UNIVERSITI MALAYA

SOILS: WHERE FOOD BEGINS

# EFFECTS OF SOIL AMENDMENTS ON GROWTH AND PROTEIN GENERATION OF PADDY GROWN ON ACID SULFATE SOIL

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# ACID SULFATE SOIL

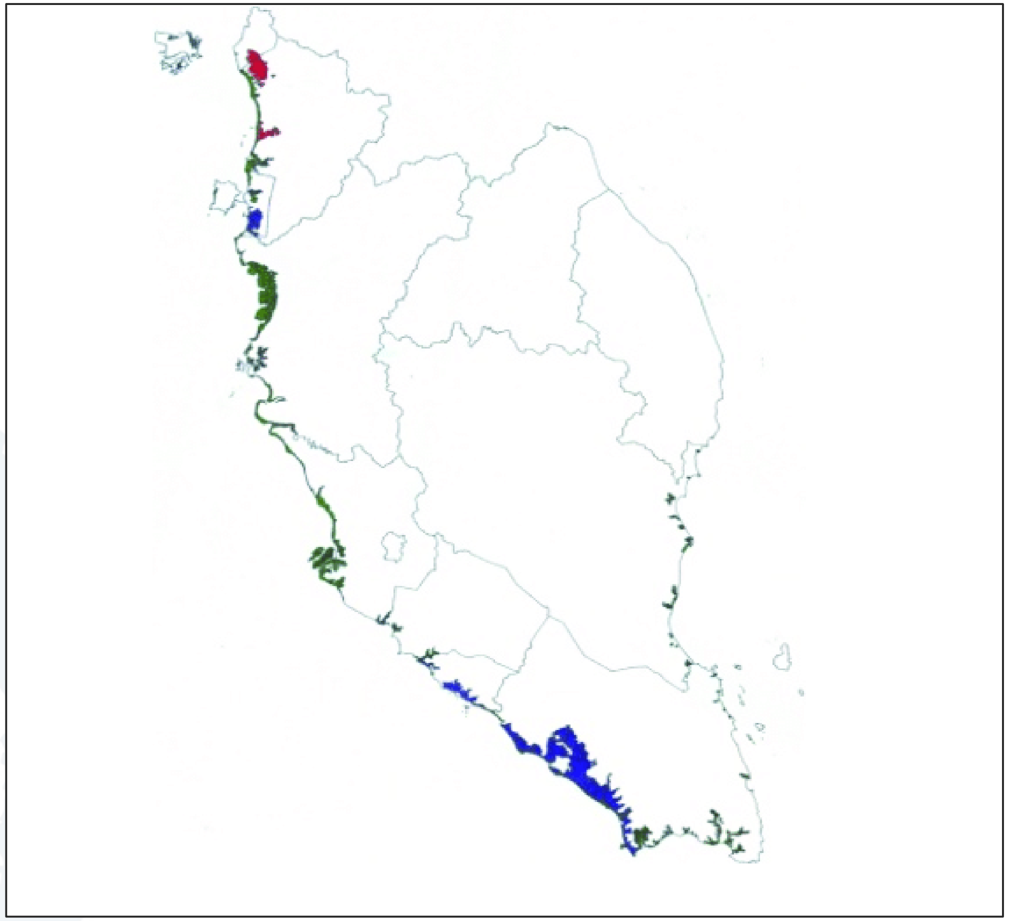
- In Malaysia, acid sulfate soil was estimated to cover about 0.5 million ha area with 110000 ha in the Peninsular Malaysia.

- Around 20,000 ha were being used for rice cultivation in Peninsular Malaysia.

- The rice yield each season is very low (< 2 t/ha)

- Due to food security and its economic importance, rice production should be increased significantly because of the population is increasing rapidly

- Acid sulfate soils are normally not suitable for crop production unless they are properly ameliorated.



Distribution of acid sulfate soil in Peninsular Malaysia (Shamshuddin et al, 2017)

# Constraints of acid sulfate soil for rice cultivation

- The soil is characterized by the presence of pyrite ($FeS_2$), which upon oxidation results in the production of high amount of acidity (pH <3.5)
- The presence of excess amounts of Al and Fe in the soils which significantly affect rice growth

Iron toxicity

# SOIL ADMENDMENTS

- Organic or inorganic material as long as it can improve soil fertility
- The application of these amendments can increase the soil pH, cation exchange capacity (CEC) (Liang *et al.*,2006)
- Improved water holding capacity and improved soil structure (Cornelissen *et al.*, 2013)
- Organic matter can remove Al from solution in acid sulfate soils chelation (Muhrizal et al. 2003)

Alleviation of acid sulfate soil

- Liming raises soil pH so as to precipitate Al as inert Alhydroxides, thereby reducing its toxicity (Shamshuddin et al. 2010)
- Ground basalt application can ameliorate acidic soils that lead to yield increase (Shamshuddin & Fauziah 2010).
- Compost (Manickam T. *et al.,* 2015)
- Biochar (Chau *et al.,* 2010)

Basalt

Compost

Liming

Biochar

# PROTEOMIC

- Proteomics is described as quantitative analysis and comprehensive identification of protein expression in an organism, cell, tissue or organelle at a specific time under certain condition (Tan et al., 2013).

