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Effects of *Kappaphycus* Drippings (KD) Foliar Fertilizer on the Growth and Yield Performance of Rice (*Oryza sativa*)

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ABSTRACT

Rice *(Oryza sativa)* is a vital staple food crop in more than 60 percent of the world, and around 430 million metric tons of rice are consumed worldwide. Moreover, to reduce synthetic fertilizer use while keeping rice production on track, the researchers decided to conduct a study on *Kappaphycus* drippings (K.D.) foliar fertilizer in rice production at Brgy, Mangayon, Compostela, Davao de Oro from July to December 2019 to determine the effects of different rates of synthetic fertilizer (S.F.) supplemented with *Kappaphycus* drippings (K.D.) foliar fertilizer. Data on the growth and yield performance of rice and the return of production cost (RPC) were evaluated. Randomized Complete Block Design (RCBD) was used in the experiment, with six treatments replicated four times. The six treatments were as follows T1 - 100% SF (Control), T2 - 90% SF + KD, T3 - 80% SF + KD, T4 - 70% SF + KD, T5 - 60% SF + KD and T6 - 50% SF + KD. The experimental plot has a 4 x 4-meter dimension. The study results showed that K.D. foliar fertilizer positively impacted rice plants' growth performance, particularly on the plant height, leaf color index (LCI), and the number of tillers and productive tillers per hill. Furthermore, rice treated with 70% SF + KD has a greater yield and increased return on production cost despite the lesser rates of synthetic fertilizer (S.F.).

INTRODUCTION

Rice (Oryza sativa) is an important staple food crop in more than 60 percent of the world; in 2008, more than 430 million metric tons of rice were consumed worldwide, according to the USDA. Approximately 50% of consumed calories by the whole population of humans depend on rice. Since rice provides 21% of energy and 15% of protein for humans, its quantity and quality require major attention (Gnanamanickam, 2009).

The rice production output in the Philippines in the year 2018 reached up to 16% to a record high of nearly 13 million metric tons (MMT) on the back of favorable weather conditions and high farmgate prices, according to the Food and Agriculture Organization (FAO) (Alcaras, 2018).

According to Bradley (2008), too much synthetic fertilizer makes the soil acidic and unproductive. That's why introducing organic fertilizer helps minimize the productivity loss of soil. Department of Agriculture (DA) encourages the farmers to use a high-yielding variety (HYV) and proper use of inputs such as fertilizer because most farmers focus on rice farming in all parts of the country where synthetic fertilizer is frequently considered the highest input. Fuentes (2010) stated that organic fertilizer application could help in certain plants' maximum growth and yield as it is a valuable source of NPK and essential elements. There have been reports that seaweed extracts are rich in natural plant growth hormones, which include cytokinin, auxins, abscisic acid, gibberellic acid, and salicylic acid (Khan *et al*., 2009; Craigie, 2011). They have also been shown to have a stimulatory effect on plant growth and can enhance plant resistance to biotic and abiotic stresses (Craigie, 2007: Gonzalez *et al*., 2013).

Moreover, seaweed has been found with the following chemical compositions: ca. 35.18% ash, 11.20% protein, 1.06% lipid, and 47.73% total carbohydrate, and the main carbohydrate was water-soluble polysaccharide. The presence of essential amino acids, which accounted for 36.35% of protein, was observed in protein analysis. The polysaccharide possessed strong antiviral activity against HSV-1 in vitro with EC50 of 8.92 ug/mL (Peng *et al*., 2004), and also seaweeds have shown effective control of root rotting fungi-like *Macrophomina phaseolina, Rhizoctonia solani, Fusarium* species and root-knot nematode *(Meloidogyne spp.)* on various crops (Sultana *et al*., 2007;2008;2009).

Hence, this study was conducted to determine the effects of different rates of synthetic fertilizer (S.F.) supplemented with *Kappaphycus* drippings (K.D.) foliar fertilizer for rice growth and yield performance.

MATERIALS AND METHODS

Location and Duration of the Study

The study was conducted at Purok-3, Brgy, Mangayon, Compostela, Davao de Oro, with the duration of four months from July to December 2019.

