International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Enhancing Peanut Productivity through Application Of Irradiated κ- Carrageenan

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Abstract: ***On-field verification trials were conducted to determine the effect of various rates of Olio-carrageenan (PGP) on Cercospora leaf spot (CLS) and rust and yield of peanut varieties specifically, BPI Pn9 and Farmer's variety. The statistical design of the field trial was a Randomized Complete Block Design (RCBD) with four replicates per treatment per experiment. The CLS and rust infections were significantly reduced with the application of 150ppm PGP by 15.2% and 36.2%, respectively. The BPI Pn 9 peanut variety applied with PGP consistently and significantly had higher pod yield up to 2.14 t/ha and seed yield of 1.63 t/ha with a corresponding 37.6% and 34.5% increase, respectively. At least Php45,771 per hectare additional income was realized from the application of PGP with a maximum MBCR of 12.3%. For Farmer's peanut variety, significant increase of 23.6% on pod yield and 36.5% on seed yield were obtained resulting to an additional income of Php 18,400/ha up to 37,800/ha with an MBCR of 21.81%.***

Keywords: Oligo-carrageenan, enhanced yield peanut, reduced disease infection

I. INTRODUCTION

Peanut (*Arachis hypogaea* L.), is a popular food legume crop in the Philippines with a protein content ranging from 26-28%. It is use as a nutritious snack and as a common ingredient in various Filipino dishes. Peanut is ideal as a food ingredient in the culinary arts because of its aroma, flavor and crunchy texture (PCARR, 1978). In 2015, the volume of production from a total harvested area of 24,580.20 ha was 29,190 mt valued at PhP 1.18 B. In the same year, the top three peanut-producing regions were Ilocos Region, Western Visayas, and Cagayan Valley (https://psa.gov.ph). The country is importing large volumes of peanut annually just to cope with the increasing demand for supply. As of fact, the country imports an average of 52,238 mt annually out of a total average supply of 82,521 mt. More than 50% of the country's peanut supply is imported mostly from China (Anonymous, 2011).

At present, the continuous use of commercial fertilizers and the non-judicious application of fungicides are some of the common practices of growers to increase peanut yield. However, these synthetic chemicals have adverse effect in the environment. Thus, efforts to minimize the use of these chemicals with organic alternatives are becoming favorable as it promotes sustainable agriculture to increase productivity.

Irradiated κ-carrageenan (at 100 kGy) enhances the growth of chrysanthemum in tissue culture and potato (Dela Rosa et al., 2002; Relleve et al., 2005). Also, it improves growth promoting effects of rice, bokchoi, mustard, and menthol (Relleve et al., 2000; Naeem et al., 2012). Foliar spraying of irradiated iota carrageenan (at 250 kGy) on *Mentha arvensis* L. induces growth attributes, herbage yield and the content and yield of essential oil and menthol content of the oil (Naeem et al., 2012). Application of irradiated iota carrageenan (at 250 kGy) also significantly improved the growth attributes, physiological and biochemical parameters, essential oil yield and the contents of main components of essential oil of fennel (*Foeniculum vulgare* Mill.) (Hashmi et al., in press).

Low molecular weight polysaccharides have been reported to possess novel features such as promotion of germination and stimulation of growth or protection of plant from fungal, bacterial and viral pathogens (Hien, 2004; Tham et al., 2001; Zeng et al., 2003). Bio-stimulators are a category of products which, by definition, increase plant productivity especially under unfavourable conditions through an increase of the plant's ability to cope with stresses. Irradiated lignocellulosic materials suppress the heavy metal and salt stress on barley plants (Kume et al., 2002). Radiation-degraded chitosan suppresses toxicity of Vanadium on soybean, rice, wheat and barley plants (Tham et al., 2001). It also shows a strong effect on the growth of Faba bean plant (El-Sawy et al., 2010). Likewise, increase in yield in soybean haa been reported (Suwanmala, 2010). Oligoalginate increases the productivity of *Zea maize* and improves its quality (Abd El-Rehim et al., 2011). When applied as leaf-sprays, it improves growth, photosynthesis, physiological activities, and alkaloid production in *Catharanthus roseus* L. significantly (Idrees et al., 2011). Irradiated sodium alginate applied in lemongrass (*Cymbopogon flexuosus*) increases essential oil production (Idrees et al., 2012). The irradiated alginate with a molecular weight less than 10^4 shows a strong effect on the growth-promotion of rice, peanut (Hien et al., 2000), and the vegetable red amaranth (*Amaranthus cruentus* L.) (Mollah et al., 2009).

