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Alternative Growth Ehancers for Rice Production: Usefulness of Wood Vinegar (PA) in Irrigated Rice (PSB Rc18)

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Abstract
This study was conducted at the MinSCAT Main Campus Rice Production Area, Alcate, Victoria, Oriental Mindoro from June to November 2017 to determine the usefulness of varying dilution of wood vinegar such:1% (1L wood vinegar:100L water); 0.5% (1L wood vinegar:200L water); and, 0.33% (1L wood vinegar:300L water) on irrigated rice (PSB Rc18 variety).
Results of the study revealed that 1% dilution could be an alternative vegetative growth enhancers of rice considering that in all growth parameters studied such as plant height, tiller counts both productive and non-productive, length of panicles and flag leaf, plants sprayed with 1% dilution produced significantly the tallest plants with 93.47cm, the most number of productive tillers with 14.54 but with the least non-productive tillers with only 0.83 and produced the longest panicles and flag leaf with 24.08 and 34.42cm, respectively. The untreated plants on the other hand, reached only the height of 87.51cm, produced only 10.42 productive tillers, had a shortest flag leaf and panicles with 29.83cm and 20.03cm but with the most number of non-productive tillers with 1.42.
With regards to the yield components; wood vinegar of 1% dilution could be a yield booster and enhancer considering that the yield per plot and per hectare of the treated and untreated plants varied significantly with margins of 1594.5grams and 1.76tons. As to the net income per hectare and return on investment, the same trend were noted with plants supplied with 1% dilution produced a net income of PhP87,653.00 and 206.36% ROI, while the untreated plants had only PhP38,934.00 and 100.8%, with differences of PhP48,719.00 and 105.56%, respectively.
On the occurrence of insect pests, dilution of wood vinegar of varying levels could be an effective pesticides considering that the treated plants showed resistance to the common insect pests in the locality such as, rice bug; and stemborers that caused whiteheads and deadhearts with numerical ratings of only 1-2.
Resistance of the treated plants to the common rice diseases such as; rice blast and bacterial leaf blight was also recorded with the rating of 1 and 2, while the untreated plants was moderately resistant to intermediate with rating of 3.
Keywords: wood vinegar, vermicompost, vermitea, organic farming, growth enhancer

1. Rationale

Vermicomposting is the process of turning organic debris into worm castings. Application of aqueous extract of vermicompost (vermicompost tea) has been shown to improve plant health, crop yield, and nutritive quality (Gamaleyet, et al., 2001; Pant, et al. 2009).

Wood vinegar on the other hand, is an organic compound which is suitable for use by organic farmers. Raw wood vinegar has more than 200 chemicals, such as acetic acid, formaldehyde, ethyl-valerate, methanol, tar (Apai and Thong deethae, 2001). The wood vinegar solution contains macro-nutrients such as magnesium, sulphur, phosphorus, calcium and potassium along with micro-nutrients. By applying wood vinegar to plants, the absorbed macro and micro nutrients are being recycled and returned by trees back into the soil (Apai and Thong deethae, 2001). Wood vinegar reportedly improves soil quality, eliminates pests, accelerates plant growth, and acts as a plant growth regulator or growth inhibitor (Apai and Thong deethae, 2001). The material has been used for the control of microbes such as bacterial and fungal diseases of various crop plants (SeoRahhakrishnan, et al., 2002).

It also contains small amount of nutrient directly taken by plants, as well as bactericidal and anthelmintic substances (Leong, 2011).

Vermitea at the rate of 1% dilution likewise, could be an alternative growth and yield enhancers for corn as it increased both the growth, yield and return on investment (ROI) of the commodity (Rogelio 2017). Twenty percent (20%) concentration level of vermitea also increase the growth and yield of eggplant as per result of the study conducted by Politud, et. al., 2016.

Through foliar application, some bacteria are killed by direct contact and the changes of the microbiological population deter the propagation of pathogenic bacteria.

The leaves become shiny and darker in color. Chlorophyll is known to increase with, which promotes the formation of sugar and amino acids for better taste of the produce (Food and Fertilizer Technology Center, Dept. of Agriculture, Thailand).

The low pH of wood vinegar accelerates oxidized ethylene and the formation of methionine (Leong, 2011). This study generally aimed to determine the growth and yield performance of PSB Rc18 irrigated rice applied with vermicast and varying levels of wood vinegar.