- The mechanisms to tolerate or alleviate Al toxicity can be understood by studying changes in gene or protein expression involved in Al toxicity tolerance in rice leaves.

- Currently, there is limited information available with regards of changes in protein expression in Al resistant plants.

- Hence, the study on the Al tolerant genes and proteins using by the 2D-PAGE technique that could be the pathway for the alleviation of Al toxicity for the rice growth promotion need to be undertaken.

# Objective

To investigate the effects of various types of soil amendments on plant growth, yield and physiological responses and protein generation on rice grown in extremely acidic conditions using ground magnesium limestone (GML), basalt, biochar and compost as soil amendments.

# Methodology

**SOIL AND GLASSHOUSE PREPARATION**

Soil collection

Treatment: Control, NPK, NPK +GML, NPK + Basalt, NPK + Biochar, NPK + compost

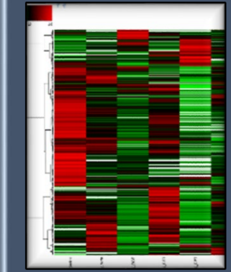
**PLANT GROWTH AND YIELD**

Growth Monitoring

Physiological parameter

Harvest Index

Crop yield



**PROTEOMIC STUDY**

Protein identification

Liquid Chromatography-tandem Mass Spectrometry

**Data Analysis**

- Analysis of Variance (ANOVA)