Manuscript published on 30 September 2019
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Generally, the study aimed to determine the effect of various rates of irradiated k-carrageenan (PGP) on Cercospora Leaf Spot (CLS) and rust of peanut and productivity. Specifically, it aimed to reduce the disease reaction and enhance yield of peanut.

II. MATERIALS AND METHOD

A. Experimental Design

On-field verification trials (two sites per variety, BPI Pn 9 Peanut variety and Farmer's variety) were conducted simultaneously from November 2017 – January 2018 to determine the efficiency of various rates of PGP on disease reaction and yield of two varieties of peanut. The experimental area in each site were laid out adopting the Randomized Complete Block Design (RCBD) as experimental design. Four replications were made per treatment.

B. Treatment and Treatment Application

The treatments are as follows:

T_1 – Control (untreated)
T_2 – 100 ppm PGP (4.8L of PGP/ha)
T_3 – 150 ppm PGP (7.2L of PGP/ha)
T_4 – Inorganic+organic fertilizers (positive control)

Except for T_4, each treatment were applied three times. The first application was made seven days after plant emergence while the second application was done seven days after the first application. The last application followed, seven days after the second application.

C. Management Practices

The proper management practices for peanut were employed to enhance seed germination and development. Seed inoculation with Rhizobium at a rate 100g per 50kg of seeds of peanut was done. Hilling up and weeding were also conducted before flowering stage. Likewise, watering was provided during field establishment, flowering stage, pod development and maturity. The kind and rate of fertilizer applied in T4 was based on the result of soil analysis. Field activities were properly documented and recorded.

D. Parameters

Ten randomly selected sample plants per treatment were used to gather the following data such as disease reaction, number of pods per plant, number of seeds per pod, shelling percentage, pod and seed yield (ton/ha), marginal benfit cost ratio (MBCR) and additional farmer's income.

E. Data Processing and Summarization

In each field trial, complete data set was analyzed through Analysis of Variance (ANOVA) using computer-run statistical software. The Least Significant Difference (LSD) test was used to compare treatment means.

III. RESULTS AND DISCUSSION

. PGP Application on BPI Pn 9 Peanut (Site 1)

Application of different rates of PGP significantly reduced the CLS infection by 39.5 – 41.9%. The BPI Pn 9 plants foliar treated with 100 ppm PGP significantly increased both pod and seed yield by 37.6% and 34.5%, respectively due to remarkable increase in the number of pods per plant thereby resulting to an additional income of at least Php 26,000/ha and an MBCR of 7.05 (Table 1).

The result conforms to the report of Idrees et al., 2011 that foliar sprays of carrageenan significantly improves growth, photosynthesis, physiological activities, and alkaloid production in *Catharanthus roseus* L. and the irradiated alginate with a molecular weight less than 10^4 shows a strong effect on the growth-promotion of rice and peanut (Hien et al., 2000).

Table 1. Summary of data of "BPI Pn9" peanut variety applied with different rates of irradiated k-carrageenan (PGP).

Treatment	CLS infection	Rust infection	No. of pods	No. of seeds	Wt. of 100	Pod yield	Seed yield	MBCR %
T_1 - Control (Untreated)	2.15^{b}	1.45	16.02^{c}	2.12^{b}	54.58	1.73^{c}	1.16^{b}	-
T_2 - 100 ppm PGP	1.30^{a}	1.53	20.57^{ab}	2.65^{a}	55.04	2.38^{a}	1.56^{a}	4.32
T_3 - 150 ppm PGP	1.25^{a}	1.18	22.05^{a}	2.77^{a}	56.52	2.22^{ab}	1.44^{a}	7.05
T_4 -Inorganic + Organic fertilizer (Positive control)	1.45^{a}	1.53	18.95^{b}	2.33^{b}	59.27	2.04b	1.33^{ab}	0.48

B. PGP Application on BPI Pn 9 Peanut (Site 2)

Results of the experiment revealed that the application of 150 ppm PGP significantly suppressed the CLS and rust infection up to 48.8% and 26.3%, respectively. This may possibly due to the ability of PGP to elicit an array of plant defense responses and biological activities when applied to plants (Hashmi et. al., 2012). In addition, irradiated pectin induces phytoalexin elicitor activity to prevent infection of plants by several fungi (Andrady et al., 1996).