Experimental Design and Treatments

The study was laid out in a Randomized Complete Block Design (RCBD) with six treatments and was replicated four times. The experimental plot has a dimension of 4 x 4 meters and a space of 0.5 meters for alleys between plots to prevent contamination of other treatments.

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Treatments were as follows:
T1 – Control (100% synthetic fertilizer)
T2 – (90% synthetic fertilizer + weekly K.D. Application)
T3 – (80% synthetic fertilizer + weekly K.D. Application)
T4 – (70% synthetic fertilizer + weekly K.D. Application)
T5 – (60% synthetic fertilizer + weekly K.D. Application)
T6 – (50% synthetic fertilizer + weekly K.D. Application)

Soil Collection, Sampling, and Analysis
Soils were collected from the experimental area at a depth of 30 cm using an auger. There were 15 subsamples collected from the entire area following the zigzag method. Samples were mixed thoroughly, air-dried for one week, pulverized finely, and sieved. One kilogram of the soil was set aside for soil analysis with the label of information containing the amount of sample in kilograms, data to be analyzed, crop to be planted, previous crop planted in the area, location of the sample collected, and person who will use the data. Samples were brought to Soil Laboratory in Davao City for soil analysis.

Cultural Practices and Management
Land Preparation
The experimental area was thoroughly plowed and properly rotavated using a mechanical rotavator three times at five days intervals until transplanting.

Seed and Seedbed Preparation
The seedbed was prepared by plowing and rotavating the soil until it became a puddle. It was prepared in a square.

Raising of Seedlings
Seeds came from a certified supplier to ensure that it is free from contaminants such as weeds and other variety; proper preparation on the seedbed was observed to warrant healthy seedlings. The seeds were placed in sacks and soaked for 24 hours until seeds were germinated. Fertilizer application on seedlings was based on the farmer's practice using 3kg of ammonium sulfate (21-0-0) applied ten days after sowing.

Pulling of Seedlings
The seedbed was irrigated three days before the pulling of seedlings to soften the soil. The seedlings were pulled carefully when the seedlings reached 20 days after sowing.

Application of Treatment
For the application of the treatment, T1 was applied 100% synthetic fertilizer, T2 90% synthetic fertilizer + weekly K.D. application, T3 80% synthetic fertilizer + weekly K.D. application, T4 70% synthetic fertilizer + weekly K.D. application, T5 60% synthetic fertilizer + weekly K.D. application and T6 50% synthetic fertilizer + weekly K.D. application.
The fertilizer recommended rate based on soil analysis was applied three times. The first application is 17 days after transplanting (DAT) second application is side dress 40 days after transplanting, and the last application will be top dressing applied 60 days after transplanting (Table 1). Meanwhile, K.D foliar fertilizer was prepared in 20ml/L

Treatment	Days After Transplanting (DAT)		
	17	40	60
100% S.F. (Control)	N (Urea) – 100kg/ha	N (AMS) – 50kg/ha K (MOP) – 50kg/ha	N (AMS) – 50kg/ha K (MOP) – 50kg/ha
90% S.F. + K.D.	N (Urea) – 90kg/ha	N (AMS) – 45kg/ha K (MOP) – 45kg/ha	N (AMS) – 45kg/ha K (MOP) – 45kg/ha
80% S.F. + K.D.	N (Urea) – 80kg/ha	N (AMS) – 40g/ha K (MOP) – 40kg/ha	N (AMS) – 40g/ha K (MOP) – 40kg/ha
70% S.F. + K.D.	N (Urea) – 70kg/ha	N (AMS) – 35kg/ha K (MOP) – 35kg/ha	N (AMS) – 35kg/ha K (MOP) – 35kg/ha
60% S.F. + K.D.	N (Urea) – 60kg/ha	N (AMS) – 30kg/ha K (MOP) – 30kg/ha	N (AMS) – 30kg/ha K (MOP) – 30kg/ha
50% S.F. + K.D.	N (Urea) – 50kg/ha	N (AMS) – 25kg/ha K (MOP) – 25kg/ha	N (AMS) – 25kg/ha K (MOP) – 25kg/ha

AMS – Ammonium sulfate
MOP – Muriate of postash

Planting of Seedlings
Pulled seedlings from the seedbed were ready for planting in a straight row following the recommended rate of 25 cm between rows and 25 cm between hills in a dimension of 4m x 4m and with two seedlings to seek uniformity of tillers. Replanting was done 3 – 4 days after transplanting to avoid uneven maturity.