- Tukey 's Test
- Pearson's correlation

**Data Analysis**

Data Processing and Protein Profiling

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# RESULT

## Effects of soil amendments on soil pH and Growth Performance of Rice Plant

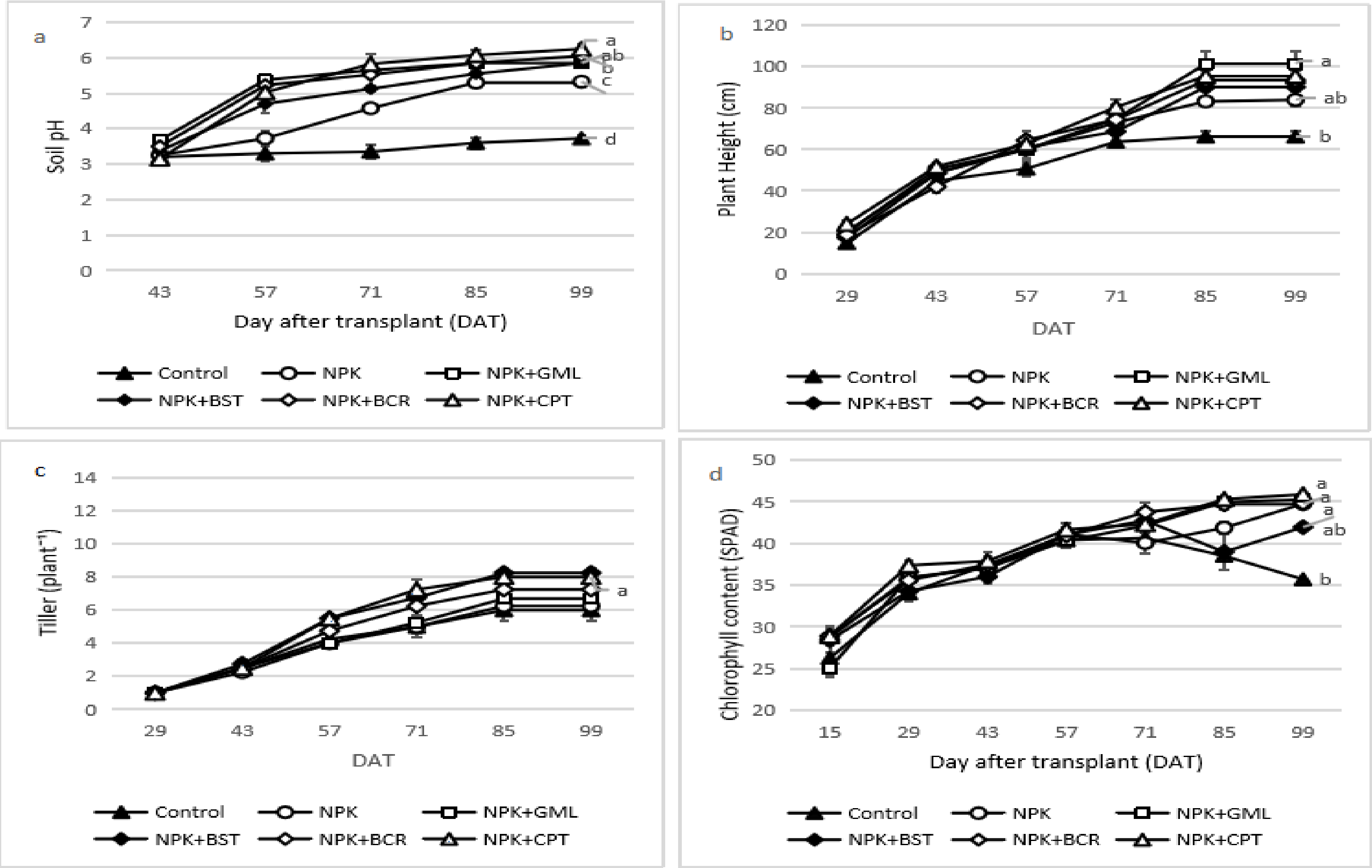



**Figure 1.** Effect of different amendments on (a) soil pH, (b) plant height, (c) tiller number and (d) chlorophyll content during the entire growth. Vertical bars indicate the standard errors of the means (n=4). Different letter indicates a significant different ($p<0.05$).

The application of soil amendments

- increased the soil pH from 3.7 to 6.2.
- Significantly higher growth performance compared to the control

# Effects of soil amendment on Physiological of Rice Plant.

## Physiological response of rice plant

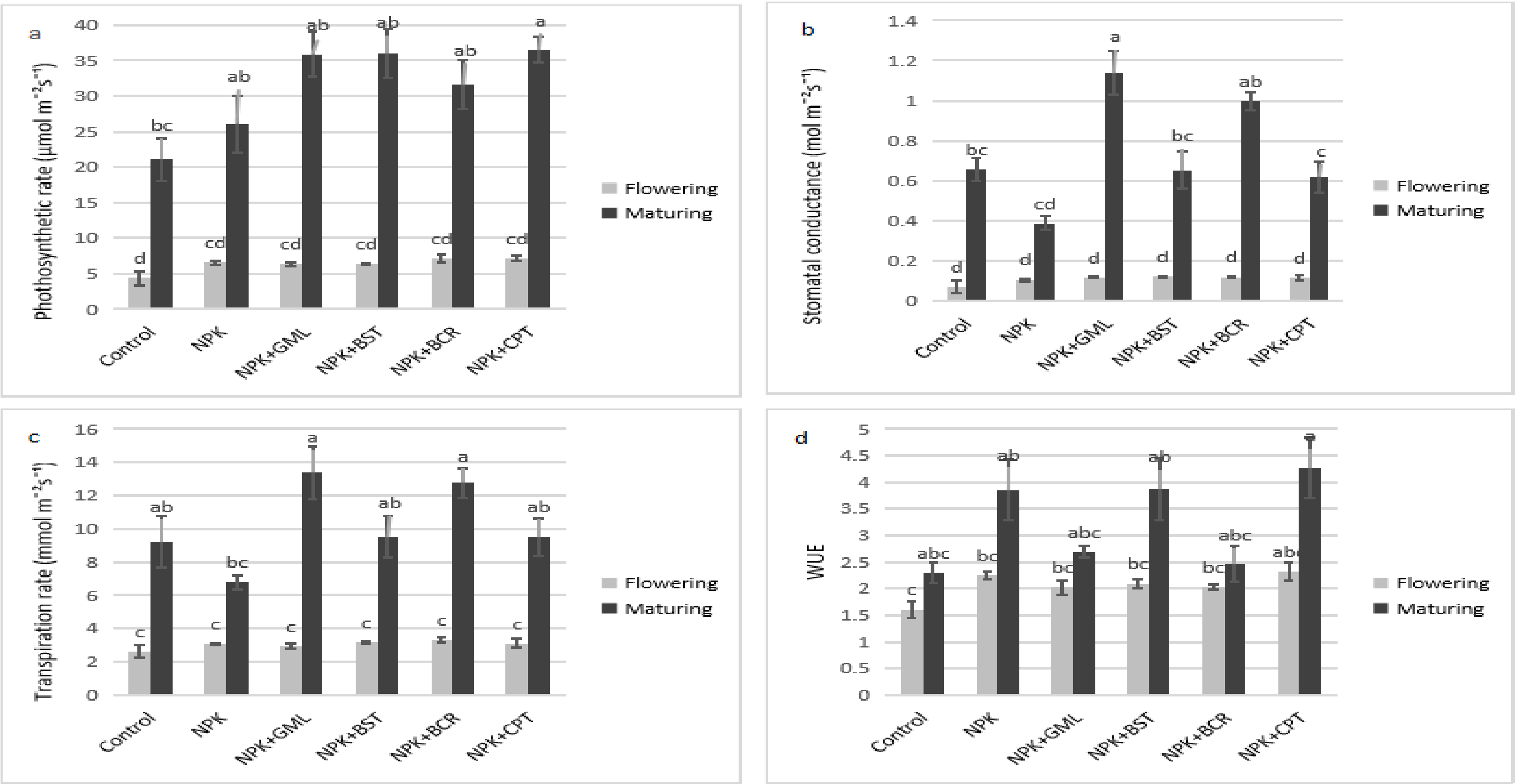



**Figure 2**. Figure indicates (a) Photosynthetic rate, (b) Stomatal conductance, (c) Transpiration rate and (d) Water use efficiency (WUE) at both flowering and maturing stage of rice plant. Each data represents the means of replicates and the vertical bar represent standard error of the mean (n=3). Different letter indicates a significant different ($p<0.05$).