2. Methodology

An area measuring 300m^2 (15m x 20m) was prepared using wetland tillage operation.
The experimental area was divided into three (3) 100m^2 blocks and treatments were assigned blocks following the Randomized Complete Block Design (RCBD).
Three (3) different solutions of wood vinegar: 10ppt; 5ppt; and, 3.3ppt were used.
Different solutions were sprayed separately to plants and the soil using knapsack sprayer. First application was done immediately after transplanting, and at two weeks interval thereafter and the last application was two (2) weeks before harvesting.
Eight sample plants per plot (four (4) hills in two adjacent rows) from the harvest area were used for data gathering.

2.1 *Plant height*

Plant height was determined by measuring the eight (8) sample plants from ground level to the tip of the leaves of the tallest tiller.

2.2 Tiller count

Separate counts of productive and unproductive tillers of eight (8) sample plants were noted a day before harvesting.

2.3 Length of panicles

Panicle of the tallest tiller of eight (8) sample plants were measured from the panicle base (neck) up to their tips, a day before harvesting.

2.4 Flagleaf length

Flagleaf of the tallest tiller of eight (8) sample plants were measured a day before harvesting the crop.

2.5 Computed grain yield per hectare

Grain yield per hectare was computed based on this formula: (PhilRice NCT Manual)

$$\text{Grain Yield (kg/ha)} = \frac{\text{CPY (g)}}{1000\text{g/kg}} \times \frac{100\text{-MC}}{86} \times \frac{10000\text{m}^2\text{/ha}}{\text{Harvest area}} \quad (1)$$

3. Results and Discussion

Results of the current study showed that the transplanted rice plants sprayed with varying levels of wood vinegar right after transplanting did not show signs of pulling and transplanting stresses, while those untreated plants underwent change on the color of their leaves which turned into yellowish green. It took four (4) days before their leaves recovered fully.

According to the report of the Food and Fertilizer Technology Center of the Thailand's Department of Agriculture, wood vinegar is an excellent plant growth promoter as it enriches the color of the plant leaves to make them shinier and darker. This happens due to the increase in chlorophyll which is the effect of ester in the wood vinegar that promotes photosynthesis. Additionally, it was cited that pyroligneous acid is truly beneficial and has progressive effects on the growth of rice plants such as height, tiller productions and length of flag leaf.

In terms of plant height, plants supplied with the highest level of 1% solution (1:100 PA and water) significantly and consistently produced the tallest plants when compared to untreated plants which appeared the shortest from the very beginning of height determination which was done one week after the application of wood vinegar with a mean of 23.91cm until the last day before it was harvested with the height of 93.47cm. The untreated plants (no wood vinegar) on the other hand, had 20.28cm on the initial determination and recorded a final height of 87.51cm.

Variations on plant height of the plants could be explained by the effects of pyroligneous acid which, according to Zhang (2013), prevents excessive nitrogen levels, the fact that nitrogen promotes plant growth which results to progressive increase in plant height. Also, differences in plant height of rice could be explained by the effects of wood vinegar because it is acidic in property and contains over 500 kinds of organic compounds, benefiting the growth of plant and increasing the resistance to diseases (Zhong, 2010). Likewise, Tsuzuki (2004) stated that application of pyroligneous acid promoted plant height, increased ear number and yield. Wood vinegar increases the plant height because it can accelerate plant growth and serves as plant growth

regulator (Payamara, 2011).

In relation to maturity of PSB Rc18 (from sowing to maturity), pyroligneous acid has no profound effect, since all treatments reached their hard dough stage at the same time and were harvested after 125 days of sowing.

Table 1. Summary table of the height of PSB Rc18 (cm) from the first to the last determination

Treatment	I	II	III	IV	V
T_1 (Control)	20.28c	42.08c	65.08b	79.03b	87.51c
T_2 (1:300 PA/H_20)	22.03b	44.30b	65.34b	85.59a	89.70bc
T_3 ((1:200 PA/H_20)	22.78ab	45.19ab	67.37a	87.46a	91.61ab
T_4 (1:100 PA/H20)	23.91a	46.39a	68.75a	89.35a	93.47a
CV =	2.5677340%	2.068074%	1.482198%	2.201044%	1.515143%

On the number of productive tillers, significant variation existed between plants supplied with 1% wood vinegar since they produced the most with 14.54, while the least was the unsupplied plants with 10.42.