Water Management
The experimental area was drained for three days to control snails and then irrigated for three days after planting for the soil to have good moisture as it is a favorable environment for rice. Simultaneously, such a procedure prevented weeds' growth until it reached the panicle stage, and water was maintained at 2 cm high. During the application, excess water in the experimental area was drained. Moreover, two weeks before harvesting, the experimental area was drained.

Weed Management

The area was weed-free by spraying pre-emergence herbicide following the dose based on a commercial herbicide brand's recommended amount per hectare. It was done one day before transplanting, and post-emergence herbicide was applied ten days after. Supplementary hand weeding was done when there were weeds in the area. Also, spraying of post-emergence herbicide in the alley between plots to control weeds was done.

Harvesting

Harvesting was done 93 days after transplanting based on the maturity of the Tubigan 35 (NSIC Rc400) rice variety (113 days). It was done from 9 o'clock in the morning onwards to reduce its moisture content. The stalks of rice were separately cut and harvested manually using a sickle. The sample plant was cut first, followed by the crop cut in the center or the 1m x 1m area. The remaining plants were cut separately and then threshed.

Data Gathered

Plant height

Plant height was measured in centimeters (cm) from the base to the tip of the plant. It was done 15 days after planting, with an interval of 15 days until the maturity stage, using four (4) randomly selected hills from each plot.

Number of tillers per hill

It was done by counting the number of tillers from four randomly selected sample plants during the maximum tillering stage at 50 DAT was done to determine the number of tillers.

Number of productive tillers per hill

Using the same sample, a productive tiller was determined by counting the number of tillers that have developed grains from four randomly selected hills during harvest.

Leaf color index (LCI)

The leaf color chart was used upon observing this aspect of research. It was taken 15 days after transplanting with an interval of 15 days until 75 days, and this data was gathered early in the morning.

Yield and yield component Weight (g) of 1000 grains

This was determined by weighing 1000 grains during harvest using an analytical balance.

Number of filled and unfilled grains per panicle

This was taken from the four randomly selected hills in every replication of the treatment. Rice grains were classified as undeveloped when it was deformed and unfilled.

Yield (t/ha)

The total weight of the rice in tons per hectare from 1 square meter (m2) in each plot was obtained using the formula below.

$$\text{Yield} = \frac{\text{Plot yield (kg/plot)} \times 10{,}000\ m^2}{\text{Plot size } (m^2)}$$

Economic Analysis

The Cost and Return Analysis of the study was based on the current price. The gross income of the total production was subtracted from the total expenses of the production.

Net Income = Gross income – Total Expenses

$$\text{RPC} = \frac{\text{Net income}}{\text{Total expenses}} \times 100\%$$

Statistical Analysis

The statistical analysis of the different data gathered was obtained through Analysis of Variance (ANOVA) following RCBD, and the differences among treatments' means were computed using Tukey's Honestly Significant Difference (HSD).

RESULTS AND DISCUSSION

Plant height (cm)

Plant height is one of the major determinants of a plant's ability to compete for light and is correlated with the canopy area (Falster & Westoby, 2003). In this study, the plant height was determined using a meter stick by measuring from the plant's base to its tip in 15 days intervals. Table 2 shows the mean plant height at

Table 2: Average plant height of rice at 15, 30, 45, 60, and 75 DAT as affected by different rates of synthetic fertilizer (S.F.) plus *Kappaphycus* Drippings (K.D.) application

Treatments	Days After Transplanting (DAT)				
	15^{ns}	30^{ns}	45^{ns}	60^{ns}	75^{ns}
100% S.F. (Control)	27.88	55.88	70.69	87.88	100.06
90% S.F. + K.D.	27.88	56.56	71.69	87.69	100.63
80% S.F. + K.D.	27.07	57.81	72.50	88.31	101.56
70% S.F. + K.D.	28.63	57.94	72.06	87.56	100.13
60% S.F. + K.D.	28.00	55.69	70.00	87.81	100.44
50% S.F. + K.D.	28.56	55.38	70.44	88.06	99.38
CV (%)	3.10	5.54	3.15	0.77	1.79

S.F.- Synthetic Fertilizer; K.D.- Kappaphycus Drippings ; ^{ns}Not Significant

15, 30, 45, 60, and 75 days after transplanting (DAT) of rice as influenced by the application of different rates of synthetic fertilizers (S.F.) plus *Kappaphycus* drippings (K.D.) foliar fertilizer. Analysis of variance revealed no significant differences among treatment means in all five data-gathering periods.