# Effects of soil amendments on Physiological of Rice Plant.

## Correlation of plant physiology

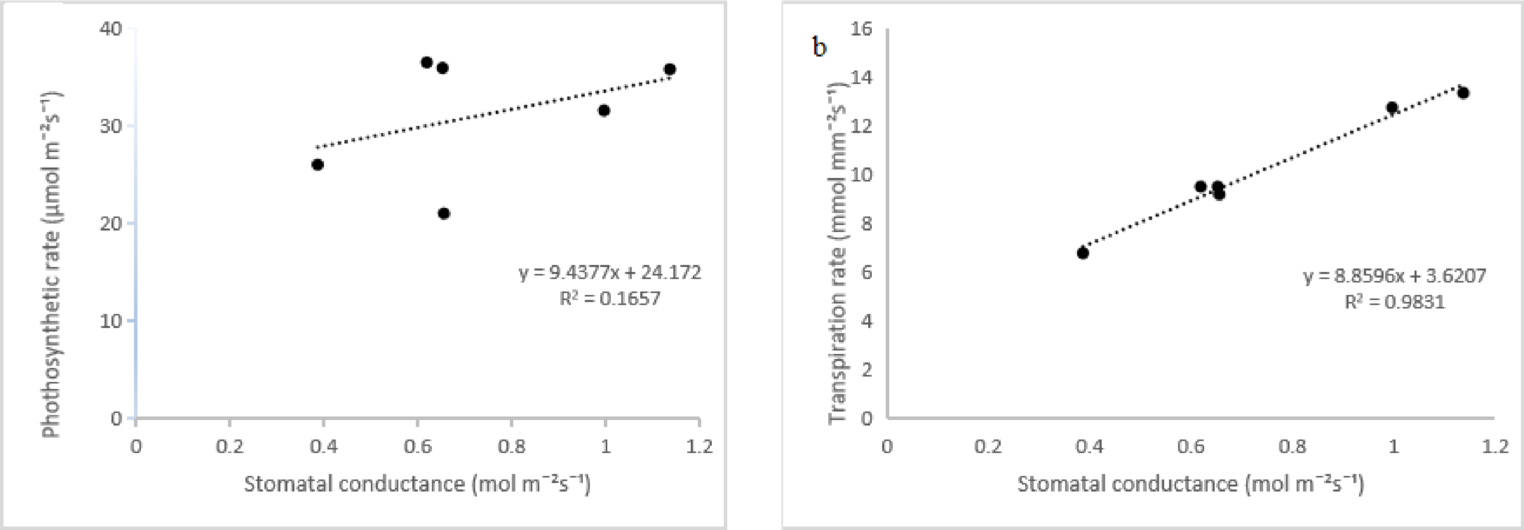



**Figure 3.** Correlations between photosynthetic rate (a) and transpiration (b) against stomatal conductance at maturing stage

| Parameter | A | $g_s$ | E | WUE |
|---|---|---|---|---|
| A | - | 0.869** | 0.893** | 0.668** |
| $g_s$ | | - | 0.980** | 0.274 |
| E | | | - | 0.297 |
| WUE | | | | - |

*p=0.05, **p=0.01.

**Table 1.** Relationship between physiological parameters in rice treatment using Pearson's correlation.

The results also showed that the photosynthetic rate, stomatal conductance, and transpiration rate are positively correlated with each other (Table 1).

Water use efficiency was only significantly correlated with stomatal conductance and transpiration rate when the stomata open, transpiration occurs, and water is released to the atmosphere.

High in WUE is a great indication as it has capability to cope with soil water deficit and holds exceptional promising to escalate both grain yield and WUE.