Table 2. Mean comparison on tiller counts (productive)

Treatment	Mean	Rank
T1	10.4200c	4
T2	11.7100bc	3
T3	12.5867ab	2
T4	14.5467a	1

Means with the same letter are not significantly different at 5% level

As regards the non-productive tillers, plants supplied with the highest concentration (1% wood vinegar) produced the least number with only 0.83 which was significantly lower than that of the untreated plants with 1.42.

Table 3. Mean comparison on tiller counts (non-productive)

Treatment	Mean	Rank
T1	1.4200b	4
T2	1.1700b	3
T3	1.0033ab	2
T4	0.8367a	1

Means with the same letter are not significantly different at 5% level

On the length of flag leaf produced by the rice plants that serves as the major source of photosynthates for the use of panicles, the same trend was noted. Plants supplied with the highest level of wood vinegar exhibited significantly the longest with 34.42cm compared with the three other treatments which showed comparable differences on their length although slight variations occurred. Variations on the length of flag leaf could be due to the effect of the solution which, based on the report of Apai and Thong deethae (2001), can improve the soil quality, eliminate pests, accelerate plant growth, and act as a plant growth regulator or growth inhibitor.

Table 4. Mean comparison on the length of flag leaf

Treatment	Mean	Rank
T1	29.8467b	4
T2	30.7267b	3
T3	31.6433b	2
T4	34.4267a	1

Means with the same letter are not significantly different at 5% level

Production of panicles of the rice plant was also affected by the levels of wood vinegar used. Just like the other morphological characteristics previously measured, plants supplied with the highest level (1%) significantly produced the longest panicle with 24.08 compared with the untreated plants with only 20.03cm.

Table 5. Mean comparison on length of panicles

Treatment	Mean	Rank
T1	20.0367c	4
T2	22.5400bc	3
T3	24.0800ab	2
T4	24.6033a	1

Means with the same letter are not significantly different at 5% level

Wood vinegar has an outstanding effect not only on the growth of the rice plants but also on its yield (Table 6), because it can increase the plant height by preventing excessive nitrogen levels, the fact that nitrogen promotes plant growth which results to progressive increase in plant height (Zhang, 2013). Differences in plant height of sweet corn could be explained by the effects of wood vinegar because it is acidic in property and contains over 500 kinds of organic compounds, benefiting the growth of plant and increasing the resistance to diseases (Zhong, 2010). Likewise, the result conformed to the findings of Tsuzuki (2004) which stated that application of pyroligneous acid promoted plant height, increased ear number and yield. Wood vinegar increases the plant height because it can accelerate plant growth and serves as plant growth regulator (Payamara, 2011), and can contribute to the crops nutrient absorption and utilization, and promote germination and growth of crops, and increase yield.

The above statements of several authors who conducted studies on the effect of wood vinegar to various crops conformed to the results of this study considering that plants supplied with varying concentrations of this substance significantly differ in actual plot yield from that of untreated plants which produced the lowest yield of only 1786 grams while plants supplied with 1%, 0.5% and 0.33% recorded higher yield of 2996 grams, 2744.33 grams and 2211.67 grams, respectively (Table 6).

Table 6. Mean comparison on actual plot yield (gram)

Treatment	Mean	Rank
T1	1786.00d	4
T2	2211.67c	3
T3	2744.33b	2
T4	2996.00a	1

Means with the same letter are not significantly different at 5% level

Considering that corrected plot yield is directly correlated to the actual plot yield, it is therefore imperative that plants with the highest actual plot yield had also the highest corrected plot yield and vice versa.

Plants supplied with 1% wood vinegar had 3948.40grams followed by the three other treatments in descending order (Table 7). Again, variations were significant.

Table 7. Mean comparison on corrected plot yield

Treatment	Mean	Rank
T1	2353.93d	4
T2	2914.97c	3
T3	3617.03b	2
T4	3948.40a	1

Means with the same letter are not significantly different at 5% level

On the grain yield per hectare of PSB Rc18 rice (Table 8), the same trend with that of the actual and corrected plot yields were noted since these three parameters are interrelated. Again, significant differences in yield per hectare were noted between treatments with plants supplied with 1% wood vinegar garnering the highest with 4.34 tons, while plants with 0.5% and 0.33% has 3.97 and 3.20 tons per hectare, respectively. Untreated plants produced the least with only 2.58 tons of grains.