The application of different rates of PGP on peanut consistently and significantly produced the most number of pods per plant, had the highest number of seeds per pod, shelling percentage and heaviest weight of 100 seeds (g) that remarkably contributed in the enhancement of both pod and seed yield of BPI Pn 9 (up to 2.14t/ha and 1.63t/ha). The results conform with the reports of Abad et al., 2015; Featonby-Smith et al., 1983 and Rama 1981 that PGP can stimulate the growth and yield of plants. Because of this, an additional income of Php 45,771.00/ha and Php 84,535.00/ha was realized through 100-150 ppm PGP application. The highest MBCR with 12.29% came from the plants treated with 150 ppm PGP (Table 2).

Table 2. Summary of data of "BPI Pn9" peanut variety applied with different rates of irradiated k-carrageenan (PGP).

Treatment	CLS infection	Rust infection	No. of pods per	No. of seeds per pod	Wt. of 100	Pod yield	Seed yield	MBCR %
T_1 - Control (Untreated)	2.15^{c}	1.60^{c}	15.28^{c}	1.92^{d}	5.91^{b}	1.65^{c}	1.21^{b}	-

T_2 - 100 ppm PGP	1.35^{b}	1.40^{b}	19.07^{ab}	2.52^{b}	6.62^{a}	2.14^{a}	1.63^{a}	8.53
T_3 - 150 ppm PGP	1.10^{a}	1.18^{a}	19.82^{a}	2.98^{a}	6.42^{a}	2.06^{ab}	1.58^{a}	12.29
T_4 -Inorganic+ Organic fertilizer (Positive control)	1.42^{b}	1.62^{c}	16.12^{bc}	2.20^{c}	5.62^{b}	1.74^{bc}	1.31^{b}	-2.64

C. PGP Application on Farmers Peanut Variety (Site 1)

Both rust and CLS infections of peanut were inhibited through foliar application of 150 ppm PGP. The untreated plants had the highest CLS and rust infections when compared to the plants treated with 100 ppm PGP and inorganic + organic fertilizer.

The 150 ppm PGP treated plants consistently performed well in terms of the number of pods per plant, number of seeds per pod, shelling percentage and weight of 100 seeds (g) resulting to a significant increase in both pod and seed yields by 30.2% and 35.9%, respectively with an equivalent additional income of Php 23,200/ha and Php 35,700/ha having an MBCR of 16.14% (Table 3). Preliminary results indicate an increase in yield of mungbean sprayed with irradiated κ-carrageenan (Abad et al., 2011). Likewise, Abad et al. (2015) reported that radiation modified κ-carrageenan increased yield of pechay (*Brassica napus* var. *chinensis*) in terms of fresh weight. When solutions of the irradiated kappa carrageenan (KC) and iota carrageenan (IC) are mixed with the growth medium for rice seedlings under hydroponics conditions, stimulation of growth is observed. Also, growth promoting activity of KC on vegetables like bok-choi and mustard have also been enhanced (Relleve et al., 2000). Fresh biomass and shoot height increases by 35% and 15%, respectively, in potato tissue culture bioassay supplemented with oligosaccharide from irradiated KC (Relleve et al., 2005).

Table 3. Summary of data of "Farmer's variety" of peanut applied with different rates of irradiated k-carrageenan (PGP).