# Effects of soil amendment on Growth and Yield of Rice Plant at harvest

**Table 1.** Effect of soil amendment on growth of rice plant.

| Treatment | Plant height | Root length | Number of tillers | Number of panicles | Size of panicles |
|---|---|---|---|---|---|
| | cm | cm | plant$^{-1}$ | plant$^{-1}$ | cm |
| Control | 86.50±3$^{b}$ | 15.50±2$^{c}$ | 5±1$^{a}$ | 4±1$^{b}$ | 16.16±2$^{b}$ |
| NPK | 92.5±3$^{ab}$ | 17.50±1$^{b}$ | 4±1$^{a}$ | 6±2$^{ab}$ | 20.18±4$^{ab}$ |
| NPK+GML | 104.75±2$^{a}$ | 21.00±1$^{a}$ | 6±0$^{a}$ | 7±2$^{ab}$ | 18.16±4$^{ab}$ |
| NPK+BST | 93.25±2$^{ab}$ | 19.50±1$^{ab}$ | 7±2$^{a}$ | 7±1$^{ab}$ | 20.85±1$^{ab}$ |
| NPK+BCR | 99.75±2$^{ab}$ | 18.00±2$^{abc}$ | 7±2$^{a}$ | 8±1$^{ab}$ | 21.22±1$^{ab}$ |
| NPK+CPT | 95.50±4$^{ab}$ | 20.75±2$^{ab}$ | 8±1$^{a}$ | 8±1$^{a}$ | 22.19±2$^{a}$ |

**Table 2.** Effect of soil amendment on rice yield and its component.

| Treatment | Grain/ panicle | filled grain | 1000 grain weight | Aboveground biomass | Harvest Index |
|---|---|---|---|---|---|
| | | % | g | g | % |
| Control | 66.00±5$^{ab}$ | 59.69±10$^{ab}$ | 16.14±3$^{b}$ | 40.46±4$^{ab}$ | 35.01±5$^{a}$ |
| NPK | 83.00±4$^{ab}$ | 58.83±3$^{b}$ | 20.48±2$^{ab}$ | 33.75±5$^{b}$ | 42.05±6$^{a}$ |
| NPK+GML | 87.00±4.2$^{ab}$ | 67.10±4$^{ab}$ | 21.00±2.6$^{ab}$ | 53.10±4.2$^{a}$ | 47.08±4.8$^{a}$ |
| NPK+BST | 104.00±2$^{ab}$ | 65.52±3.6$^{ab}$ | 19.43±2$^{ab}$ | 47.17±3$^{ab}$ | 70.25±6$^{a}$ |
| NPK+BCR | 64.00±3.1$^{b}$ | 57.54±3$^{b}$ | 19.42±1$^{ab}$ | 45.10±2$^{ab}$ | 55.62±4.5$^{a}$ |
| NPK+CPT | 121.00±5.4$^{a}$ | 83.40±$^{a}$ | 23.30±$^{a}$ | 44.54±$^{ab}$ | 88.71±$^{a}$ |

- The grain yield was attributed by number of grain per panicle, percentage of filled grain, grain weight density, aboveground biomass and harvest index (Wei et al., 2011).
- The application of compost alone gives the highest reading in percentage of filled grain, 1000 grain weight, grain number per panicle, and harvest index.

