Yield and Profitability of Lowland Rice (*Oryza sativa* L. var. PSB Rc18) as Influenced by Nitrogen and Potassium Fertilizers

Dan Jay-ar P. Amac[1], & Ulysses A. Cagasan[2]
Department of Agronomy, Visayas State University
Baybay City, Leyte, Philippines
[2]ulycagasan@vsu.edu.ph

Article Information

History:
Received: 15AUG2020
Final Revision: 26SEP2020
Accepted: 05NOV2020

Keywords:
Efficiency
Fertilizers
Productivity
Rate
Yield

Abstract: *Nitrogen (N) and Potassium (K) fertilizers are the macronutrients needed by the rice plants for its growth and development. This study determined the effects of different levels of N and K fertilizers on the growth, yield, and profitability of lowland rice. Nitrogen levels were designated as the main-plot (N_1 - 60 kg ha^{-1} N and N_2 - 120 kg ha^{-1} N), and potassium levels were considered as the subplot (K_0 - no fertilizer application, K_1 - 30 kg ha^{-1} K_2O, K_2 - 60 kg ha^{-1} K_2O, and K_3 - 90 kg ha^{-1} K_2O). The experimental area of 332.5 m2 was laid out in a split-plot in an RCBD with three replications. The results revealed that 60 kg ha^{-1} N application produced a more number and higher percent filled grains $panicle^{-1}$, resulting in higher grain yield (tha^{-1}). Moreover, 0 and 30-60 kg ha^{-1} K applications resulted in the early heading of PSB Rc18. In contrast, the application of 90 kg ha^{-1} K produced a broader leaf area index (LAI) than the control. On the other hand, the application of 60 kg ha-1 N gave the highest net income of PhP 26,242.00 ha^{-1}. Likewise, rice plants applied with 60 kg ha^{-1} K_20 fertilizer had the highest net gain of PhP36,995.00 ha^{-1} followed by plants applied with 90 kg ha^{-1} K_20 of PhP30,348.00. Hence, 60 kg ha^{-1} N and 60 kg ha^{-1} K_20 for NSIC Rc18 rice variety are recommended for optimum yield and higher net income.*

I. INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of more than 80% of the world's population, including the Philippines (Rice Global Production, 2018). However, rice production in the country is insufficient due to low yield per unit area per unit time. Several factors affect crop yield. These include low soil fertility, erratic climatic conditions, and improper cultural management practices (Goder, 2013). Balanced application of fertilizer is one of the techniques to improve soil fertility and consequently, enhance rice production. The application of enough amount of nutrients needed by the plants is essential to efficiently utilize resources. However, we have to guide the farmers to do this activity on the farm (Ranjbar et al., 2007).

Some farmers did not consider the importance of potassium (K) fertilizer in rice production, Islam, A, & Muttaleb, A. (2016). Potassium is one of the essential nutrients needed by the rice plants. It improves plant vigor and helps prevent lodging. It is also known to improve rice yield and grain quality (Babu et al. 2005; IRRI, 2007; Srivastava & Singh, 2007). It performs an essential role in enzyme activation, photosynthesis, protein synthesis, and plant water relations. It enables plants to resist diseases (Hasanuzzaman et al., 2018). It is also essential in carbohydrate and nitrogen metabolism.

Furthermore, potassium promotes the growth of meristematic tissues and adjusts stomatal movements (Montaos, 2004). The potassium application significantly increased the number of tillers, increased the number of spikelets per panicle, and the percentage of filled grain (Islam & Muttaleb, 2016).

Moreover, K is one of the macro-elements needed by the plants in a more considerable amount. In general, K participates in many enzymatic and physiological processes, notably in the opening and closing of stomata, facilitating the gas exchange in the plant leaves and improving oxygen flow within the plant systems. Li et al. (2014) not only discovered the use of K in an increasing number of filled grains, grain size, and weight, but also the increase in tolerance to climatic factors like drought and pests and diseases.