Treatment	CLS infection	Rust infection	No. of pods	No. of seeds	Wt. of 100	Pod yield	Seed yield	MBCR%
T_1 - Control (Untreated)	2.05^{c}	1.92^{c}	13.22^{c}	2.33^{c}	47.80^{bc}	1.34^{c}	0.91^{c}	-
T_2 - 100 ppm PGP	1.50^{b}	1.55^{b}	15.62^{b}	2.75^{b}	48.78^{b}	1.69^{ab}	1.20^{b}	9.58
T_3 - 150 ppm PGP	1.32^{a}	1.23^{a}	17.75^{a}	3.40^{a}	51.58^{a}	1.92^{a}	1.42^{a}	16.14
T_4 -Inorganic+ Organic fertilizer (Positive control)	1.65^{bc}	1.68^{bc}	14.05^{bc}	2.45^{bc}	47.16^{c}	1.52^{bc}	1.02^{c}	-1.1

D. PGP Application on Farmers Peanut Variety in (Site 2)

The CLS and rust infections were significantly reduced by 15.2 and 36.2%, respectively through foliar application of 150 ppm PGP. In addition, yield parameters were enhanced by 150 ppm PGP application giving a significant increase of 23.6% and 36.5% per hectare on pod and seed yield, respectively. Radiation-depolymerized polysaccharides like carrageenan have shown various biological effects on plants. These oligomers, when applied to plants in the form of foliar sprays, elicit various kinds of biological and physiological activities, including promotion of plant growth, seed germination, shoot elongation, root growth and flower production. According to Farmer et al. (1991), Darvill et al. (1992) and John et al. (1997) oligosacharides play a role of cell signaling in plants for induction of phytoalexin.

The yield increase through 100 ppm and 150 ppm PGP application corresponded to an additional income of Php 18,400/ha up to Php 37,800, respectively, with an MBCR of 21.81%.

Table 4. Summary of data of "Farmer's variety" of peanut applied with different rates of irradiated oligo-carrageenan (PGP).

Treatment	CLS infection	Rust infection	No. of pods per plant	No. of seeds per pod	Wt. of 100 seeds (g)	Pod yield (t/ha)	Seed yield (t/ha)	MBCR%
T_1 - Control (Untreated)	1.65^{bc}	1.88^{c}	13.8^{b}	2.33^{c}	45.42^{c}	1.49^{b}	0.94^{b}	-
T_2 - 100 ppm PGP	1.48^{ab}	1.50^{b}	15.97^{ab}	3.15^{a}	51.43^{b}	1.73^{a}	1.27^{a}	6.07
T_3 - 150 ppm PGP	1.40^{a}	1.20^{a}	18.05^{a}	2.90^{ab}	54.55^{a}	1.95^{a}	1.48^{a}	21.81
T_4 -Inorganic+ Organic fertilizer (Positive control)	1.73^{c}	1.77^{c}	12.93^{b}	2.75^{b}	50.15^{b}	1.40^{b}	1.01^{b}	0.36

E. Meteorological Data

The data reflected in Figures 1 – 3 are the minimum and maximum temperature, relative humidity and the amount of rainfall incurred in Pampanga from Nov 2017 to Jan 2018. The minimum temperature ranges from 23.5°C – 24.5°C while the maximum temperature is from 30.5°C – 31.1°C. The amount of rainfall recorded ranged from 8.9mm – 97.8mm while the relative humidity (RH) observed is from 76 – 72 RH. During the study, the environmental condition favors development of the major fungal diseases particularly CLS and rust.

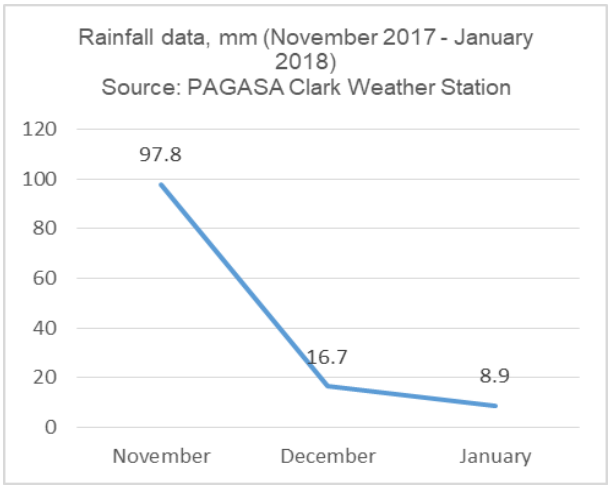

Figure 2. Recorded rainfall Magalang, Pampanga, Philippines (November 2017 – January 2018)