Table 8. Mean comparison on grain yield per hectare (kg)

Treatment	Mean	Rank
T1	2589.3d	4
T2	3206.54c	3
T3	3978.7b	2
T4	4343.6a	1

Means with the same letter are not significantly different at 5% level

In terms of net income per hectare and return on investment (ROI) (Tables 9 &10), considering that it is directly interrelated to the yield, it is therefore logical that plants having the highest yield (1% wood vinegar) got the highest net income per hectare and return on investment with PhP87653.00 and 206.36%, while the untreated plants got the lowest with a net income of only PhP38934.00 and ROI of 100.8%.

Table 9. Cost of Production for One (1) Hectare Irrigated Rice (PSB Rc18) Applied with Varying Levels of Wood Vinegar (Pyroligneous Acid)

Item/Activities	**Man-day (PhP250/d)**	**T_1 (Control)**	**T_2 (1:300) PA&H_2O**	**T_3 (1:200) PA&H_2O**	**T_4 (1:100) PA&H_2O**
A. Operational Cost					
1. Land preparation	(Contract basis from 1st plowing to final levelling of the field)	6000.00	6000.00	6000.00	6000.00
2. Seedbed preparation	1	250.00	250.00	250.00	250.00
3. Seed soaking, incubation and sowing	1	250.00	250.00	250.00	250.00
4. Application of Vermicast	5	1250.00	1250.00	1250.00	1250.00
5. Marking of the area	1	250.00	250.00	250.00	250.00
6. Pulling of seedlings	6	1500.00	1500.00	1500.00	1500.00
7. Transplanting of seedlings	12	3000.00	3000.00	3000.00	3000.00
8. Application of PA	9	-0-	2250.00	2250.00	2250.00
9. Care of the crop	10	2500.00	2500.00	2500.00	2500.00
10. Harvesting	10	2500.00	2500.00	2500.00	2500.00
11. Postharvest activities	8	2000.00	2000.00	2000.00	2000.00
Sub-Total	**63**	**13500.00**	**15750.00**	**15750.0**	**15750.00**
B. Inputs					
1. Seeds (60 kg @ P1250/40kg bag)		1875.00	1875.00	1875.00	1875.00
2. Vermicast (2000kg @ 10/kg)		20000.00	20000.00	20000.0	20000.00
3. Wood vinegar (100/L)		-0-	450.00 (4.5L)	650.00 (6.5L)	1300.00 (13L)
Sub-total		**21875.00**	**22235.00**	**22525.0**	**23175.00**
C. Other Materials					
1. Container (12/pc)		720.00 (60 pcs)	840.00 (70 pcs)	1020.00 (85 pcs	1080.00 (90 pcs)
2. Plastic straw		150.00	150.00	150.00	150.00
Sub-total		**870.00**	**990.00**	**1170.00**	**1230.00**
D. Incidental Expenses					
1. Meals, snacks, etc.		2500.00	2500.00	2500.00	2500.00
Sub-total		**2500.00**	**2500.00**	**2500.00**	**2500.00**
Total Cost of Production		**38,745.00**	**41475.00**	**41945.0**	**42655.00**

Rate/man-day = PhP250.00

Table 10. Summary Table on Cost and Return Analysis for One (1) Hectare Irrigated Rice (PSB Rc18) Applied with Varying Levels of Wood Vinegar (Pyroligneous Acid)

Item	T reatment			
	T_1 (Control)	T_2 (1:300- PA & H_20)	T_3 (1:200- PA & H_20)	T_4 (1:100-PA & H_20)
A. Operational Cost	13500.00	15750.00	15750.0	15750.00
B. Inputs	21875.00	22235.00	22525.0	23175.00
C. Other Materials	750.00	750.00	870.00	1050.00
D. Incidental Expenses	2500.00	2500.00	2500.00	2500.00
Total Cost of Production	**38,625.00**	**41235.00**	**41645.0**	**42475.00**
Yield per Hectare (Kg)	**2589.30**	**3206.54**	**3978.70**	**4343.60**
Price Per Kg (PhP)	**30.00**	**30.00**	**30.00**	**30.00**
Gross Income (PhP)	**77679.00**	**96196.20**	**119361.00**	**130308.00**
Net Income	**38934.00**	**49721.20**	**77416.00**	**87653.00**
Return on Investment (%)	**100.8**	**120.58**	**185.89**	**206.36**

With regard to lodging incidence of PSB Rc18 as affected by wood vinegar, it could be noted that all plants were resistant regardless of treatments considering that all plants were standing from transplanting until it reached the mature grain stage and the harvesting time. In terms of reaction to pests and diseases, PhilRice (2003), described that the PSB Rc18 (Ala) variety is moderately susceptible to stem borer, intermediate reaction to blast, bacterial leaf blight, tungro, brown planthopper and green leafhopper (Tables 11-15).