# Identification of Protein in Rice Plant Sample from Glasshouse study.

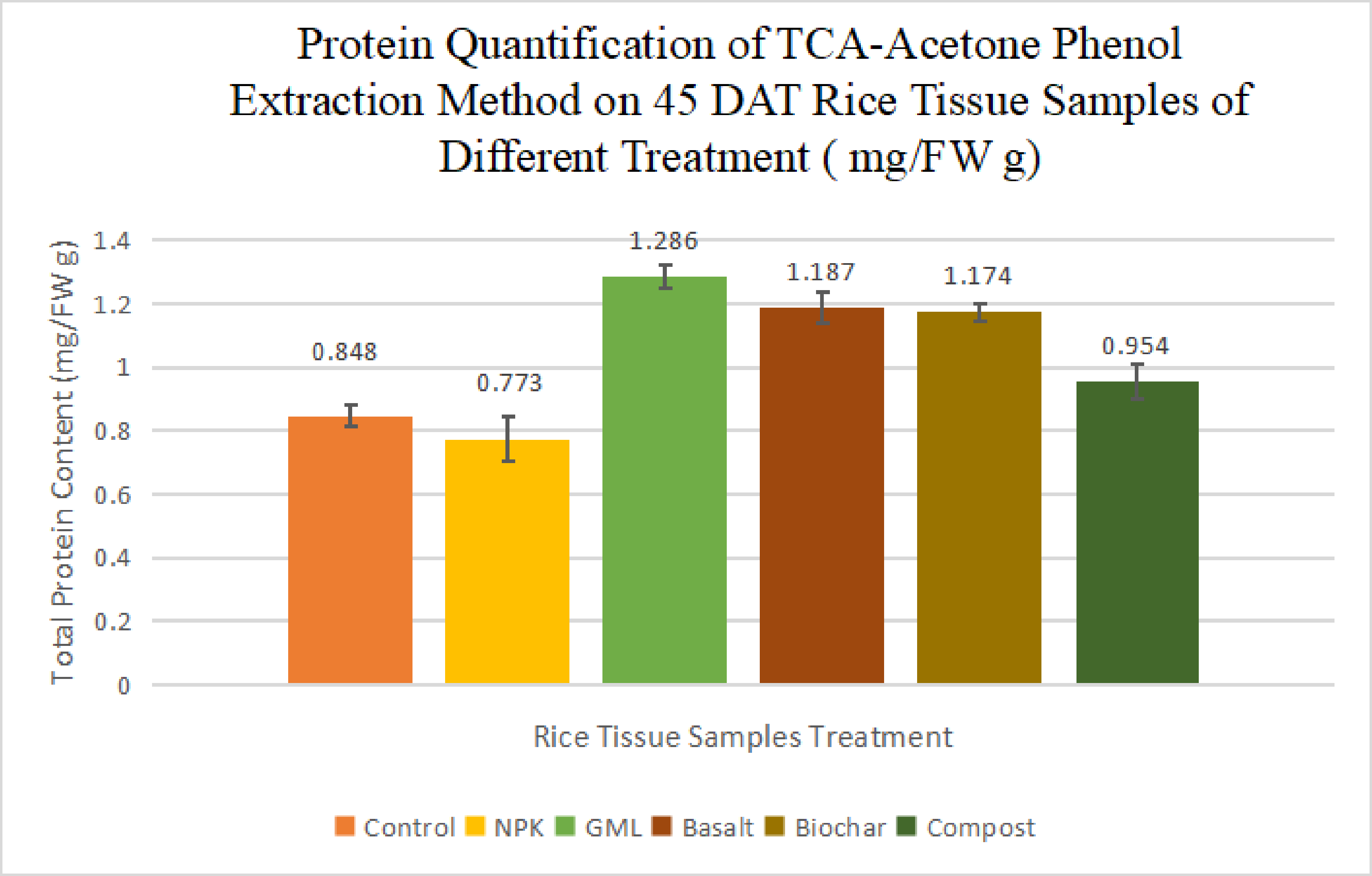
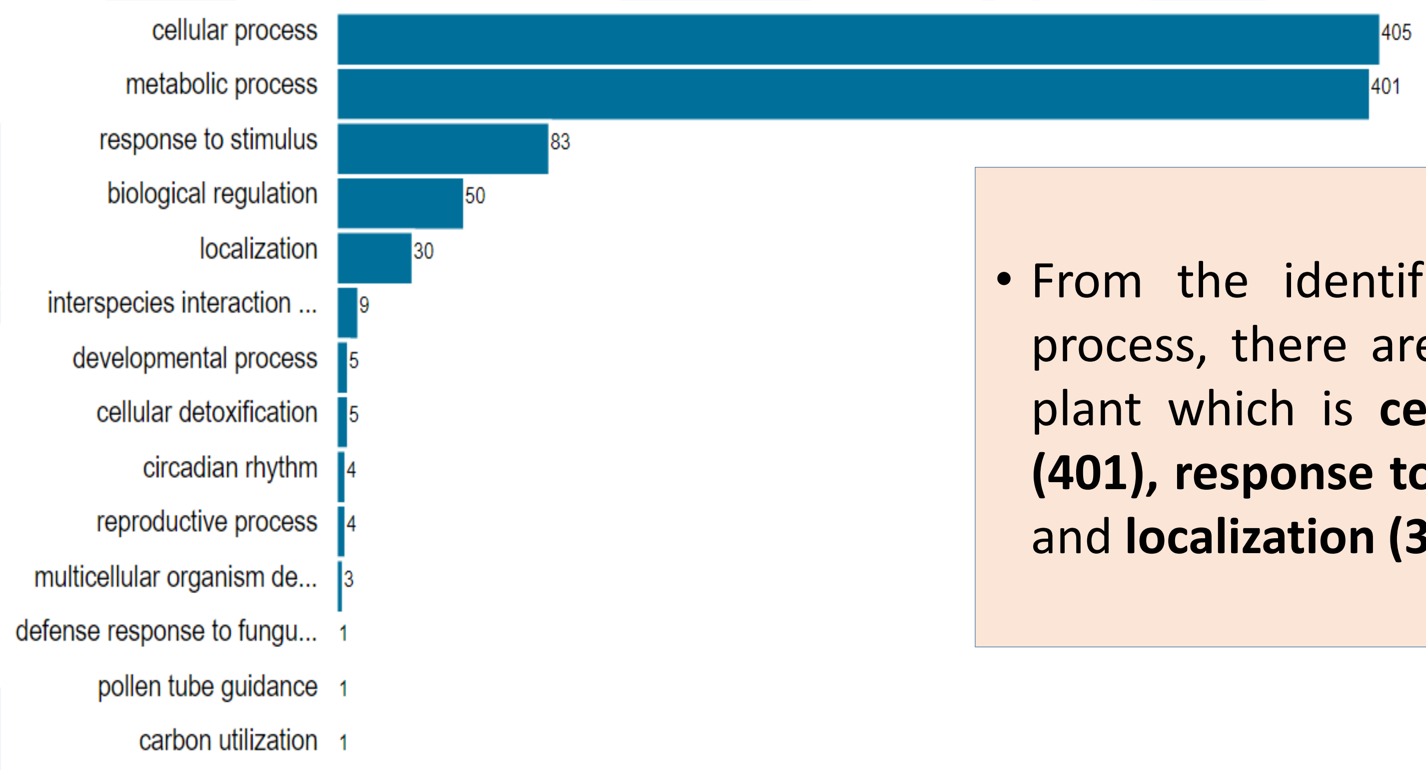





**Figure 4.** Total protein content in different rice tissue samples with different treatment. Mean values with different letters are significantly different at $p < 0.05$.