Numerically, at 70 DAT, the highest plant height was recorded in rice treated with 80% S.F. + K.D. with 101.56 cm, while rice treated with 100%, 90%, 70%, and 60% S.F. + K.D. ranged from 100.06 cm to 106.63 cm. On the other hand, rice treated with 50% S.F. + K.D. got 99.38 cm. Despite the lesser rate of synthetic fertilizer, rice plants treated with 50% to 90% S.F. +KD were able to g*et al*most the same plant height of 100% (Control), and some results were even better. According to Craigie (2007), liquid seaweed extracts can be attributed to plant height because it is composed of natural plant growth hormones that include auxins, which enhance the plant's growth. Ludwig-Müller (2011) added that auxin is a plant hormone produced in the stem tip that promotes cell elongation.

Leaf Color Index (LCI)

The leaf color index (LCI) was evaluated using a leaf color chart (LCC) from PhilRice. It is a substitute for a Soil-Plant Analysis Development (SPAD) chlorophyll meter that estimates rice's leaf nitrogen status for timely nitrogen fertilizer application. Table 3 presents the LCI of rice as affected by applying different rates of synthetic fertilizer (S.F.) plus Kappaphycus drippings (K.D.) foliar fertilizer. It was observed that there was no significant difference in the LCI of rice throughout the study. Numerically, the highest leaf color index (LCI), regardless of the treatment, was recorded during 15 DAT and 75 DAT, which ranges from 4.88 to 4.94. According to El Din *et al.* (2008), the application of seaweed extract has been known to affect chlorophyll levels in plant leaves.

Table 3: Average leaf color index (LCI) of rice at 15, 30, 45, 60, and 75 DAT as affected by different rates of synthetic fertilizer (S.F.) plus *Kappaphycus* Drippings (K.D.) application

Treatments	Days After Transplanting (DAT)				
	15^{ns}	30^{ns}	45ns	60^{ns}	75^{ns}
100% S.F. (Control)	4.88	4.75	4.13	4.13	4.94
90% S.F. + K.D.	4.94	4.69	4.00	4.19	4.94
80% S.F. + K.D.	4.88	4.69	4.06	4.13	4.88
70% S.F. + K.D.	4.94	4.50	4.06	4.00	4.88
60% S.F. + K.D.	4.94	4.50	4.13	4.06	4.88
50% S.F. + K.D.	4.94	4.38	4.13	3.94	4.88
CV (%)	2.80	0.10	3.47	3.56	2.74

Total Number of Tillers and Productive Tillers

The total number of tillers and productive tillers was gathered by manual counting in the field. Table 4 shows the number of tillers per hill and productive tillers affected by different rates of synthetic fertilizer (S.F.) and weekly application of *Kappaphycus* drippings (K.D.). Analysis of variance shows no significant difference among treatment means of the total number of tillers per hill and productive tillers. Numerically, the highest number of tillers per hill was recorded in rice treated with 100% S.F. of 17.19 tillers per hill. Meanwhile, rice tillers per hill of other treatments (90% S.F. to 50% S.F. + K.D.) range from 15.13 to 16.63. On the other hand, in numerical data, the highest number of productive tillers was recorded from rice treated with 100% S.F. of 13.31, while other treatments (90% S.F. to 50% S.F. + K.D.) ranged from 12.56 to 13. 25.