Results of the study found out that wood vinegar not only improves soil quality, accelerates plant growth, and acts as a plant growth regulator or growth inhibitor but also eliminates pests which relates to the study of Apai and Thong deethae (2001). Likewise, it is used for the control of microbes such as bacterial and fungal diseases of various crop plants as revealed by the study of SeoRahhakrishnan, et al. (2002).

Sadakichi, Kishimito and Hirowaka Tsuyoshi, in their article entitled "Wood Vinegar and Biochar in Agriculture: How to Improve Crop Quality While Reducing Dependence on Agricultural Chemicals," stated the multiple beneficial effects of wood vinegar including the ability to control diseases and pests, to increase microbes, and to facilitate root growth.

Likewise, they stated that if wood vinegar were to be compared to medicine, it could be called a "herbal medicine".

Wood vinegar contains a small amount of nutrients directly taken by the plants. It also contains very few elements that cause bactericidal and anthelmintic effect. When it is correctly applied, it enhances the intake of fertilizers and reduces the damages by various diseases. Wood vinegar enhances rooting, regulating the nutrients condition of the soil and balancing the microbiological population. The changes in the microbiological population not only greatly reduce the tendency of soil borne diseases but also increase the vitality of the roots and hence, enable better uptake of nutrients (Leong, 2011).

The above cited results of the studies conducted could be the possible reasons why the rice plants (PSB Rc18) sprayed with varying levels of wood vinegar showed resistance to pests and diseases observed.

Table 11. Mean comparison on the reaction to Rice bug of PSB Rc18 applied with PA

Treatment	Mean	Rank
T1	5.0833a	4
T2	2.0833b	3
T3	1.5833b	2
T4	1.3333b	1

Means with the same letter are not significantly different at 5% level

Table 12. Mean comparison on field rating for rice stemborers (%deadhearts)

Treatment	Mean	Rank
T1	12.433a	4
T2	7.300ab	3
T3	6.367b	2
T4	5.967b	1

Means with the same letter are not significantly different at 5% level

Table 13. Mean comparison on reaction to stemborers (whiteheads)

Treatment	Mean	Rank
T1	8.8000a	4
T2	5.0000b	3
T3	4.4667bc	2
T4	4.0333c	1

Means with the same letter are not significantly different at 5% level

Table 14. Mean comparison on field rating for stemborers (whiteheads)

Treatment	Mean	Rank
T1	2.3333a	4
T2	1.5000b	3
T3	1.4333b	2
T4	1.3333b	1

Means with the same letter are not significantly different at 5% level

Table 15. Mean comparison on BLB Disease

Treatment	Mean	Rank
T1	2.2500a	4
T2	1.4667b	3
T3	1.4667b	2
T4	1.1000b	1

Means with the same letter are not significantly different at 5% level

Conclusion

Based on the result of the research, it is concluded that 1% dilution of wood vinegar (PA) could be an alternative vegetative growth enhancers and yield booster of irrigated rice (PSB Rc18) and can suppress pests and diseases of rice if sprayed to the plants and into the soils once every two weeks.

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Appendix Tables

Table 1. 1. Plant height one week after application of Wood Vinegar (cm)

Treatment	REPLICATION 1	2	3	Total	Mean	Rank
1	20.10	20.21	20.53	60.84	20.28	4
2	21.56	22.34	22.19	66.09	22.03	3
3	22.94	22.89	22.53	68.36	22.79	2
4	24.70	22.96	24.08	71.74	23.91	1
Rep Total	89.30	88.40	89.33			
Grand Total				267.03		
Grand Mean					89.01	

Table 1.1a. Analysis of variance on plant height one week after the application of WV

SV	DF	SS	MS	Fc	Prob>F
Replication	2	0.13965000	0.06982500	0.21	0.8133ns
Treatment	3	20.95189167	6.98396389	21.40	
Error	6	1.95828333	0.32638056		
Total	11	23.04982500			