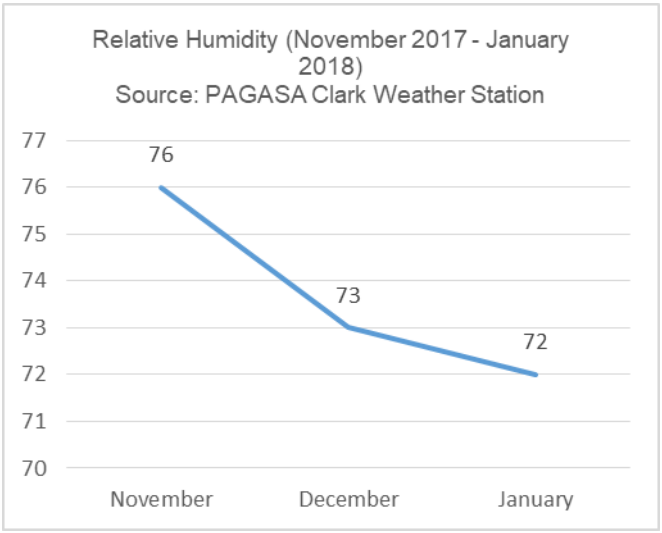

Figure 3. Recorded relative humidity in Magalang, Pampanga, Philippines (November 2017 – January 2018).

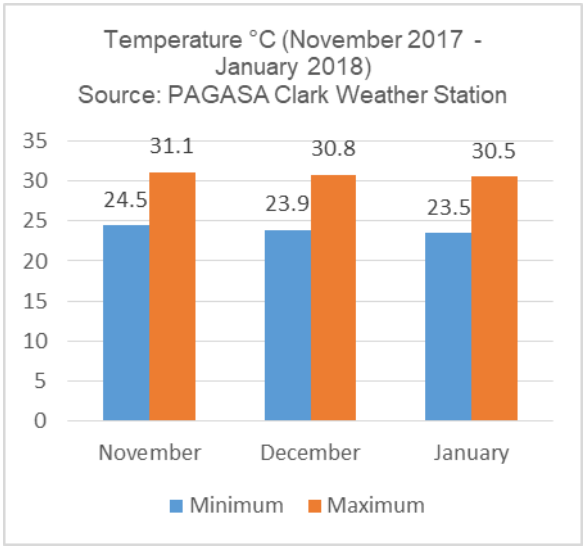

Figure 1. Recorded temperature in Magalang, Pampanga, Philippines (November 2017 – January 2018)

IV. SUMMARY AND CONCLUSION

The BPI Pn9 PGP treated plants had significantly lower CLS infection by 26.3% to 39.5% and rust infection by 41.9% to 48.8%. The application of different rates of PGP consistently and significantly produced high figures on yield parameters that remarkably contributed in the enhancement of both pod and seed yield of BPI Pn9 up to 2.14t/ha and 1.63t/ha. Peanut treated with 100 ppm PGP significantly increased the pod and seed yield by 37.57% and 34.5%. An additional income of 45,771.00 and Php 84,535.00/ha was realized through 100-150 ppm PGP application on peanut. The highest MBCR with 12.29% came from plants treated with 150 ppm PGP.

Meanwhile, 150ppm PGP applied to the Farmer's peanut variety significantly reduced the CLS and rust infections by 15.2 and 36.2% resulting to a significant increase of 23.6% and 36.5% on pod and seed yield per hectare. Through enhanced yield, an additional income of Php 18,400/ha up to Php 37,800/ha was achieved giving an MBCR of 21.81%.

The application of 150ppm PGP in peanut is recommended to suppress disease particularly cercospora leaf spot and rust, and improve yield of peanut resulting in enhanced productivity and increased farmers' income

Acknowledgement

The authors extend their heartfelt thanks to the Department of Science and Technology-Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST-PCAARRD) for funding the study.

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In addition to his accomplishments, he developed 20 National Seed Industry Council (NSIC) – registered varieties of plant and fruit trees and created technologies that are already IP registered - 1 patent and 1 utility model. He also published 2 books, authored 9 book articles including 38 publications in local and international reputable journals. Moreover, he is a constant oral and poster presenter during fora, symposia or conventions and a member of several organizations including one of the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) Pool of Experts on Ornamental and Medicinal Crops since 1996 and on Agricultural Resources Management since 2016. Likewise, he is a consistent resource person in his field of expertise. As proof of his accomplishments and hard work, he has received a total of 29 awards.