On the other hand, Nitrogen is a critical element in profitable rice production because it is the essential nutrient element determining the crop's yield potential (Bijay-Singh & Singh, 2017). It is needed by rice in a relatively higher amount than phosphorus and potassium (Xiong et al. 2013). During the vegetative stage, it is required to promote growth and tillering, which determines the potential number of panicles. Nitrogen is also needed during reproductive and ripening stages to develop more spikelets per panicle and more filled grains. Too much nitrogen fertilizer application to rice resulted in excessive vegetative growth, lodging, susceptibility to insect pests, nutrient toxicity, decreased grain yield, and higher production cost. On the other hand, an inadequate supply of Nitrogen may lead to low growth and development (Shukla et al., 2015).

Studies indicated that Nitrogen and potassium had complementary effects in improving rice yield and grain quality (Uddin et al., 2013). Ranjbar et al. (2007) stated that an adequate amount and proper timing of these nutrients might increase rice yield. They added that combined application of N and K into three equal splits at the active tillering, panicle initiation and flowering stages gave the highest profits of rice in Bangladesh. Several studies on the effect of Nitrogen and Potassium in rice have been conducted. However, it needs to be verified for the effective and efficient monitoring of the gaps in the results of the study as the climatic conditions were fast-changing. This study was conducted to determine the effects of varying nitrogen and potassium fertilizers on the development and yield performance of lowland rice, effects on soil properties, and profitability per hectare in lowland rice production.

II. METHODOLOGY

The study was conducted from August to December 2018 using Umingan clay loam soil with an alluvial origin. The area had a pH of 5.42 with 2.69% organic matter, 0.24% total N, 8.61 mg kg-1 available P, and 1.01 me 100 g-1 exchangeable K. This indicated that the soil was strongly acidic with low organic matter, medium in total Nitrogen, low in available phosphorus and high extractable K contents (Landon, 2014).

Before establishing the experiment, ten (10) soil samples were collected at random from the experimental area at a depth of 0-20 cm. The samples were composited, air dried, sieved using 2 mm wire mesh, and submitted to the Central Analytical Services Laboratory (CASL) of the Philippine Rootcrops Research Center (Philrootcrops), Visayas State University, Visca, Baybay City, Leyte. The samples were analyzed for soil pH, total Nitrogen, organic matter, available P, and exchangeable K using the standard methods of PCARRD (1980).

All of the treated plots were uniformly applied with solophos (0-20-0) at 60 kg ha^{-1} P_2O_5. Half of the total amounts of N, P2O5, and K2O were applied at transplanting, and the remaining half were broadcasted during panicle initiation. Also, all of the recommended cultural management practices for rice production were strictly followed. As shown in Table 1, the climatic conditions at the study's time were favorable to the rice plants (IRRI, 2007).

Research Design

The experiment was laid out in a split-plot arranged in a Randomized Complete Block Design (RCBD) with three replications. Nitrogen levels (N_1 - 60 kg ha^{-1} N and N_2 - 120 kg ha^{-1} N) were designated as the main plot, and potassium

Table 1

Total monthly Rainfall (mm), average daily minimum and maximum temperatures (^oC), and average daily relative humidity (%) throughout the experiment

Months	Total Rainfall (mm)	Temperature (^0C)		Relative Humidity (%)
		Minimum	Maximum	
August	106.23	23.75	31.90	79.50
September	625.00	23.78	31.76	83.56
October	510.12	24.40	30.45	81.76
November-Dec 4	523.00	23.45	30.60	83.14
Total	1,764.35	-	-	-
Mean	-	23.84	31.17	81.99

ISSN 2449-4577 (online) 2408-283X (print)

levels (K_0 - no fertilizer application, K_1 - 30 kg ha^{-1} K_2O, K_2 - 60 kg ha^{-1} K_2O, K_3 - 90 kg ha^{-1} K_2O) were assigned as the subplot.

Research Samples

The research samples used in this study were randomly selected using 10 sample plants in each treatment plot.