Yield and Yield Components

The summary of yield components is shown in Table 5. The Tubigan 35 rice variety (Rc400) was harvested after 113 days. No significant difference between filled and

Table 4: Average total number of tillers per hill and productive tillers as affected by different rates of synthetic fertilizer (S.F.) plus *Kappaphycus* Drippings (K.D.) application

Treatments	Total number of tillers per $hill^{ns}$	Total number of productive $tillers^{ns}$
100% S.F. (Control)	17.19	13.31
90% S.F. + K.D.	16.25	13.25
80% S.F. + K.D.	16.63	13.00
70% S.F. + K.D.	15.56	12.94
60% S.F. + K.D.	15.44	12.63
50% S.F. + K.D.	15.13	12.56
CV (%)	9.70	0.05

Table 5: Summary table of the yield components as affected by different rates of synthetic fertilizer (S.F.) plus *Kappaphycus* Drippings (K.D.) application

Treatments	Filled grains per panicle^{ns}	Unfilled grains per panicle^{ns}	Weight (g) of 1000 Seeds^{ns}	Average yield of 1 m^2 in grams (g) **
100% S.F. (Control)	123.63	23.23	33.35	612.25a
90% S.F. + K.D.	121.68	23.25	33.48	599.25ab
80% S.F. + K.D.	121.01	22.995	33.06	589.75ab
70% S.F. + K.D.	119.36	24.29	33.38	581.00bc
60% S.F. + K.D.	119.50	24.31	32.96	556.25c
50% S.F. + K.D.	118.85	24.41	32.98	552.50c
CV (%)	2.77	3.70	1.76	2.13

unfilled grains per panicle and the weight of 1000 seeds. On the other hand, the highest average yield of 1m2 was noted in rice treated with 100% S.F. of 612.25g but comparable to 90% S.F. + K.D. and 80% S.F. + K.D. with 599.25g and 589.75g, respectively. The results implied that the use of the reduced rate of S.F. combined with K.D. could significantly contend with the application of 100% S.F. (Control).

Economic Analysis

The economic analysis of rice production as affected by different rates of synthetic fertilizer (S.F.) + K.D. was presented in Table 6. The highest yield was recorded in the rice treated with 100% synthetic fertilizer of 6.12t/ha but comparable to rice treated with 90% S.F.+ K.D. and 80% S.F. + K.D. with 5.99t/ha and 5.90t/ha, respectively. Moreover, rice treated with 70%S.F. + K.D. got 5.81t/ha and comparable to 60% SF + K.D. and 50% S.F. + K.D. with 5.56t/ha and 5.28t/ha, respectively. However, it can be observed that the rice treated with 70% S.F. + K.D. got the highest return of production cost of 144.92%, followed by rice treated with 60% S.F. + K.D. and 50% S.F. + K.D. of 143.45% and 141.03%, respectively. The result implied that application with K.D. positively influenced the yield of the rice plants despite the lesser rate of synthetic fertilizer.

Table 6: Economic Analysis of rice as affected by different rates of synthetic fertilizer (S.F.) plus *Kappaphycus* Drippings (K.D.) application

Treatments	Yield (t/ha)**	Price/ kilo (Php)	Gross income (Php)	Total expenses (Php)	Net income (Php)	RPC (%)
100% S.F. (Control)	6.12a	19.00	116,280.00	48,774.80	67,505.20	138.40
90% S.F. + K.D.	5.99ab	19.00	113,810.00	47,459.60	66,350.40	139.80
80% S.F. + K.D.	5.90ab	19.00	112,100.00	46,266.00	65,834.00	142.29
70% S.F. + K.D.	5.81bc	19.00	110,390.00	45,072.40	65,317.60	144.92
60% S.F. + K.D.	5.56c	19.00	105,640.00	43392.40	62,247.60	143.45
50% S.F. + K.D.	5.28c	19.00	100,320.00	41621.20	58,698.80	141.03
CV (%)	2.26					

CONCLUSIONS

The results of the study showed that the application of K.D. foliar fertilizer positively influenced rice growth and yield and increased the return of production cost (RPC) particularly the 70% S.F + K.D. However, the findings of the study is limited only to the particular locality. Hence, it can be recommended to conduct further field demonstration trials in other rice-producing areas to validate the results. Thus, this study revealed that the use of this Kappaphycus drippings (K.D.) foliar fertilizer significantly contribute to the reduction of the amount of production cost and help minimize soil acidity and unproductivity, resulting to increased production yield.

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