CV – 2.5677340% ns – not significant * - significant

Table 1.2. Plant height one (1) month after application of Wood Vinegar (cm)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	40.08	44.40	41.76	126.24	42.08	4
2	43.85	45.09	43.96	132.90	44.30	3
3	44.88	45.34	45.35	135.57	45.19	2
4	46.20	46.89	46.08	139.17	46.39	1
Rep Total	175.01	181.72	177.15			
Grand Total				533.88		
Grand Mean					177.96	

Table1.2a. Analysis of variance on plant height one month after application of PA

SV	DF	SS	MS	Fc	Prob>F
Replication	2	5.87405000	2.93702500	3.47	0.0997
Treatment	3	29.83260000	9.94420000	11.75	0.0064
Error	6	5.07935000	0.84655833		
Total	11	40.78600000			

CV – 2.068074% ns – not significant * - significant

Table 1.3. Plant height two (2) months after the application of Wood Vinegar (cm)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	64.91	65.99	64.36	195.26	65.09	4
2	65.03	66.11	64.89	196.03	65.34	3
3	67.53	69.34	65.25	202.12	67.37	2
4	69	71.23	66.03	206.26	68.75	1
Rep Total	266.47	272.67	260.53			
Grand Total				799.67		
Grand Mean					266.56	

Table 1.3a. Analysis of variance on plant height two months after application of WV

SV	DF	SS	MS	Fc	Prob>F
Replication	2	18.42526667	9.21263333	9.44	0.0140
Treatment	3	27.29442500	9.09814167	9.33	0.0112
Error	6	5.85360000	0.97560000		
Total	11	51.57329167			

CV – 1.482198% ns – not significant * - significant

Table 1.4. Plant height three (3) months after application of Wood Vinegar (cm)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	79.39	77.21	80.51	237.11	79.04	4
2	83.81	82.67	90.31	256.79	85.60	3
3	84.63	87.25	90.51	262.39	87.46	2
4	85.48	88.61	93.98	268.07	89.36	1
Rep Total	333.31	335.74	355.31			
Grand Total				1024.36		
Grand Mean					341.45	

Table 1.4a. Analysis of variance on plant height three months after application of PA

SV	DF	SS	MS	Fc	Prob>F
Replication	2	72.7408167	36.3704083	10.30	0.0115
Treatment	3	181.3136000	60.4378667	17.12	0.0124
Error	6	21.1812500	3.5302083		
Total	11	275.2356667			

CV – 2.201044% ns – not significant * - significant

Tabble 1.5. Plant height a day before harvesting the crop (cm)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	86.03	87.63	88.88	262.54	87.51	4
2	88.74	89.38	91	269.12	89.71	3
3	92	90.94	91.89	274.83	91.61	2
4	95.51	91.63	93.29	280.43	93.48	1
Rep Total	362.28	359.58	365.06			
Grand Total				1086.92		
Grand Mean					362.31	

Table 1.5a. Analysis of variance on plant height a day before harvesting the crop

SV	DF	SS	MS	Fc	Prob>F
Replication	2	3.75406667	1.87703333	1.00	0.4229
Treatment	3	58.85606667	19.61868889	10.42	0.0086
Error	6	11.30033333	1.88338889		
Total	11	73.91046667			

CV – 1.515143% ns – not significant * - significant

Table 2. Tiller Counts (Productive)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	9.38	10.13	11.75	31.26	10.42	4
2	11.50	11.63	12	35.13	11.71	3
3	13	12.13	12.63	37.76	12.59	2
4	15.13	12.38	16.13	43.64	14.54	1
Rep Total	49.01	46.27	52.51			
Grand Total				144.79		
Grand Mean					49.26	

Table 2a. Analysis of variance on tiller counts (productive)

SV	DF	SS	MS	Fc	Prob>F
Replication	2	4.89126667	2.44563333	2.41	0.1710
Treatment	3	27.03355833	9.01118611	8.86	0.0127
Error	6	6.10086667	1.01681111		
Total	11	38.02569167			

CV – 8.187595% ns – not significant * - significant

Table 3. Tiller Counts (Non-productive)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	1.88	1.25	1.13	4.26	1.42	4
2	1.38	1.13	1	3.51	1.17	3
3	1.13	1.13	0.75	3.01	1.00	2
4	0.88	1	0.63	2.51	0.84	1
Rep Total	5.27	4.51	3.51			
Grand Total				13.29		
Grand Mean					1.11	