Data Collection Method

For the agronomic characteristics, the parameters evaluated for this study were: number of days from transplanting to heading and maturity, plant height (cm) at harvest, fresh straw yield (tha^{-1}), and leaf area index (LAI). The following parameters were measured for the yield and yield characteristics: number of productive tillers $hill^{-1}$, number of filled grains $panicle^{-1}$, percent filled grains, the weight of 1,000 grains (g), and total grain yield (tha^{-1}). Harvest index and meteorological data were also gathered and analyzed. Moreover, profitability analysis, as well as initial and final soil analysis, were also conducted.

Data Analysis

The analysis of variance (ANOVA) was done using the Statistical Tool for Agricultural Research (STAR) version 1.0. Mean comparison was made using the Honestly Significant Difference (HSD) test at 5% level of significance.

Ethical Consideration

The authors declare no conflict of interest regarding the publication of this paper because they are the owner of this research paper.

III. RESULTS AND DISCUSSION

Agronomic Characteristics

The agronomic characteristics of lowland rice as affected by different levels of nitrogen and potassium fertilizers are presented in Table 2. Results show that number of days from transplanting to heading was significantly ($p<0.05$) influenced by the different levels of nitrogen and potassium fertilizers. Likewise, LAI of NSIC Rc18 was significantly ($p<0.05$) affected by K. Rice plants' application applied with 60 kg ha^{-1} N and 60-90 kg K_2O ha^{-1} headed earlier than the plants applied with 120 kg ha-1 N and applied with 0-30 kg K_2O ha^{-1}. The application of a higher level of N (120 kg ha^{-1}) resulted in an

Table 2

Agronomic characteristics of lowland rice (Oryza sativa L. var. PSB Rc18) as influenced by different levels of nitrogen and potassium fertilizers

Treatments	Number of days from sowing to		Plant Height (cm)	Leaf Area Index (LAI)	Straw Yield (t ha^{-1})
	Heading	Maturity			
Nitrogen level (a)					
N_1= 60 kg ha^{-1} N	87.83^a	109.25	120.49	4.92	27.88
N_2= 120 kg ha^{-1} N	89.83^b	109.67	122.50	4.58	29.26
Mean	88.33	109.46	121.49	4.75	28.57
Potassium level (b)					
K_0= Control	87.67^a	108.83	118.97	3.29^b	29.37
K_1= 30 kg ha^{-1} K_2O	88.00^a	108.83	121.97	4.08^{ab}	29.34
K_2= 60 kg ha^{-1} K_2O	89.50^b	109.83	123.23	4.65^a	31.39
K_3= 90 kg ha^{-1} K_2O	89.17^b	110.33	121.80	4.97^a	32.19
Mean	88.33	109.46	121.49	4.25	28.57
CV(a) %	1.06	1.22	4.83	25.77	15.29
CV(b) %	0.61	0.87	2.55	17.75	26.38

Note: *In a column, means followed by the same letters and without letters are not significantly different at 5% level, HSD* increase in the number of days from sowing to heading. This is because the application of higher N promotes excessive vegetative growth, which delayed the onset of the heading stage of rice.

Moreover, regardless of N levels, rice plants applied with 30-60 kg K_2O ha^{-1} and those not applied with potassium fertilizer headed earlier than rice plants applied with 90 kg ha-1 K2O. On the other hand, higher LAI was obtained in plants applied with 90 kg ha^{-1} K_2O (K_3), but this value was not significantly different from the LAI of the plants applied with 30 and 60 kg ha^{-1} K_2O. Rice plants applied with 30 (K_1) and 60 kg ha^{-1} K (K_2) had LAI comparable to the control (K0). This conforms to Goder (2013) findings that the required amount of potassium fertilizer for rice is not as high compared to Nitrogen. There are also reports that most soils grown with rice in Asia do not need much potassium fertilizer due to the element's inherent availability in the soil.

