Carrageenan are responsible for improving growth, and resistance to biologic pressures such as plant diseases actuated by carrageenan application (Stadnik and Freitas, 2014). The application of carrageenan at one-week interval enhanced growth, manufacturing of food and metabolism of plants Castro et al. (2012). Also, the highest MBCR of 19.71 derived from the Carrageenan treatment (Table 4).

Table 4. *Disease reaction, agronomic characteristics and yield potential of Pagasa 7 mungbean variety applied with different extracts in Tarlac*

Treatments	CLS infection	Rust infection	No. of pods per plant	No. of seeds per pod	Weight of 100 seeds (g)	Yield (t/ha)	MBCR
T_1- Farmer's Practice	2.20 ± 0.14[b]	1.10 ± 0.00	11.44 ± 0.86	9.80 ± 0.62[b]	5.13 ± 0.09[b]	0.92 ± 0.13[b]	-
T_2-Carrageenan	1.65 ± 0.047[a]	1.10 ± 0.00	11.69 ± 0.91	11.47 ± 0.84[a]	6.24 ± 0.87[a]	1.37 ± 0.11[a]	19.71
T_3- Boron	2.08 ± 0.15[b]	1.10 ± 0.00	10.05 ± 0.52	10.05 ± 0.65[b]	4.90 ± 0.34[b]	1.05 ± 0.13[b]	2.14
T_4- NPV	2.10 ± 0.20[b]	1.15 ± 0.06	10.63 ± 1.34	10.40 ± 0.37[b]	5.99 ± 0.14[a]	0.86 ± 0.10[b]	-3.63
T_5- Vermitea	2.40 ± 0.27[b]	1.12 ± 0.05	10.56 ± 0.83	10.05 ± 0.39[b]	5.06 ± 0.31[b]	0.95 ± 0.22[b]	-1.13

Values are mean of four replications ± standard deviation. Mean values in each column with the same letters are not significantly different according to the Least Significant Difference (LSD) at $P < 0.05$.

Table 5. *Disease reaction, agronomic characteristics and yield potential of Kulabo mungbean variety applied with different extracts in Pampanga*

Treatment	CLS Infection	Rust Infection	No. of Pods/ Plant	No. of Seeds/ Pod	Weight of 100 Seeds (g)	Shelling Percentage	MBCR	Yield (t/ha)
T_1-Control	2.63 ± 0.05[b]	2.95 ± 0.10	10.49 ± 0.87	11.59 ± 0.14	6.21 ± 0.28[b]	60.74 ± 1.77[b]	19.58	1.26 ± 0.13[b]
T_2-Carrageenan	2.38 ± 0.05[a]	3.03 ± 0.13	10.51 ± 0.45	11.68 ± 0.14	6.72 ± 0.06[a]	67.56 ± 2.42[a]	25.51	1.67 ± 0.11[a]
T_3-Boron	2.40 ± 0.08[a]	2.98 ± 0.13	13.47 ± 1.65	11.71 ± 0.15	6.35 ± 0.21[b]	67.96 ± 2.47[a]	22.50	1.80 ± 0.13[a]
T_4-NPV	2.43 ± 0.10[a]	2.95 ± 0.10	12.02 ± 2.62	11.78 ± 0.05	6.83 ± 0.32[a]	65.63 ± 2.67[a]	5.26	1.75 0.10[a]
T_5-Vermitea	2.50 ± 0.16[ab]	3.03 ± 0.10	10.59 ± 1.01	11.68 ± 0.05	6.69 ± 0.23[a]	65.86 ± 2.12[a]	5.26	1.49 ± 0.22[ab]

Values are mean of four replications ± standard deviation. Mean values in each column with the same letters are not significantly different according to the Least Significant Difference (LSD) at P < 0.05.

Another pilot testing field trial was conducted in Pampanga. Using Kulabo mungbean variety, researcher was able to find out that plants treated with Boron, Carrageenan have significantly higher seed yields (Table 5). A remarkable additional yield of 0.41-0.54t/ha was achieved. Such yield is equivalent to Php24,600.00-32,400.00/ha (@60.00/kg), an additional potential income. Increased yield per hectare was due to the consistent significant increase in terms of weight of 100 seeds (g), shelling percentage and a notable lower rating infection of CLS when compared to the untreated. Carrageenan, an extract from seaweed, contains macro and micronutrients such as vitamins, amino acids, cytokinins, auxins- and abscisic acid-like growth-stimulating elements (Mooney et al., 1986) and reported by Featonby-Smith et al., (1983); Abad et al., (2015) to enhance both the growth and yield of plants resulting in developed resistance against environmental stress. On the other hand, Boron is vital for plant growth because it helps in the photosynthetic capacity as well as in the pod and seed development of a certain crop.

Figure 5. *Cercospora Leaf Spot*

Figure 6. *Leaf Rust Disease*

4.0 Conclusion and Recommendation

In the first study under the rice-based cropping system, the Vermitea-and Carrageenan-treated Pagasa 19 exhibited the lowest CLS and rust infections. Also, the Carrageenan-treated plants yielded the rest of the treatments. In a corn-based cropping system, though insignificant differences were noted across the parameters, the Carrageenan treatment performed well in terms of yield resulting in increased income. In the second study, the yield/ha and income of Carrageenan-treated Pagasa 19 and Pagasa 7 mungbean varieties was significantly higher compared to the other treatments while the Kulabo variety which was applied either with Carrageenan, Boron, and NPV significantly improved the yield and gave high additional income.

The use of improved ICM system is essential to improve the soil condition and moisture content, to reduce disease infection and to increase agronomic characteristics, and yield resulting in enhance productivity and increase in farmers' income. To attain this, planting of NSIC-approved Pagasa 7, Pagasa 19 and Kulabo mungbean varieties after rice or corn is suggested. Likewise, the application of extracts, particularly Carrageenan and the use of BCA in mungbean is also needed to reduce yield loss due to CLS and rust.

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