# List of process and number of proteins involved in biological process of rice plant protein samples




- From the identified 485 protein involved in biological process, there are **five main processes** take place in the plant which is **cellular process (405), metabolic process (401), response to stimulus (83)**, **biological regulation (50)** and **localization (30)**

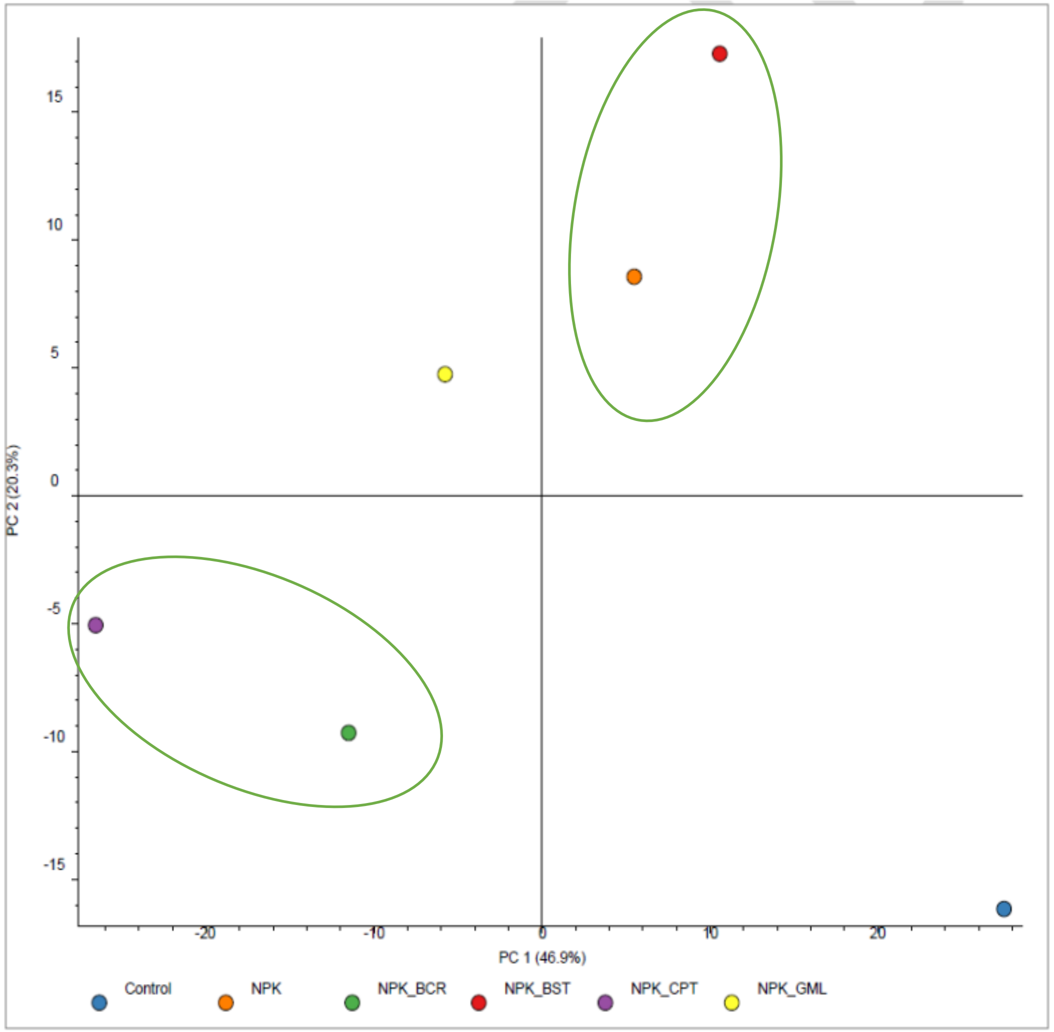
**Figure 5.** List of process and number of proteins involved in biological process of rice plant protein samples in this research. Data from UniProt.org, 2021.