Grain Yield, Yield Components and Harvest Index

The grain yield and yield components and the harvest index of lowland rice as influenced by the different levels of nitrogen and potassium fertilizers are presented in Tables 3 and 4. Results revealed that the application of potassium significantly ($p<0.05$) influenced the number of filled grains, total grain yield (tha^{-1}), and harvest index of PSB Rc18 rice variety. Plants applied with 60 kg ha^{-1} N, regardless of K levels, had a higher number of filled grain panicle^{-1}, percent fertility, and grain yield (t ha^{-1}) than those applied with 120 kg ha^{-1} N. This result was supported by the report of Xiong et al. (2013) which showed that rice used with 60 kg ha^{-1} N had higher percent filled grains panicle^{-1}. Moreover, Billones (2005) reported that the application of 60 kg ha^{-1} N in lowland rice resulted in a higher number of productive tillers and consequently resulted in higher grain yield tha^{-1}. This result implied that 60 kg ha^{-1} N is the rate at which optimum grain yield NSIC Rc18 could be attained. On the other hand, plants applied with 60-90 kg ha^{-1} K_2O had comparably more number of filled grains per panicle and consequently resulted in higher yield (tha^{-1}) than plants applied with 0-30 kg ha^{-1} K_2O. In general, the low yield observed in these treatments was due to the slight effect of the tungro virus that attacked the rice plants during the early stage of crop growth.

Table 3

Yield and yield characteristics of lowland rice (Oryza sativa L. var. PSB Rc18) as influenced by different levels of nitrogen and potassium fertilizers

Treatments	No. of productive tillers hill^{-1}	Panicle length (cm)	No. of filled grains panicle^{-1}	Percent (%) fertility	Weight (g)	
					Grains panicle^{-1}	1000 grains
Nitrogen level (a)						
N_1= 60 kg ha^{-1} N	17.33	24.82	154.74^a	68.00^a	28.48	27.03
N_2= 120 kg ha^{-1} N	17.20	24.66	91.42^b	61.00^b	24.07	25.61
Mean	17.27	24.74	98.08	64.00	26.28	26.32
Potassium level (b)						
K_0= Control	16.33	24.54	87.87^c	61.00	24.60	26.80
K_1=30 kg ha^{-1} K_2O	16.87	24.31	100.22^b	67.00	25.48	25.42
K_2=60 kg ha^{-1} K_2O	18.07	24.90	199.02^a	63.00	26.67	26.42
K_3=90 kg ha^{-1} K_2O	17.80	25.20	195.22^a	65.00	28.35	26.63
Mean	17.27	24.74	98.08	64.00	26.28	26.32
CV (a) %	22.35	2.67	9.23	9.88	23.93	15.40
CV (b) %	9.41	2.22	13.81	10.14	21.24	12.06

Note: *In a column, means followed by the same letters and without letters are not significantly different at 5% level, HSD*

ISSN 2449-4577 (online) 2408-283X (print)

Table 4

Grain yield and harvest index of lowland rice (Oryza sativa L. var. PSB Rc18) as influenced by different levels of nitrogen and potassium fertilizers

Treatments	Grain yield (t ha^{-1})	Harvest index (HI)
Nitrogen level (a)		
N_1= 60 kg ha^{-1} N	3.43^a	0.35
N_2= 120 kg ha^{-1} N	2.20^b	0.33
Mean	2.82	0.34
Potassium level (b)		
K_0= Control	2.86^b	0.47^a
K_1=30 kg ha^{-1} K_2O	2.54^b	0.45^a
K_2=60 kg ha^{-1} K_2O	3.67^a	0.32^b
K_3=90 kg ha^{-1} K_2O	3.40^a	0.31^b
Mean	3.12	0.34
CV(a) %	28.56	9.61
CV(b) %	19.50	7.78

Note: *In a column, means followed by the same letters and without letters are not significantly different at 5% level, HSD*

Table 5 shows the interaction effects of N and K levels on the harvest index of PSB Rc18. Without K application, the N rate at 60 kg ha-1 resulted in a higher harvest index of PSB Rc18. However, doubling the nitrogen fertilizer rate to 120 kg, ha^{-1} N significantly reduced the harvest index value. The application of K at a higher rate (90 kg ha^{-1} K) with 60 kg ha^{-1} N also reduced the harvest index value. However, increasing the amount of N to 120 kg, ha^{-1} increased the harvest index value of PSB Rc18. These results suggest that the application of 60 kg ha^{-1} N would favor the partitioning of photosynthates to develop more grains even without K application. However, the application of 60 kg ha^{-1} N and a higher amount of potassium did not favor photosynthates partitioning as it significantly reduced the HI value.