Table 3a. Analysis of variance on tiller counts (non-productive)

SV	DF	SS	MS	Fc	Prob>F
Replication	2	0.38960000	0.19480000	6.60	0.0305
Treatment	3	0.55729167	0.18576389	6.29	0.0278
Error	6	0.17713333	0.02952222		
Total	11	1.12402500			

CV – 15.51425% ns – not significant * - significant

Table 4. Length of panicle (cm)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	20.98	23.75	21.38	66.11	20.04	4
2	21.09	23.83	22.70	67.62	22.54	3
3	23.88	24.31	24.05	72.24	24.08	2
4	24.75	25	24.06	73.81	24.60	1
Rep Total	90.70	96.89	92.19			
Grand Total				279.78		
Grand Mean					93.26	

Table 4a. Analysis of variance on length of panicles

SV	DF	SS	MS	Fc	Prob>F
Replication	2	5.21885000	2.60942500	4.32	0.0688
Treatment	3	13.43936667	4.47978889	7.42	0.0192
Error	6	3.62448333	0.60408056		
Total	11	22.28270000			

CV – 3.333589% ns – not significant * - significant

Table 5. Length of flag leaf (cm)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	28.14	31.00	30.40	89.54	29.85	4
2	31	30.00	31.18	92.18	30.73	3
3	31.38	31.66	31.89	94.93	31.64	2
4	35	33.63	34.65	103.28	34.43	1
Rep Total	125.52	126.29	128.12			
Grand Total				3040.3		
Grand Mean					1013.43	

Table 5a. Analysis of variance on the length of flag leaf

SV	DF	SS	MS	Fc	Prob>F
Replication	2	0.89181667	0.44590833	0.48	0.6423
Treatment	3	35.44202500	11.81400833	12.64	0.0053
Error	6	5.60925000	0.93487500		
Total	11	41.94309167			

CV – 3.053897% ns – not significant * - significant

Table 6. Actual Plot Yield (g)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	1875	1750	1733	5358	1786	4
2	2150	2235	2250	6635	2211.7	3
3	2650	2733	2850	8233	2744.3	2
4	2995	2883	3110	8988	2996	1
Rep Total	9670	9601	9943			
Grand Total				29214		
Grand Mean					2434.5	

Table 6a. Analysis of Variance on Actual Plot Yield

SV	DF	SS	MS	Fc	Prob>F
Replication	2	16354.500	8177.250	0.03	0.4113
Treatment	3	2644457.667	881485.889	111.47	<.0001
Error	6	47446.833	7907.806		
Total	11	2708259.000			

CV – 3.652735% ns – not significant * - significant

Table 7. Corrected Plot Yield (g)

	REPLICATION				
Treatment	1	2	3	Total	Mean
1	2471.2	2306.5	2284.1	7061.8	2353.9
2	2833.7	2945.7	2965.5	8744.9	2914.0
3	3492.7	3602.1	3756.3	10851.1	3617.0
4	3947.4	3799.8	4098.0	11845.2	3948.4
Rep Total	12745	12654.1	13103.9		
Grand Total				38503	
Grand Mean					3208.6

Table 7a. Analysis of variance on corrected plot yield

SV	DF	SS	MS	Fc	Prob>F
Replication	2	28282.672	14141.336	1.03	0.4120
Treatment	3	4592392.417	1530797.472	111.69	<.0001
Error	6	82237.948	13706.325		
Total	11	4702913.037			

CV – 3.648776% ns – not significant * - significant

Table 8. Grain yield per hectare (Kg)

	REPLICATION				
Treatment	1	2	3	Total	Mean
1	2718.4	2512.5	2537.1	7768	2589.3
2	3117.1	3240.3	3262.0	9619.4	3206.5
3	3841.9	4131.9	3962.3	11936.1	3978.7
4	4342.1	4179.7	4508.9	13030.7	4343.6
Rep Total	14019.5	14064.4	14270.3		
Grand Total				42354.2	
Grand Mean					3529.5

Table 8a. Analysis of variance on grain yield per hectare

SV	DF	SS	MS	Fc	Prob>F
Replication	2	8942.622	4471.311	0.21	0.8130
Treatment	3	5558247.217	1852749.072	88.79	<.0001
Error	6	125205.298	20867.550		
Total	11	5692395.137			