## Principle Component Analysis (PCA) based on the unique genes differentially expressed demonstrated by treatment samples

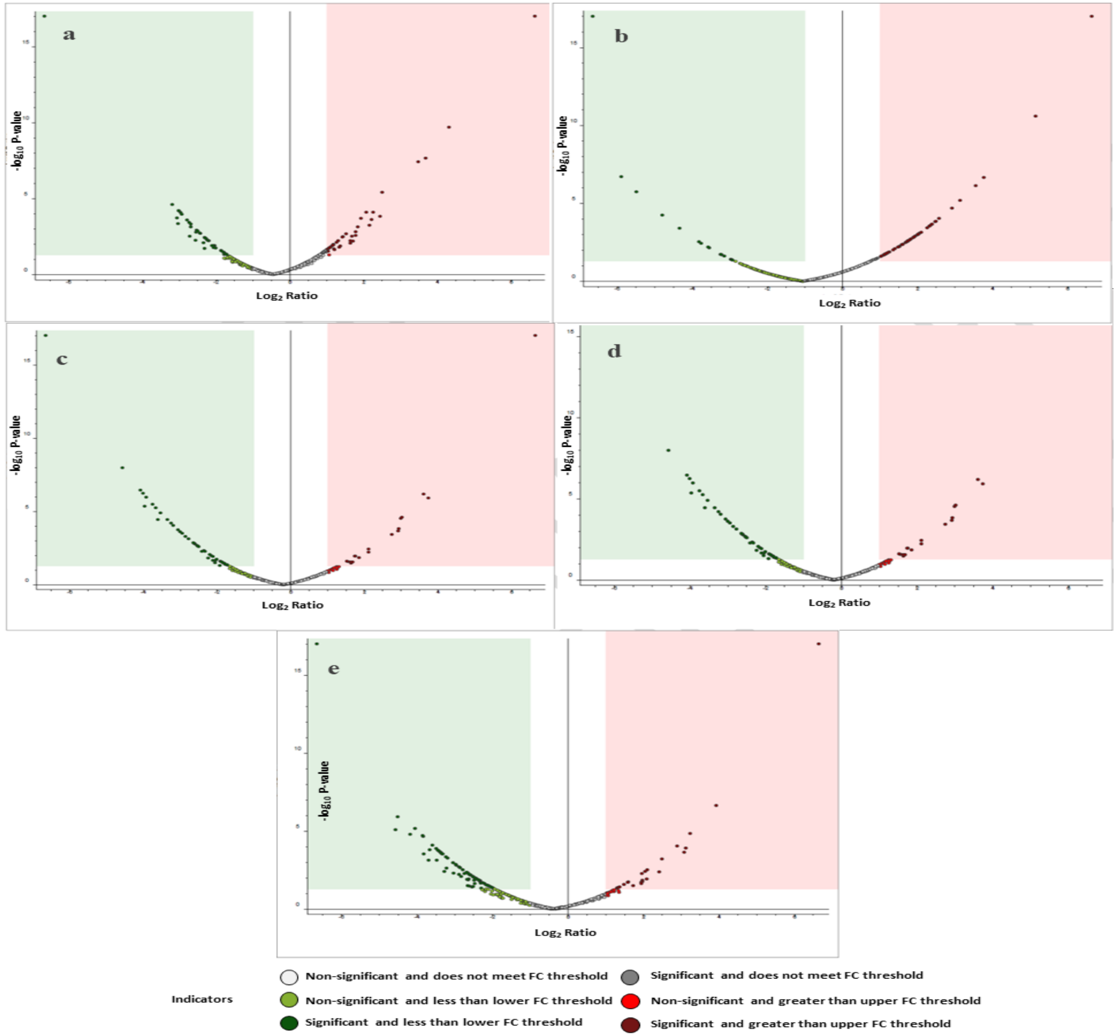
From the data obtained; four cluster of treatments were observed.

Compost and biochar treatments were observed in one cluster, basalt and ground magnesium limestone in one cluster, control and NPK fertilizer in different cluster.

This shows that organic and inorganic treatments resulted in a different effect to the parameters observed in this research.



# Differentially Expressed Protein in Rice Planted with Different Soil Amendments




Differentially expressed proteins between (a) NPK Fertilizer treatment and Control treatment (b) Biochar and Control (c) Basalt treatment and Control (d) Compost treatment and Control (e) Ground Magnesium Limestone treatment and Control

From the volcano plot obtained, it can be identified that treatment of ranking from GML, basalt, compost and biochar give a significant and greater than lower FC threshold.

These results demonstrated that some proteins expression levels first decreased in the control studies and then increased in rice leaves in response to organic amendment



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# Conclusion

- From the research conducted, rice plant treated with compost followed by biochar has shown the best performance in increasing the soil pH and rice growth performance
- 769 protein profiles were generated from rice plant and 485 of protein was involved in biological process of rice plant. The main five biological process that identified is cellular process (405) metabolic process (401), response to stimulus (83), biological regulation (50) and localization (30).
- Among the treatment, rice plant grown on acid sulfate soil applied with soil amendments shows the significant value of protein in the differential expression of proteins generated in rice plant.
- Therefore, protein profiling may be future discussed and study as it gives a useful information to tackle the responsive proteins that play a major role in treating acid sulfate soil.

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# Thank you