Initial soil analysis showed that the area had a pH of 5.42 with 2.69 % organic matter, 0.24 % total N, 8.61 mg kg^{-1} available P, and 1.014 me 100 g^{-1} exchangeable K (Table 6). These results indicated that the soil was strongly acidic with low organic matter, medium in total Nitrogen, low in available phosphorus, and low in extractable K contents, Table 7 (Landon, 2014). Final soil analysis revealed a slight increase in Final soil pH in all the treatment plots except in treatment applied with 60 kg N and 60 kg ha^{-1} K (N_1 K_2).

Likewise, there was a slight increase in total N except in N_1 K_3 (60 kg N and 90 kg ha^{-1} K) and N_2 K_3 (120 N and 90 kg ha^{-1} K). All treatment plots showed an increase in % OM and available P (mg kg^{-1}). The increase in soil pH, % OM, total N, and available P (mg kg^{-1}) could be attributed to the added inorganic fertilizers into the experimental area. However, as the soil becomes more acidic, phosphorus availability in the soil decreases (IRRI 2007).

Table 5

Interaction effects of N and K levels on the harvest index (HI) of lowland rice (Oryza sativa L.) PSB **Rc18**

Treatments	N Levels (kg ha^{-1} N)	
	60	120
Potassium Levels		
K_0 = (Control)	0.497a	0.327b
K_1 = 30 kg ha^{-1} K_2O	0.461ab	0.338b
K_2 = 60 kg ha^{-1} K_2O	0.330b	0.300b
K_3 = 90 kg ha^{-1} K_2O	0.288c	0.332b

Note: *In a column and rows, means followed by the same letters are not significantly different at 5% level, HSD.*

Table 6

Soil test results before planting and after the harvest of lowland rice (Oryza sativa L.) in soil applied with different levels of Nitrogen and excessive amounts of potassium fertilizers

Soil Analysis	Soil pH (1:2.5)	OM (%)	Total N (%)	Available P ($mgkg^{-1}$)	Exchangeable K ($me100g^{-1}$)
Values of soil chemical properties suitable for lowland rice production (IRRI, 2007)	6.6-7.3	4 – 10	0.5-1.0	10 – 50	0.20- 0.50
Initial	5.42	2.69	0.24	8.61	0.71
Final					
N_1K_0= 60 kg N and 0 kg K ha$^-$	5.72	3.90	0.24	11.89	0.59
N_1K_1= 60 kg N and 30 kg K ha$^-$	5.78	3.67	0.24	9.52	0.65
N_1K_2 =60 kg N and 60 kg K ha$^-$	5.42	3.50	0.24	12.66	0.72
N_1K_3 = 60 kg N and 90 kg K ha^{-1}	5.45	3.44	0.21	11.14	0.62
N_2K_0= 120 kg N and 0 kg K ha$^-$	5.49	3.90	0.25	12.92	0.84
N_2K_1 =120 kg N and 30 kg K ha$^-$	5.61	3.58	0.25	9.36	0.67
N_2K_2 =120 kg N and 60 kg K ha$^-$	5.51	3.52	0.24	10.35	0.70
N_2K_3 =120 kg N and 90 kg K ha$^-$	5.70	3.73	0.23	12.65	0.74
Mean	5.59	3.66	0.24	11.31	0.69

Table 7

Profitability analysis hectare^{-1} of lowland rice PSB Rc18 as influenced by different levels of nitrogen and potassium fertilizers