CV – 4.092800% ns – not significant * - significant

Table 11. Reaction to Rice Bug Damage of PSB Rc18 Applied with PA (%)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	5	4.5	5.75	15.25	5.083	4
2	2.5	2	1.75	6.25	2.083	3
3	1.25	2	1.5	4.75	1.583	2
4	1.25	1.5	1.25	4	1.333	1
Rep Total	10	10	10.25			
Grand Total				30.25		
Grand Mean					10.07	

Table 11a. Analysis of variance on the reaction to rice bug of PSB Rc18 applied with PA

SV	DF	SS	MS	Fc	Prob>F
Replication	2	0.01041667	0.00520833	0.02	0.9781
Treatment	3	27.14062500	9.04687500	36.60	0.0003
Error	6	1.4062500	0.23437500		
Total	11	28.55729167			

CV – ns – not significant * - significant

Table 12. Field Rating to Rice Stemborers of PSB Rc18 Applied with PA (% Deadhearts)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	8.5	13.8	15	37.3	12.43	4
2	8	6.9	7	21.9	7.3	3
3	9.2	5	4.9	19.1	6.37	2
4	7.5	6	4.4	17.9	5.97	1
Rep Total	33.2	31.7	31.3			
Grand Total				96.2		
Grand Mean					32.07	

Table 12a. Analysis of Variance on field rating to rice stemborers (%deadhearts)

SV	DF	SS	MS	Fc	Prob>F
Replication	2	0.50166667	0.25083333	0.04	0.9642
Treatment	3	80.83666667	26.94555556	3.94	0.0721
Error	6	41.0183333			
Total	11	122.3566667			

CV – % ns – not significant * - significant

Table 13. Field Rating for Rice Stemborers of PSB Rc18 Applied with PA (% Whiteheads)

	REPLICATION					
Treatment	1	2	3	Total	Mean	Rank
1	9	8.6	8.8	26.4	8.8	4
2	5.2	4.8	5	15	5.0	3
3	5	4.6	3.8	13.4	4.47	2
4	4.5	3.9	3.7	12.1	4.03	1
Rep Total	23.7	21.9	21.3			
Grand Total				66.9		
Grand Mean					22.3	

Table 13a. Analysis of Variance on field rating to rice stemborers (%whiteheads)

SV	DF	SS	MS	Fc	Prob>F
Replication	2	0.78000000	0.39000000	4.94	0.0539
Treatment	3	43.00916667	14.33638889	181.73	.0001
Error	6	0.47333333			
Total	11	44.26250000			

CV – 5.04% ns – not significant * - significant

Table 14. Reaction to Rice Blast Disease

Treatment	REPLICATION 1	2	3	Total	Mean	Rank
1	2.5	2	2.5	7.0	2.33	4
2	1.8	1.5	1.2	4.5	1.5	3
3	1.4	1.6	1.3	4.3	1.43	2
4	1.5	1.3	1.2	4	1.33	1
Rep Total	7.2	6.4	6.2			
Grand Total				19.8		
Grand Mean					6.59	

Table 14a. Analysis of Variance on reaction to Rice Blast Disease

SV	DF	SS	MS	Fc	Prob>F
Replication	2	0.14000000	0.07000000	1.40	0.3170
Treatment	3	1.91000000	0.63666667	12.73	0.0052
Error	6	0.30000000			
Total	11	2.35000000			

CV – % ns – not significant * - significant

Table 15. Reaction to Bacterial Leaf Blight Disease

Treatment	REPLICATION 1	2	3	Total	Mean	Rank
1	2.75	2	2	6.75	2.25	4
2	1.7	1.5	1.2	4.4	1.47	3
3	1.5	1.6	1.3	4.4	1.47	2
4	1	1.3	1.4	3.7	1.23	1
Rep Total	6.95	6.4	5.9			
Grand Total				19.25		
Grand Mean					6.42	

Table 15a. Analysis of Variance on reaction to Bacterial Leaf Blight Disease

SV	DF	SS	MS	Fc	Prob>F
Replication	2	0.26791667	0.13395833	2.36	0.1752
Treatment	3	2.11395833	0.70465278	12.42	0.0055
Error	6	0.34041667			
Total	11	2.72229167			

CV – % ns – not significant * - significant