	Grain Yield (t ha^{-1})	Gross Income (PhP)	Cost of Production (PhP)	Net Income (PhP)
Nitrogen level (a)				
N_1= 60 kg N ha^{-1}	3.032^a	60,640.00	34,393.57	26,246.43
N_2= 120 kg N ha^{-1}	2.201^b	44,020.00	36,262.00	7,758.00
Potassium level (b)				
K_0= Control	2.86^b	57,260.00	33,075.66	24,184,34
K_1=30 kg K_2O ha^{-1}	2.54^b	50,840.00	34,178.16	16,661.84
K_2=60 kg K_2O ha^{-1}	3.67^a	73,400.00	36,404.66	36,995.34
K_3=90 kg K_2O ha^{-1}	3.40^a	68,000.00	37,651.66	30,348.34

Note: *Unit price of palay (dried) = PhP 20.00kg^{-1}*

On the other hand, exchangeable K (me100g^{-1}) had decreased in all treatment plots. This result could be attributed to the rice plants' utilization of K nutrients for its reproductive growth, specifically during the grain filling stage. Some of the K elements were also leached as the K fertilizer is very mobile in the soil. Moreover, the K element is much absorbed by the rice plants to develop the rice straws and grains, as indicated in the straw yield hectare^{-1}. Irrespective of potassium levels, results revealed that rice plants applied with 60 kg ha^{-1} N produced higher net income (PhP 26,246.43 ha^{-1}) than rice applied with 120 kg ha^{-1} N (PhP 7,758.00 ha^{-1}). On the other hand, rice plants with potassium fertilizer at 60 K_2O ha^{-1} (K_2) got the highest net income (PhP 36,995.00 ha^{-1}). This was followed by plants applied with 90 kg ha^{-1} K_2O (K_3) at PhP 30,348.00 ha^{-1} and those not applied with fertilizer (K_0) with PhP 24,184.00. The lowest net income of PhP 16,661.00 ha^{-1} was obtained from the treatment

ISSN 2449-4577 (online) 2408-283X (print)

applied with 30 kg ha^{-1} K_2O. The net income varied among the treatments due to the differences in grain yield and the fertilizers used. These results further implied that it is unnecessary to apply more potassium fertilizer because it has the more available amount of K retained in the soil (Islam & Muttaleb, 2016).

IV. CONCLUSION

Proper nutrient management is a critical practice for effective and efficient utilization of resources in rice production. Hence, efficiency and productivity are critical tools in crop production. In this study, results revealed that the application of 60 kg ha^{-1} N produced a more number and higher percent filled grains panicle-^{1}, resulting in higher grain yield (tha^{-1}). Moreover, 0 and 30-60 kg ha^{-1} K applications resulted in the early heading of PSB Rc18. In contrast, the application of 90 kg ha^{-1} K produced a broader leaf area index (LAI) than the control. On the other hand, 60 kg ha^{-1} N's application gave the highest net income of PhP 26,242.00 ha^{-1}. Likewise, rice plants applied with 60 kg ha^{-1} K_20 fertilizer had the highest net gain of PhP36,995.00 ha^{-1}. Hence, it is recommended to use 60 kg ha^{-1} N and 60 kg ha^{-1} K_20 for NSIC Rc18 rice variety for optimum yield and higher net income. Increasing the rate to 120 kg ha-^{1} N significantly reduced the HI value; hence, not recommended to overdose the N fertilizer for rice production. It is further recommended that enough amount of fertilizer is applied in rice to contribute to the total farmers` productivity and income.

ACKNOWLEDGEMENT

The researchers would like to thank the research committee for their efforts to check and improved the output of this study.

.

REFERENCES

Babu, Y. J., Nayak, D. R., & Adhya, T. K. (2005). Potassium application reduces methane emission from a flooded field planted to rice. *Biology and Fertility of Soils*, *42*(6), 532–541. https://doi.org/10.1007/s00374-005-0048-3

Bijay-Singh, & Singh, V. K. (2017). Fertilizer Management in Rice. *Rice Production Worldwide*, 217–253. https://doi.org/10.1007/978-3-319-47516-5_10

Billiones, F. E. (2005). *Lowland rice as influenced by different planting methods and levels of nitrogen application.* (thesis). Visayas State University, Baybay City, Leyte, Philippines.

Fageria,, N. K., & Baligar, V. C. (2017). *Growth and Mineral Nutrition of Field Crops* (2nd ed.). Marcel Dekker Inc., New York.

Goder, M. I. (2013). *Effects of different potassium fertilizer levels on the growth and yield of lowland rice at high rates of nitrogen fertilization.* (thesis). Visayas State University, Baybay City, Leyte, Philippines.

Hasanuzzaman, M., Borhannuddin Bhuyan, M. H. M., Fujita, M., Chowdhury Masud, A. A., Al Mahmud, J., Hossain, S., & Nahar, K. (2018, January 23). *Potassium: A Vital Regulator of Plant Responses and ...* Agronomy. https://www.mdpi.com/2073-4395/8/3/31/pdf.

IRRI. (2007). *Potassium (K)*. Potassium (K) - IRRI Rice Knowledge Bank. https://bit.ly/2JqFatZ

Islam, A., & Muttaleb, A. (2016). Effect of potassium fertilization on yield and potassium nutrition of Boro rice in a wetland ecosystem of Bangladesh. *Archives of Agronomy and Soil Science*, *62*(11), 1530–1540. https://doi.org/10.1080/03650340.2016.1157259

Landon, J. R. (2014). Booker Tropical Soil Manual. *Taylor & Francis Group* . https://doi.org/10.4324/9781315846842

Li, J., Lu, J., Li, X., Ren, T., Cong, R., & Zhou, L. (2014, February 28). *Dynamics of Potassium Release and Adsorption on Rice Straw Residue*. PLOS ONE. https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0090440.

Montaos, N. M. (2004). *The response of sweetpotato to varying levels of potassium application* (thesis). Visayas State University, Baybay City, Leyte, Philippines.

Ranjbar, G., Bahmaniar, M., & Ahmadian, S. (2007). Effects of N and K Applications on Agronomic Characteristics of Two Iranian and Landrace Rice (Oryza sativa L.) Cultivars. *Pakistan Journal of Biological Sciences*, *10*(6), 880–886. https://doi.org/10.3923/pjbs.2007.880.886

Shukla, V. K., Tiwari, R. K., Malviya, D. K., Singh, S. K., & Ram, U. S. (2015). Performance of rice varieties about nitrogen levels under irrigated condition. *Academic Journals*, *10*(12), 1517–1529. https://doi.org/10.5897/AJAR2015.9567

Srivastava, P. C., & Singh, U. S. (2007). Effect of Graded Levels of Nitrogen and Sulfur and Their Interaction on Yields and Quality of Aromatic Rice. *Journal of Plant Nutrition*, *30*(5), 811–828. https://doi.org/10.1080/01904160701290113

Xiong, J., Ding, C. Q., Wei, G. B., Ding, Y. F., & Wang, S. H. (2013). Characteristic of Dry-Matter Accumulation and Nitrogen-Uptake of Super-High-Yielding Early Rice in China. *Agronomy Journal*, *105*(4), 1142–1150. https://doi.org/10.2134/agronj2012.0297

Xiong, J., Ding, C. Q., Wei, G. B., Ding, Y. F., & Wang, S. H. (2013). Characteristic of Dry-Matter Accumulation and Nitrogen-Uptake of Super-High-Yielding Early Rice in China. *Agronomy Journal*, *105*(4), 1142–1150. https://doi.org/10.2134/agronj2012.0297

Purdue University. (2020). *APA Tables and Figures // Purdue Writing Lab*. Purdue Writing Lab. https://bit.ly/2CXaiOS.

Squirrell, T. (2018, February 14). *Five Common Essay Mistakes to Avoid*. Tim Squirrell, PhD. https://bit.ly/31vOx2l.

ISSN 2449-4577 (online) 2408-283X (print)